Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2013

Computing COMP3

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

Tuesday 11 June 2013 1.30 pm to 4.00 pm

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

Time allowed
- 2 hours 30 minutes

A

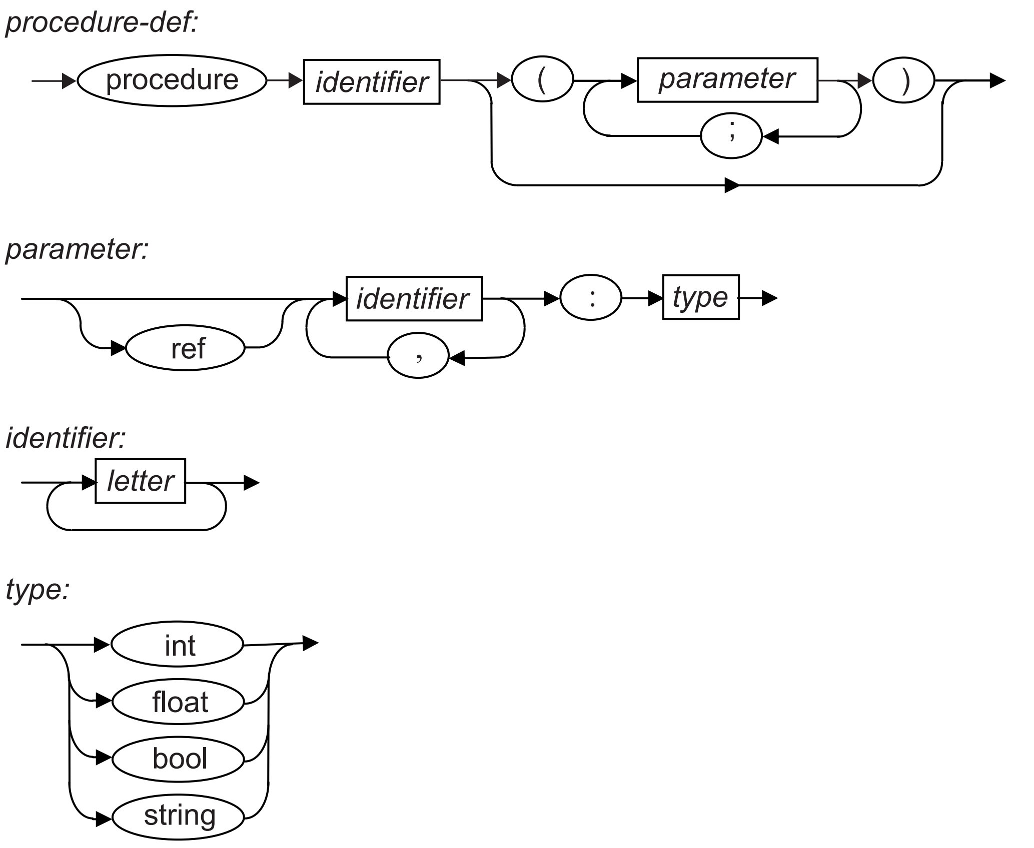
Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this 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.
- The use of brand names will **not** gain credit.
- Question 5 (f) should be answered in continuous prose. In this question you will be marked on your ability to:
  - use good English
  - organise information clearly
  - use specialist vocabulary where appropriate.

Answer **all** questions in the spaces provided.

1 In a particular programming language, the correct syntax for four different constructs is defined by the syntax diagrams in **Figure 1**.

Figure 1



A *letter* is any alphabetic character from "a" to "z" or "A" to "Z".

In this language an example of a valid *identifier* is `loopCount` and an example of a valid *type* is `int`.

1 (a) For each row in the table below, write **Yes** or **No** in the empty column to identify whether or not the **Example** is a valid example of the listed **Construct**.

Construct	Example	Valid? (Yes/No)
identifier	`Player2name`	
parameter	`x,y:bool`	
procedure-def	`procedure square(s:real)`	
procedure-def	`procedure rect(w:int,h:int)`	

(4 marks)

1 (b) A student has written Backus-Naur Form (BNF) production rules that are supposed to define the same constructs as the syntax diagrams in **Figure 1**. Their BNF rules are shown in **Figure 2**.

Figure 2

```
<procedure-def>::= procedure <identifier> ( <paramlist> )
<paramlist>    ::= <parameter> | <parameter> ; <paramlist>
<parameter>    ::= <identlist> : <type> |
                   ref <identlist> : <type>
<identlist>    ::= <identifier> | <identifier> , <identlist>
<identifier>   ::= <letter> | <letter> <identifier>
<type>         ::= int | float | bool | char | string
```

A `<letter>` is any alphabetic character from `"a"` to `"z"` or `"A"` to `"Z"`.

