Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
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10	
11	
12	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2012

Computing COMP3

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

Tuesday 12 June 2012 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.
- The use of brand names will **not** gain credit.
- Questions 5(c) and 8(b) should be answered in continuous prose. In these questions you will be marked on your ability to:
  - use good English
  - organise information clearly
  - use specialist vocabulary where appropriate.

Do not write outside the box

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

1 An operating system is designed to hide the complexities of the hardware from the user and to manage the hardware and other resources.

Give **three** different types of management of either hardware or other resources that are performed by an operating system.

1 .....

.....

2 .....

.....

3 .....

.....

(3 marks)

3

2 **Figure 1** shows some production rules that have been used to define the syntax of valid mathematical expressions in a particular programming language.

Figure 1

```
<expression> ::= <factor> | <factor> * <factor> | <factor> / <factor>
<factor> ::= <term> | <term> + <term> | <term> - <term>
<term> ::= - <expression> | <number>
<number> ::= <digit> | <digit> <number>
<digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
```

2 (a) What notation method has been used in **Figure 1**?

.....

(1 mark)

Do not write outside the box

2 (b) Complete **Table 1** by writing **Yes** or **No** in the empty column to indicate whether or not the strings are valid examples of the statement types from **Figure 1**.

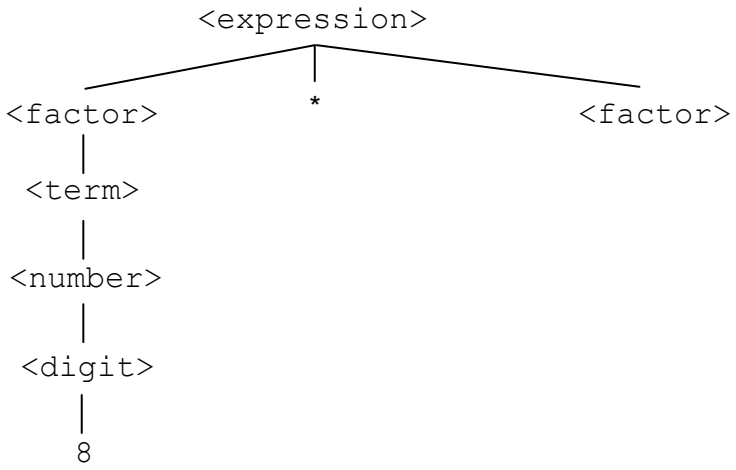
Table 1

Statement type	String	Valid (Yes/No)
<number>	129.376	
<factor>	23 + 17	

(2 marks)

2 (c) A tree can be used to demonstrate that an <expression> is valid. This is known as a parse tree.

Complete the parse tree below to show that 8 * 4 + 21 is a valid <expression>.



(3 marks)

6

Turn over for the next question

Do not write outside the box

3 (a) Time complexity is one of the two measures that are used to describe the complexity of an algorithm.

What is the other measure?

.....

(1 mark)

3 (b) A student has been asked to write a program to list duplicate entries in a file containing a list of words. **Figure 2** shows her first attempt at planning an algorithm. The algorithm will not work in all circumstances.

Figure 2

```
Open file
N ← Number of items in file
For Pos1 ← 1 To N Do
  Read item at position Pos1 in file into variable W1
  For Pos2 ← 1 To N Do
    Read item at position Pos2 in file into variable W2
    If W1 = W2 And Not (Pos1 = Pos2)
      Then Output 'Duplicate: ' , W1
    EndIf
  EndFor
EndFor
Close file
```

The basic operation in the algorithm is the `If` statement that compares two words.

The contents of a particular file are shown in **Figure 3**.

Figure 3

File position	Item
1	Rope
2	Dagger
3	Rope

Do not write outside the box

3 (b) (i) Complete **Table 2** below by tracing the execution of the algorithm in **Figure 2** when it is applied to the file in **Figure 3**.

Table 2

N	Pos1	W1	Pos2	W2	Output

(3 marks)

3 (b) (ii) Tick **one** box in the table below to indicate the correct order of time complexity of the algorithm that the student has written.