1 (b) (i) The BNF production rules in **Figure 2** contain two errors. These errors mean that they do not represent the same statement types as the syntax diagrams in **Figure 1**.

Describe the **two** errors.

Error 1: ....

....

Error 2: ....

....

(2 marks)

1 (b) (ii) The production rule for a `<paramlist>` is recursive.

Explain why recursion has been used in this production rule.

....

....

....

....

(1 mark)

7

Turn over for the next question

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

2 (a) Four bit patterns that are stored in this computer's memory are listed in **Figure 3** and are labelled with the letters **A** to **D**. Three of the bit patterns are valid floating point numbers and one is not.

Figure 3

	Mantissa								Exponent			
A	0 •	1	0	0	0	0	0	0	1	0	0	0
B	0 •	1	0	0	0	0	0	0	1	1	1	1
C	0 •	0	1	0	1	0	0	0	0	1	1	0
D	1 •	0	1	0	1	0	0	0	0	1	0	1

Complete **Table 1** below. In the **Correct letter (A-D)** column write the appropriate letter from **A** to **D** to indicate which bit pattern in **Figure 3** is an example of the type of value described in the **Value description** column.

Do **not** use the same letter more than once.

Table 1

Value description	**Correct letter (A-D)**
A negative value.	
The smallest positive value that can be represented.	
A value that is not valid in the representation because it is not normalised.	

(3 marks)

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

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

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

Working: ....

....

....

(1 mark)

Answer: ....

(1 mark)

2 (c) Write the normalised floating point representation of the negative denary value -7.75 in the boxes below. Show how you have arrived at your answer.

Working: ....

....

....

....

(2 marks)

Answer:

Mantissa								Exponent			
	•										

(1 mark)

Question 2 continues on the next page

2 (d) There can be a loss of precision when a denary number is stored using this floating point system.

The closest possible representation of the denary number 6.9 is shown below.

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

By converting this bit pattern back into denary it can be seen that the actual number stored is 6.875, not 6.9.

2 (d) (i) Calculate the absolute error that has occurred.

....

....

(1 mark)

2 (d) (ii) Calculate the relative error that has occurred.

....

....

(1 mark)

2 (d) (iii) Explain how the floating point system used could be modified to allow a more accurate representation of 6.9.

....

....

....

(2 marks)

12

Do not write outside the box

3 Data is being transmitted along a serial link using asynchronous data transmission and odd parity.

3 (a) Explain what *serial data transmission* is and how it differs from *parallel data transmission*.

....

....

....

(2 marks)

3 (b) **Figure 4** shows a byte of data being transmitted along the serial link using odd parity.

Write the missing values of the **Stop bit**, **Parity bit** and **Start bit** on **Figure 4**.

Figure 4

		1	0	0	1	1	1	0	0	
Stop bit	**Parity bit**	**Byte of data**								**Start bit**

Direction of data transmission →

(2 marks)

3 (c) Explain what *asynchronous data transmission* is.

....

....

....

....

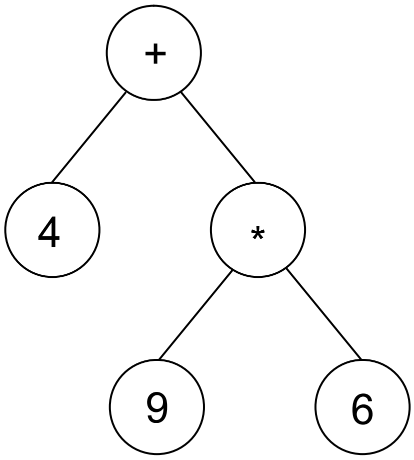
(1 mark)

5

Turn over for the next question

4 A tree can be used to represent a mathematical expression. This is known as an expression tree. **Figure 5** is an expression tree for the infix expression 4 + 9 * 6.

Figure 5



4 (a) An expression tree is an example of a rooted tree.

State the contents of the root node: ....

List the contents of **all** of the leaf nodes: ....

(2 marks)

4 (b) The expression tree in **Figure 5** could be represented using three one-dimensional arrays named **A**, **B** and **C**. **Figure 6** shows a representation of **Figure 5** together with the array indices.

Figure 6

Arrays

Index	A	B	C
[1]	+	2	3
[2]	4	0	0
[3]	*	4	5
[4]	9	0	0
[5]	6	0	0

Describe the role of each of the arrays **A**, **B** and **C**.