Order of time complexity	Tick one box
$O(a^n)$	
$O(n)$	
$O(n^2)$	

(1 mark)

3 (b) (iii) Justify your answer to part (b)(ii).

.....

.....

.....

.....

(2 marks)

7

Turn over ▶

Do not write outside the box

4 A particular long-distance data transmission system transmits data signals as electrical voltages using copper wire.

4 (a) What is the relationship between the bandwidth of the copper wire and the bit rate at which the data can be transmitted?

.....

.....

.....

(1 mark)

4 (b) The system is affected by latency.

What is *latency* in the context of data communications?

.....

.....

(1 mark)

The system uses four different voltage levels so that two data bits can be transmitted with each signal change.

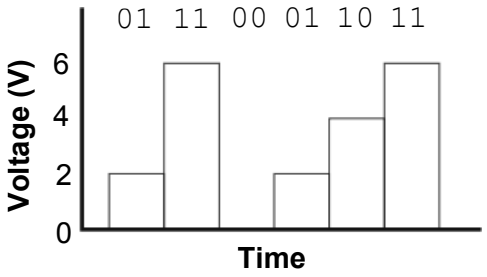
Table 3 shows the signal levels (in volts) that the system uses for particular binary patterns.

Table 3

Binary pattern	Signal level (volts)
00	0
01	2
10	4
11	6

Using this system, the binary pattern 011100011011 would be transmitted as the voltage sequence 2,6,0,2,4,6 as shown in **Figure 4**:

Figure 4



Do not write outside the box

4 (c) What, **precisely**, is the relationship between the bit rate and the baud rate for this system?

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.....

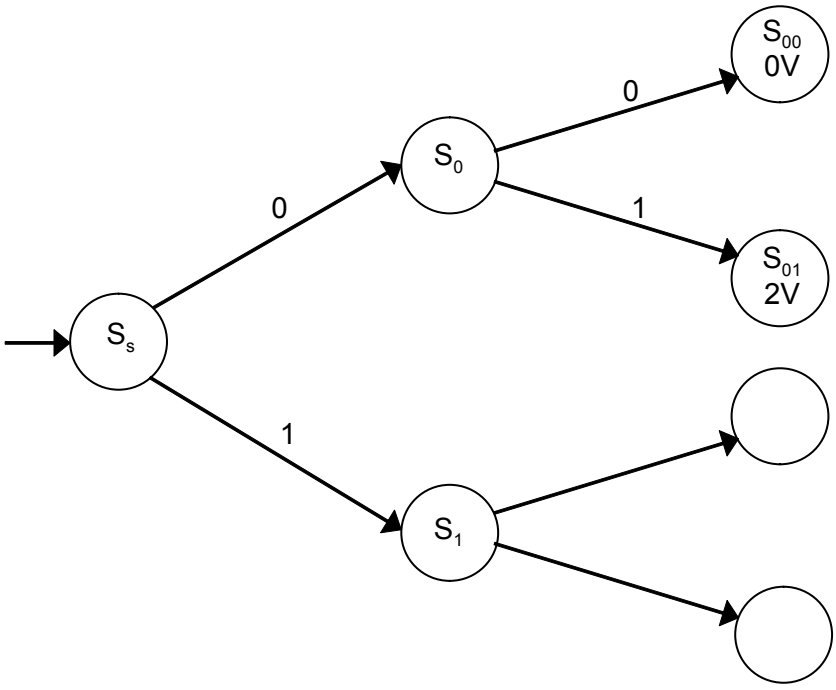
(1 mark)

4 (d) A Moore machine is a type of finite state machine that produces output. The transitions are labelled with the inputs and each state is labelled with a name and the output that it produces; if a particular state has no output then it is labelled with just a name.

Figure 5 shows an incomplete diagram of a Moore machine that will convert a two-bit binary code into the signal level (in volts) that is transmitted to represent it, as listed in **Table 3**.

Complete **Figure 5**. Label all of the transitions and the states that are currently unlabelled. The machine should work for the four binary patterns 00, 01, 10 and 11.

Figure 5



(4 marks)

7

Turn over for the next question

Do not write outside the box

5 Software is being developed to allow secure transmission of data over the Internet.

The two computers involved in a communication will be known as A and B.

5 (a) What is *encryption*?

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.....

.....

(1 mark)

5 (b) The data that are being transmitted will be encrypted using public and private keys. A and B will each have a public key and a private key.

A will encrypt the data that it is sending using B's public key.

Explain why the data should **not** be encrypted using:

5 (b) (i) A's public key.

.....

.....

.....

(1 mark)

5 (b) (ii) A's private key.

.....

.....

.....

(1 mark)

Do not write outside the box

5 (c) The communication will be made more secure by the use of a digital signature attached to the end of the message.

- State the purpose of the digital signature.
- Explain how it will be created and used in the data transmission process from A to B.

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.

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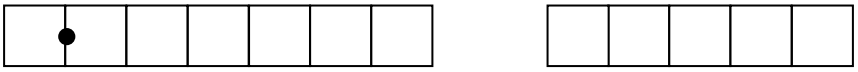
(6 marks)

9

Do not write outside the box

6 A normalised floating point representation uses a 7-bit mantissa and a 5-bit exponent, both stored using **two's complement format**.

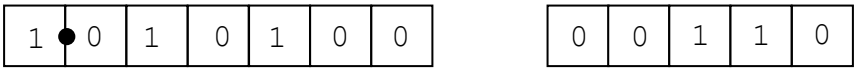
6 (a) In binary, write the most **negative** number that can be represented using this normalised floating point system in the boxes below:



Mantissa Exponent

(2 marks)

6 (b) This is a floating point representation of a number:



Mantissa Exponent

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

Working: .....

.....

.....

(1 mark)

Answer: .....

(1 mark)

6 (c) Write the normalised floating point representation of the denary value 416 in the boxes below. Show how you have arrived at your answer.

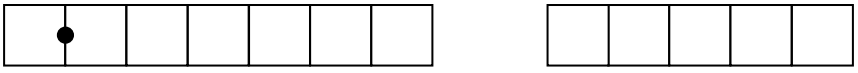
Working: .....

.....

.....

(1 mark)

Answer:



Mantissa Exponent

(1 mark)

Do not write outside the box

6 (d) Write the normalised floating point representation of the negative denary value -12.5 in the boxes below. Show how you have arrived at your answer.

Working: .....

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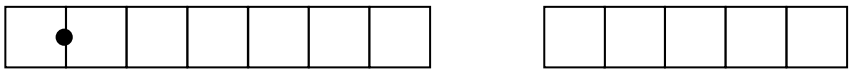
(2 marks)

Answer:



(1 mark)

6 (e) **Table 4** lists three different calculations that might cause an error to occur in a floating point system.

Complete **Table 4** by stating the name of the type of error that may occur for each calculation. You should **not** give the same answer more than once.

Table 4

Calculation	Type of error
Multiplying two very large numbers together.	
Dividing a number by a very large number.	
Adding together two numbers of very different sizes eg a tiny number to a very big number.	

(3 marks)

12

Turn over for the next question

Do not write outside the box

7 An object-oriented program is being written to store details of the hardware devices that are connected to a computer network in a college. This will be used by the network manager to perform an audit of the equipment that the college owns.

Two different types of devices are connected to the network. They are printers and computers. The computers are categorised as being laptops, desktops or servers.

A class **Device** has been created and two subclasses, **Printer** and **Computer** are to be developed. The **Computer** class will have three subclasses: **Laptop**, **Desktop** and **Server**.

7 (a) Draw an inheritance diagram for the six classes.

(3 marks)

7 (b) The **Device** class has data fields **MACAddress**, **DeviceName** and **Location**.