A: ....

B: ....

C: ....

(3 marks)

Do not write outside the box

4 (c) What does an entry of `0` in array **B** indicate?

....

....

(1 mark)

4 (d) The procedure in **Figure 7** describes a type of tree traversal that can be carried out on the representation of the tree shown in **Figure 6**.

Figure 7

```
Procedure Traverse(Pos:Integer)
  If B[Pos] > 0 Then Traverse(B[Pos])
  If C[Pos] > 0 Then Traverse(C[Pos])
  Output A[Pos]
End Procedure
```

Using the table below, trace the execution of the procedure when it is called using `Traverse(1)`. You may not need to use all of the lines provided in the table.

Pos	Output

(4 marks)

4 (e) Which type of tree traversal does the procedure `Traverse` carry out?

....

(1 mark)

4 (f) What does the output of the procedure represent?

....

(1 mark)

12

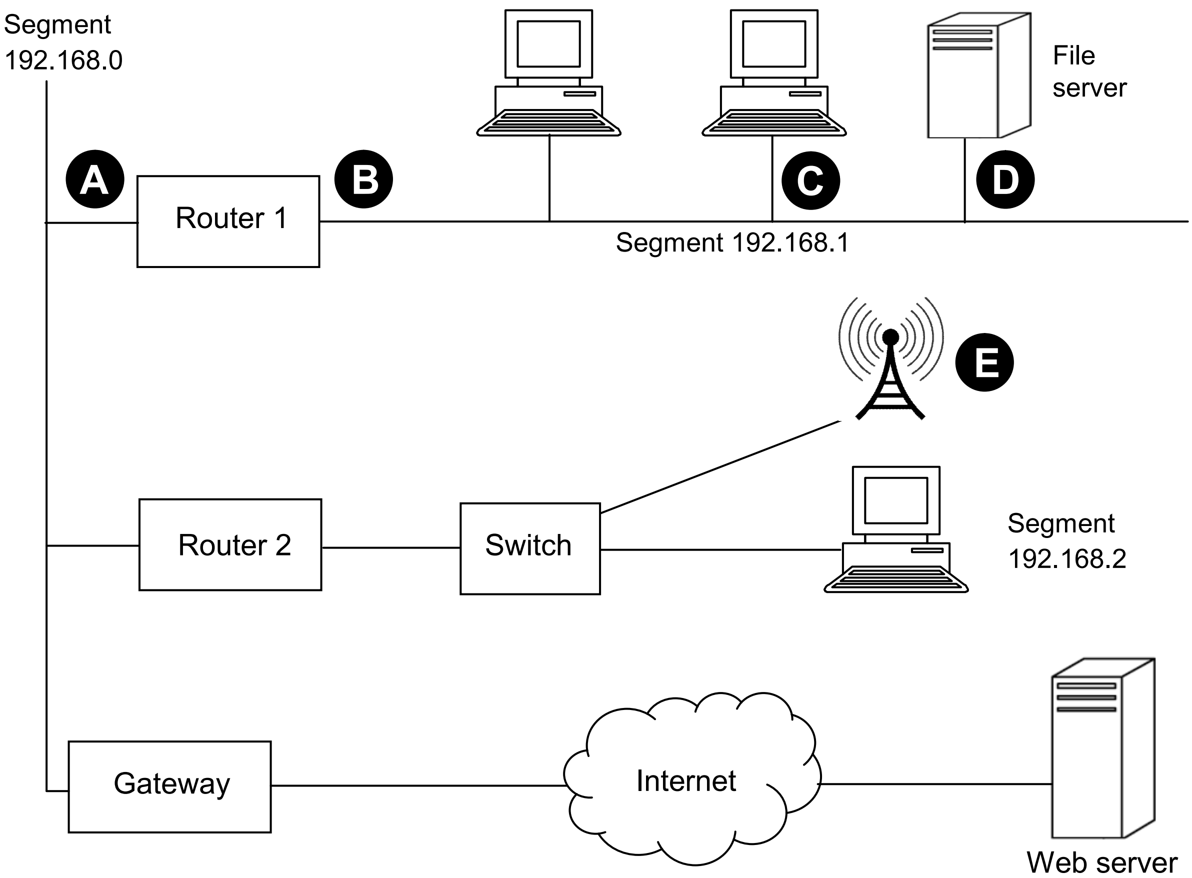
Turn over ▶

5 A student is using her computer at school.

Figure 8 shows the physical topology of the Local Area Network (LAN) to which her computer is connected. The LAN is divided up into segments. It also shows a web server that her computer connects to through the Internet.