The class definition for **Device** is:

```
Device = Class
           Public
             Procedure AddDevice
             Function GetMACAddress
             Function GetDeviceName
             Function GetLocation
           Private
             MACAddress: String
             DeviceName: String
             Location: String
         End
```

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

- **ProcessorName**: Stores the name of the company that manufactured the processor.
- **RAMCapacity**: Stores the capacity of the RAM installed in the computer, in gigabytes.
- **HDDCapacity**: Stores the capacity of the Hard Disk Drive installed in the computer, in gigabytes.

Do not write outside the box

Write the class definition for **Computer**.

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(4 marks)

7 (c) The **Laptop** class has the additional data field **BluetoothInstalled**. This field will indicate whether or not the laptop is fitted with a Bluetooth module.

Write the class definition for **Laptop**.

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(2 marks)

Do not write outside the box

7 (d) Explain what Bluetooth is and give an example of a task for which a laptop user might use Bluetooth.

What Bluetooth is:.....

.....

.....

(2 marks)

Example use: .....

.....

.....

(1 mark)

12

8 A systems analyst is planning a system for the administration of student courses to be used in an office in a college. The system must allow users at ten workstations to access and update a central database.

8 (a) The analyst initially plans to use either a peer-to-peer or a server-based network.

Explain why a server-based network is likely to be more appropriate than a peer-to-peer network in this situation.

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(2 marks)

Do not write outside the box

8 (b) After considering other alternatives, the analyst finally decides to use a thin-client network.

Explain how a thin-client network works and how the use of a thin-client network instead of a traditional rich-client (thick-client) network will affect the selection of the hardware to be used by the system.

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.

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(4 marks)

8 (c) The system will be networked within the college. This network will then be connected to the Internet so that staff who are out of the college can log in and access the system. This connection will use a gateway.

What is the purpose of the gateway?

.....

.....

(1 mark)

7

Do not write outside the box

9 A library uses a database management system (DBMS) to store details of the books that it stocks, its members and the loans that it has made. These details are stored in a database using the following three relations:

Book(BookID, Title, Author, Publisher)

Member(MemberID, Surname, Forename, HouseNumber, StreetName, Town, County, Postcode, DateOfBirth, EmailAddress)

Loan(MemberID, BookID, LoanDate, DueBackDate, Returned)

The library does not stock more than one copy of the same book.

9 (a) The key in the Loan relation is made up of three attributes.

What is the name given to a key that is made up of multiple attributes?

.....

(1 mark)

9 (b) The relations in this database have been fully normalised.

State **two** properties that the relations in a fully normalised database must have.

Property 1: .....

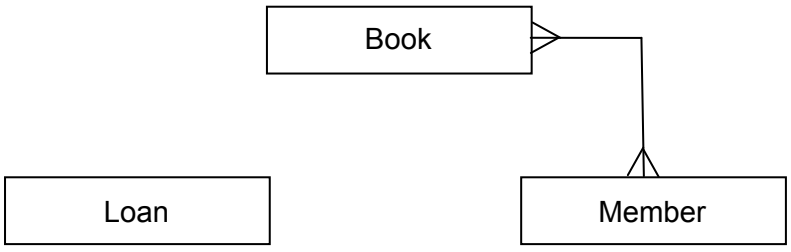
.....

Property 2: .....

.....

(2 marks)

9 (c) Complete the Entity-Relationship diagram below to show the degree of the **two** missing relationships between the entities.



(2 marks)

Do not write outside the box

9 (d) The library is holding a 'meet the author' event at which members will be able to meet the author Lucas Bailey. The librarian wants to send e-mails to all of the library members who have read any of his books to invite them to the event.

Write an SQL query to retrieve the EmailAddress, Forename and Surname of the people to whom e-mails should be sent.

```
SELECT

FROM



WHERE
```

(5 marks)

9 (e) A new book is to be added to the library stock. The book details are:

- BookID: 837023
- Title: Kenyan Safari
- Author: Karen Matu
- Publisher: African Travel Guides

Write the SQL commands that will add this book into the database.

```
INSERT INTO .....

VALUES .....

.....
```

(2 marks)

Question 9 continues on the next page

Do not write outside the box

The definitions of the three relations in the database on page 16 are repeated here so that you can answer Question **9 (f)** on this page without having to turn back in the question booklet.