The student is using computer **C**.

Figure 8



5 (a) Suggest suitable IP addresses for:

5 (a) (i) the "Router 1" port labelled **A** ....

5 (a) (ii) the "Router 1" port labelled **B** ....

5 (a) (iii) the network adapter card in the student's computer, labelled **C**

....

(3 marks)

5 (b) What physical network topology is used within segment 192.168.1?

....

(1 mark)

Do not write outside the box

5 (c) When the computers in segment 192.168.1 were configured on the network, they were programmed with a subnet mask.

What subnet mask would have been used?

....

(1 mark)

5 (d) The student has been accessing data from the file server computer that is labelled **D** on **Figure 8**. This file server uses a server operating system.

Explain what a *server operating system* is.

....

....

....

(1 mark)

5 (e) Some other students using laptops are connected to the LAN by Wi-Fi through the Wireless Access Point that is labelled **E** on **Figure 8**. Wireless communication is less secure than communication using cables.

5 (e) (i) Describe **one** measure that could be implemented by the Wireless Access Point to improve the security of the network.

....

....

....

(1 mark)

5 (e) (ii) Explain why Wi-Fi has been chosen for this connection rather than Bluetooth.

....

....

....

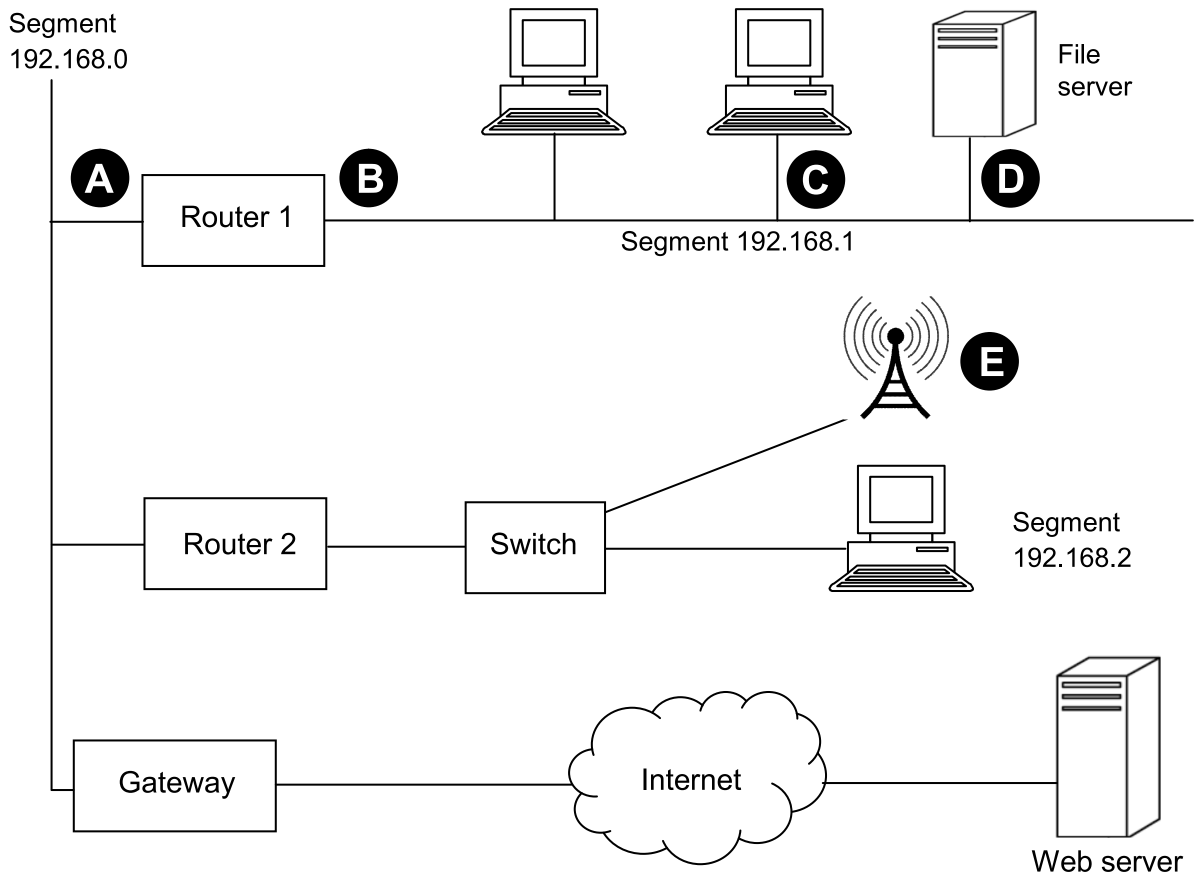
(1 mark)

Question 5 continues on the next page

Do not write outside the box

Figure 8 is repeated below so that you can answer question part **5 (f)** without having to turn back in the question paper booklet.

Figure 8 (repeated)



The student now uploads a file from her computer to a web server over the Internet.

5 (f) Write a detailed description of how one packet of data that the student is uploading to the web server will be routed from her computer in the United Kingdom to the web server that is located in Chicago in the United States of America. You may assume that the web browser software on the student's computer has already looked up, using a domain name server, the IP address of the web server.

Your description should cover:

- how the packet will be routed within the LAN from the student's computer to the gateway **and**
- how, once it has reached the gateway, the packet will be routed across the Internet to the web server that the data is being uploaded to.

In your answer you will be assessed on your ability to use good English, and to organise your answer clearly in complete sentences, using specialist vocabulary where appropriate. *(8 marks)*

Your answer to question 5 (f) may be continued on the next page

Turn over ▸

....

....

....

....

....

....

....

....

5 (g) The web server has a routable IP address.

The student's computer has a non-routable IP address.

Explain **two** differences between routable and non-routable IP addresses.

Difference 1: ....

....

Difference 2: ....

....

(2 marks)

18

Do not write outside the box

6 An algorithm is a sequence of unambiguous instructions for solving a problem.

6 (a) Three different algorithms, A, B and C, have the following orders of time complexity:

Algorithm A: $O(a^n)$
Algorithm B: $O(n^2)$
Algorithm C: $O(n)$

List the algorithms A, B and C in order with the most efficient at the top of the list.

Most efficient: ....

....

Least efficient: ....

(1 mark)

6 (b) Some problems are intractable.

6 (b) (i) What does it mean for a problem to be described as *intractable*?

....

....

....

(2 marks)

6 (b) (ii) One of the problems listed in the table below is intractable.

Place **one** tick next to the intractable problem.

Problem	**Intractable? (Tick one)**
The travelling salesman problem	
The problem of sorting a list of names into alphabetic order	
The Halting problem	

(1 mark)

4

Turn over for the next question

Do not write outside the box

7 A particular Turing machine has states S_B, S_0, S_1, S_R and S_T. S_B is the start state and S_T is the stop state. The machine stores data on a single tape which is infinitely long in one direction. The machine's alphabet is 0, 1, #, x, y 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:

$$\delta(S_B, 1) = (S_1, y, \rightarrow)$$

means:

IF the machine is currently in state S_B AND the input symbol read from the tape is 1
THEN the machine should change to state S_1, write a y to the tape and move the read/write head one cell to the right

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

$\delta(S_B, 0) = (S_0, x, \rightarrow)$
$\delta(S_B, 1) = (S_1, y, \rightarrow)$
$\delta(S_B, \#) = (S_T, \#, \rightarrow)$

$\delta(S_0, 0) = (S_0, 0, \rightarrow)$
$\delta(S_0, 1) = (S_0, 1, \rightarrow)$
$\delta(S_0, \#) = (S_0, \#, \rightarrow)$
$\delta(S_0, \square) = (S_R, 0, \leftarrow)$