Book(BookID, Title, Author, Publisher)

Member(MemberID, Surname, Forename, HouseNumber, StreetName, Town, County, Postcode, DateOfBirth, EmailAddress)

Loan(MemberID, BookID, LoanDate, DueBackDate, Returned)

9 (f) The system requirements have changed. The library now needs to be able to stock more than one copy of the same book. Two different copies of the same book will have the same BookID.

Explain how the database design could be modified to meet this new requirement, whilst ensuring that the database remains normalised.

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(3 marks)

Do not write outside the box

9 (g) The DBMS organises the data in the database in files using hashing.

9 (g) (i) Why is hashing used?

.....

.....

(1 mark)

9 (g) (ii) In the context of storing data in a file, explain what a *hash function* is.

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.....

.....

.....

(2 marks)

9 (g) (iii) Collisions can occur when hashing is used.

In this context, explain what a *collision* is and how one might be dealt with.

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(2 marks)

20

Turn over for the next question

Do not write outside the box

10 A graph can be drawn to represent a maze. In such a graph, each graph vertex represents one of the following:

- the entrance to or exit from the maze
- a place where more than one path can be taken
- a dead end.

Edges connect the vertices according to the paths in the maze.

Figure 6 shows a maze and **Figure 7** shows one possible representation of this maze. Position 1 in **Figure 6** corresponds to vertex 1 in **Figure 7** and is the entrance to the maze. Position 7 in **Figure 6** is the exit to the maze and corresponds to vertex 7. Dead ends have been represented by the symbol ⟝ in **Figure 7**.

Figure 8 shows a simplified undirected graph of this maze with dead ends omitted.

Figure 6

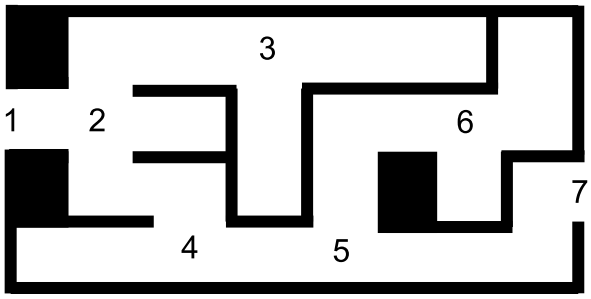
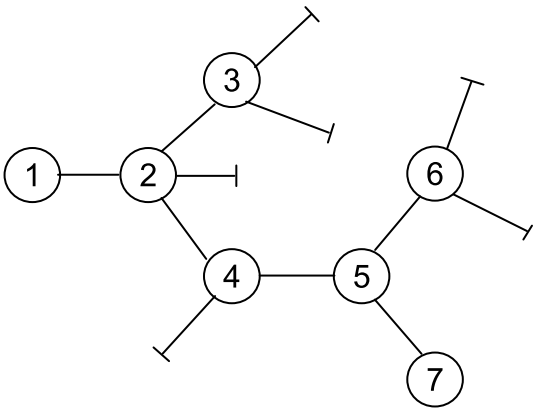
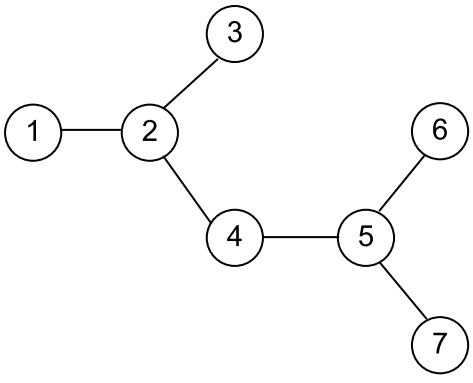


Figure 7



Representation of maze including dead ends

Figure 8



Graph representing maze with dead ends omitted

Do not write outside the box

10 (a) The graph in **Figure 8** is a tree.

State **one** property of the graph in **Figure 8** that makes it a tree.

.....

.....

(1 mark)

10 (b) The graphs of some mazes are not trees.

Describe a feature of a maze that would result in its graph **not** being a tree.

.....

.....

(1 mark)

10 (c) Complete the table below to show how the graph in **Figure 8** would be stored using an adjacency matrix.

(2 marks)

Question 10 continues on the next page

Do not write outside the box

10 (d) (i) What is a *recursive routine*?

.....

.....

(1 mark)

10 (d) (ii) To enable the use of recursion a programming language must provide a stack.

Explain what this stack will be used for and why a stack is appropriate.

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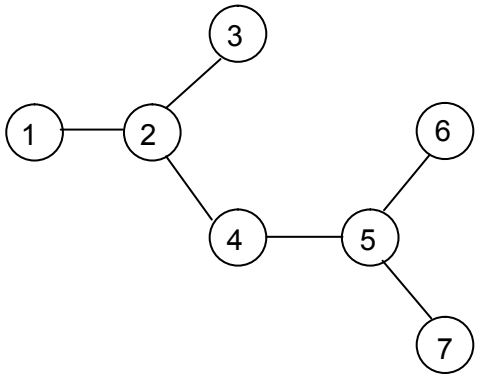
(2 marks)

Figure 8 from page 20 is repeated here so that you can answer Question 10(e) without having to turn back in the question booklet.

Figure 8 (repeated)



10 (e) A recursive routine can be used to perform a depth-first search of the graph that represents the maze to test if there is a route from the entrance (vertex 1) to the exit (vertex 7).

The recursive routine in **Figure 9** is to be used to explore the graph in **Figure 8**. It has two parameters, `V` (the current vertex) and `EndV` (the exit vertex).

Do not write outside the box

Figure 9

```
Procedure DFS(V, EndV)
  Discovered[V] ← True
  If V = EndV Then Found ← True
  For each vertex U which is connected to V Do
    If Discovered[U] = False Then DFS(U, EndV)
  EndFor
  CompletelyExplored[V] ← True
EndProcedure
```

Complete the trace table below to show how the `Discovered` and `CompletelyExplored` flag arrays and the variable `Found` are updated by the algorithm when it is called using `DFS(1,7)`.

The details of each call and the values of the variables `V`, `U` and `EndV` have already been entered into the table for you. The letter `F` has been used as an abbreviation for `False`. You should use `T` as an abbreviation for `True`.

				Discovered							CompletelyExplored							
Call	**V**	**U**	**EndV**	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**Found**
	-	-		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
DFS(1,7)	1	2	7															
DFS(2,7)	2	1	7															
		3	7															
DFS(3,7)	3	2	7															
DFS(2,7)	2	4	7															
DFS(4,7)	4	2	7															
		5	7															
DFS(5,7)	5	4	7															
		6	7															
DFS(6,7)	6	5	7															
DFS(5,7)	5	7	7															
DFS(7,7)	7	5	7															
DFS(5,7)	5	-	7															
DFS(4,7)	4	-	7															
DFS(2,7)	2	-	7															
DFS(1,7)	1	-	7															

(5 marks)

12

Turn over ▶

Do not write outside the box

11 (a) Complete the missing parts of the question posed by the Halting problem in **Figure 10**.

Figure 10

> Is it possible in general to ..... that
>
> can tell, given any program and its inputs and without
>
> ....., whether the given program with
>
> its given inputs will halt?

(2 marks)

11 (b) What is the significance of the Halting problem?

.....

.....

(1 mark)

3

12 Regular expressions can be used to search for strings. For example, `de(f|g)*h+` matches any string that starts with `de` and is followed by zero or more instances of either `f` or `g` followed by one or more instances of `h`.

Write regular expressions that will match:

12 (a) any string that starts with a letter `a`, ends with a letter `c` and has one or more occurrences of the letter `b` in the middle of it, ie the expression should match the strings `abc`, `abbc`, `abbbc` and so on.

.....

(1 mark)

12 (b) any string that starts with either a `0` or a `1`, followed by zero or more occurrences of the digit `1` ie the expression should match the strings `0`, `1`, `01`, `11`, `011` and so on.

.....

(1 mark)

2

END OF QUESTIONS

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