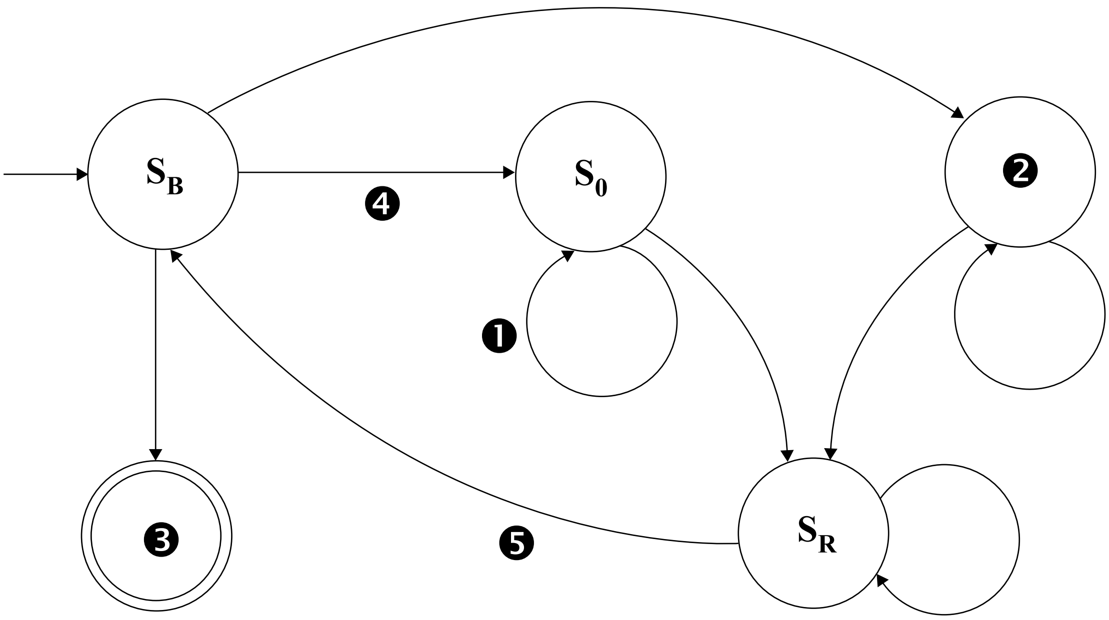
$\delta(S_1, 0) = (S_1, 0, \rightarrow)$
$\delta(S_1, 1) = (S_1, 1, \rightarrow)$
$\delta(S_1, \#) = (S_1, \#, \rightarrow)$
$\delta(S_1, \square) = (S_R, 1, \leftarrow)$

$\delta(S_R, 0) = (S_R, 0, \leftarrow)$
$\delta(S_R, 1) = (S_R, 1, \leftarrow)$
$\delta(S_R, \#) = (S_R, \#, \leftarrow)$
$\delta(S_R, x) = (S_B, 0, \rightarrow)$
$\delta(S_R, y) = (S_B, 1, \rightarrow)$

Do not write outside the box

Figure 9 shows an unlabelled finite state transition diagram for this machine. Some of the state transition arrows represent more than one of the machine's transition rules. For example, the arrow labeled ❶ represents the three rules: $\delta\ (S_0, 0) = (S_0, 0, \rightarrow)$, $\delta\ (S_0, 1) = (S_0, 1, \rightarrow)$ and $\delta\ (S_0, \#) = (S_0, \#, \rightarrow)$.

Figure 9



7 (a) (i) Which states are represented by the labels ❷ and ❸ in **Figure 9**?

❷ ....   ❸ ....

(1 mark)

7 (a) (ii) Which of the machine's transition rule(s) is/are represented by the arrow labelled ❹ in **Figure 9**?

....

....

(1 mark)

7 (a) (iii) Which of the machine's transition rule(s) is/are represented by the arrow labelled ❺ in **Figure 9**?

....

....

(1 mark)

Turn over ▸

The machine's transition rule, δ, is repeated here so that you can answer question **7(b)** without having to turn back in the question paper booklet.

$\delta(S_B, 0) = (S_0, x, \rightarrow)$
$\delta(S_B, 1) = (S_1, y, \rightarrow)$
$\delta(S_B, \#) = (S_T, \#, \rightarrow)$

$\delta(S_0, 0) = (S_0, 0, \rightarrow)$
$\delta(S_0, 1) = (S_0, 1, \rightarrow)$
$\delta(S_0, \#) = (S_0, \#, \rightarrow)$
$\delta(S_0, \square) = (S_R, 0, \leftarrow)$

$\delta(S_1, 0) = (S_1, 0, \rightarrow)$
$\delta(S_1, 1) = (S_1, 1, \rightarrow)$
$\delta(S_1, \#) = (S_1, \#, \rightarrow)$
$\delta(S_1, \square) = (S_R, 1, \leftarrow)$

$\delta(S_R, 0) = (S_R, 0, \leftarrow)$
$\delta(S_R, 1) = (S_R, 1, \leftarrow)$
$\delta(S_R, \#) = (S_R, \#, \leftarrow)$
$\delta(S_R, x) = (S_B, 0, \rightarrow)$
$\delta(S_R, y) = (S_B, 1, \rightarrow)$

Do not write outside the box

7 (b) This Turing machine is carrying out a computation. The machine starts in state S_B with the string 01# on the tape. All other cells contain the blank symbol, □ (not shown).

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. The first three steps and final state have been completed for you.

Step								State
1.	0	1	#				...	S_B
	↑							
2.	x	1	#				...	S_0
		↑						
3.	x	1	#				...	S_0
			↑					
4.							...	
5.							...	
6.							...	
7.							...	
8.							...	
9.							...	
10.							...	
11.							...	
12.							...	
13.							...	
14.							...	
15.							...	
16.							...	S_T

(6 marks)

Question 7 continues on the next page

Turn over ▸

Do not write outside the box

7 (c) (i) Describe the purpose of the symbols x and y in this Turing machine's alphabet.

....

....

(1 mark)

7 (c) (ii) What does the Turing machine do?

....

....

(1 mark)

11

Do not write outside the box

8 An interactive operating system maintains a list of the processes that are currently waiting to execute (run). The processes are stored in order of the priority that is associated with their execution. This priority can be set as "High", "Normal" or "Low".

Figure 10 and **Figure 11** below show two different ways in which the storage of the process list could be implemented.

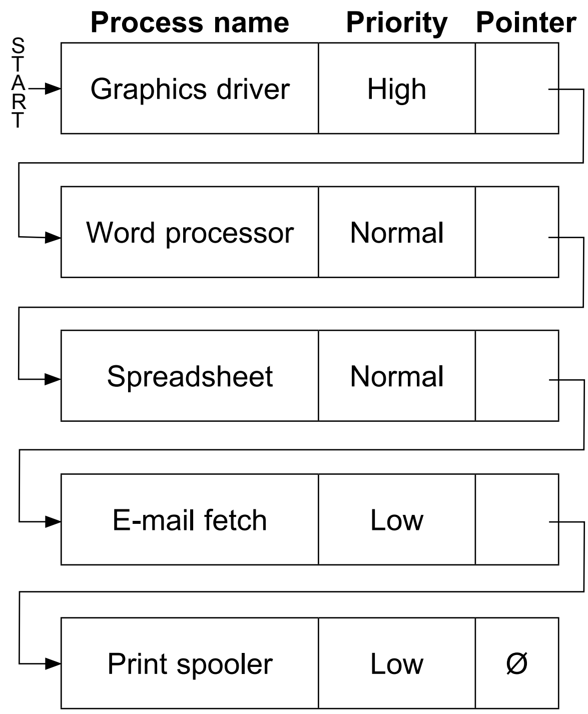
Figure 10

Static implementation: as an ordered list using a fixed size array.

Index	Process name	Priority
[1]	Graphics driver	High
[2]	Word processor	Normal
[3]	Spreadsheet	Normal
[4]	E-mail fetch	Low
[5]	Print spooler	Low
⋮		
[100]		

Figure 11

Dynamic implementation: as a linked list using dynamic memory allocation.



The process at the start of the list will be run next. In **Figure 10** and **Figure 11**, this is the "Graphics driver" process.

When a new process is initiated it is inserted into the list immediately after the last process of the same priority. A "Computer game" process with "High" priority would be inserted into the list in **Figure 10** and **Figure 11** between the "Graphics driver" and "Word processor" processes.

When a process is completed it is deleted from the list.

Question 8 continues on the next page

8 (a) Explain **two** differences between a dynamic data structure and a static data structure.

Difference 1: ....

....

Difference 2: ....

....

(2 marks)

8 (b) The **static implementation** is less efficient at inserting new items into the list than the **dynamic implementation**.

Explain why this is the case.

....

....

....

....

....

(2 marks)

8 (c) At a higher level of abstraction, the process list maintained by the operating system could be viewed as a type of queue.

What type of queue?

....

(1 mark)

Turn over for the next question

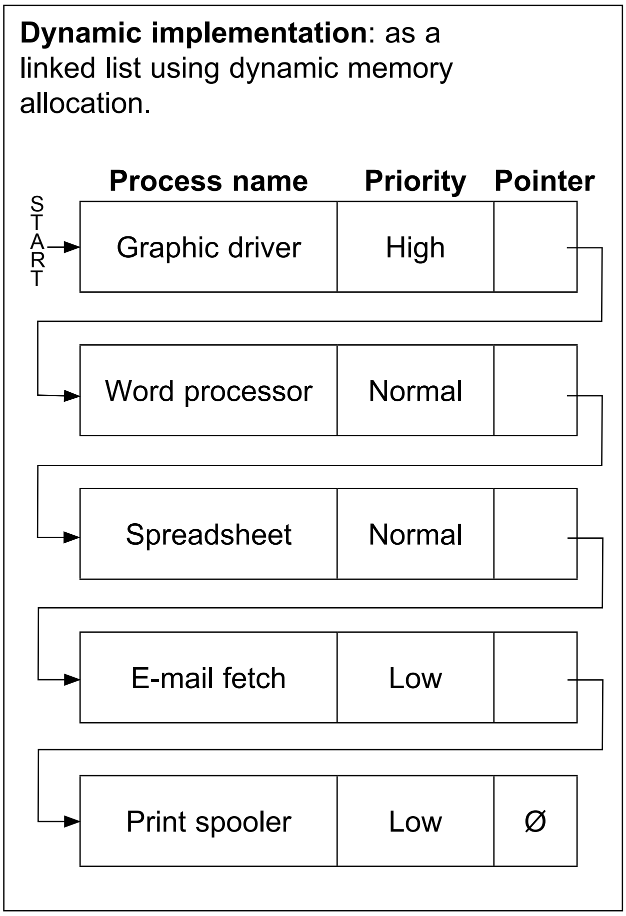
DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Turn over ▶

Do not write outside the box

Figure 11 is repeated below so that you can answer the remaining question parts without having to turn back in the question booklet.

Figure 11 (repeated)



8 (d) Consider the **dynamic implementation** in **Figure 11**.

8 (d) (i) What will the heap be used for in this implementation?

....

....

(1 mark)

8 (d) (ii) In **Figure 11** pointers are shown as arrows.

When the linked list is created in a programming language, what will the integer value stored in a pointer represent?

....

....

(1 mark)

8 (d) (iii) Write an algorithm of the steps that would be involved in inserting a new process "Database" with priority "Normal" into the dynamic implementation linked list in **Figure 11**.

The algorithm will need to:

- find the correct position to insert the new process at, **then**
- make the necessary changes to insert the information about the new process.

You may wish to use a **Current Node Pointer** and a **Previous Node Pointer** in your response.

Your algorithm only needs to cater for a list that already contains some processes at each priority level.

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(7 marks)

14

Do not write outside the box

9 A company sells furniture to customers of its store. The store does not keep the furniture in stock. Instead, a customer places an order at the store and the company then orders the furniture required from its suppliers. When the ordered furniture arrives at the store a member of staff telephones or e-mails the customer to inform them that it is ready for collection. Customers often order more than one type of furniture on the same order, for example a sofa and two chairs.

Details of the furniture, customers and orders are to be stored in a relational database using the following four relations:

Furniture(FurnitureID, FurnitureName, Category, Price, SupplierName)

CustomerOrder(OrderID, CustomerID, Date)

CustomerOrderLine(OrderID, FurnitureID, Quantity)

Customer(CustomerID, CustomerName, EmailAddress, TelephoneNumber)

9 (a) These relations are in Third Normal Form (3NF).

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

Meaning: ....

....

....

....

(2 marks)

Why important: ....

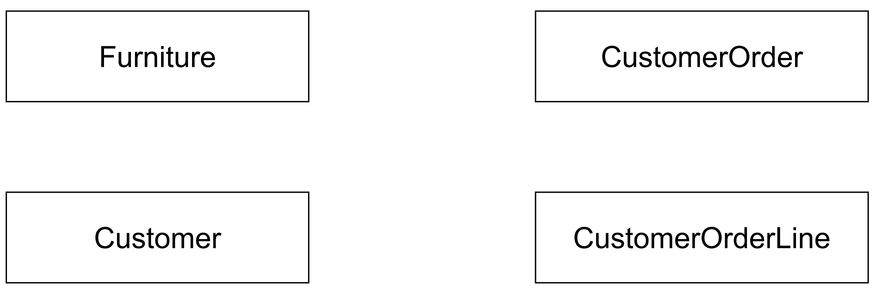
....

....

....

(2 marks)

9 (b) On the incomplete Entity-Relationship diagram below show the degree of any **three** relationships that exist between the entities.



(3 marks)

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

CREATE TABLE Furniture (

....

....

....

....

....

....)

(3 marks)

9 (d) A fault has been identified with the product that has FurnitureID number 10765. The manager needs a list of the names and telephone numbers of all of the customers who have purchased this item of furniture so that they can be contacted. This list should contain no additional details and must be presented in alphabetical order of the names of the customers.

Write an SQL query that will produce the list.

....

....

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....

....

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....

....

....

....

(6 marks)

Do not write outside the box

9 (e) The system requirements have changed. When an order is placed the system must now record the name of the sales person who took the order.

Place **one** tick next to the correct SQL command below that should be used to update the structure of the database so that this information can be recorded.

Command	**Correct? (Tick one)**
ALTER TABLE	
CREATE FIELD	
INSERT COLUMN	

(1 mark)

17

END OF QUESTIONS