

Matric No: _____

EDINBURGH NAPIER UNIVERSITY

SCHOOL OF COMPUTING

ALGORITHMS AND DATA STRUCTURES

SET09117

Academic session: **DECEMBER** Diet: **FIRST**

2017

Exam duration: **2:00** Reading time: **0**

(excluding reading time) Total exam time: **2:00**

Please read full instructions before commencing writing

Exam paper information

- Total number of pages: **Six (6)**
- Number of questions: **Four (4)**
- Attempt all four (4) questions

Special instructions

- None

Special items

- Calculator

Examiner(s): Simon Wells, Simon Powers, Emma Hart

1)

- a. Describe the operation of a Turing Machine. In your answer you should consider the roles of the tape, symbols, states, and operations.

(8 marks)

- b. What is meant when Computer Scientists refer to the Halting Problem? In your answer you should briefly describe the problem and explain the implications for everyday computer use.

(8 marks)

- c. You have implemented a game that is played on a board that is x squares wide by y squares high. To print the contents of every board location you have the following function:

```
def print_board(board):  
    for x in range(height):  
        for y in range(width):  
            print board[x][y]
```

Using “Big O” notation describe the complexity of this function and explain what happens as boards of increasing size are used.

(9 marks)

[Total 25 marks]

2)

a. Describe, with an example, what is meant by the phrase “divide and conquer algorithm”.
(5 marks)

b. Using basic data structures, outline a strategy for identifying whether a given string is a Palindrome (a string that reads the same backwards as forwards, for example “madam”). In your answer you should consider any limitations to your approach.
(8 marks)

c. Apply the selection sort algorithm to the following array of numbers:

[21, 86, 17, 78, 29, 76]

For each iteration of the algorithm identify the least element in the unsorted list and write out the sorted & unsorted sub-lists.

(12 marks)

[Total 25 marks]

- 3) Consider a chained hash table of size 5, where each bucket is implemented as a linked list where new elements are inserted at the head. The hash table uses the following hash function:

$$h(x) = x \text{ modulo } 5$$

- a. Insert the following elements in order, showing the array and linked lists after inserting each element:

5, 15, 3, 27, 38, 7, 47, 1, 9, 6

(14 marks)

- b. Explain the relationship between the load factor of the hash table and the time taken to find an item in a chained hash table.

(4 marks)

- c. Give one advantage of chained hash tables compared to open-addressed hash tables.

(2 marks)

- d. Passwords are typically stored on a server in hashed form rather than as plain text. Explain how adding a salt to a password before hashing helps protect against Rainbow Table attacks.

(5 marks)

[Total 25 marks]

4)

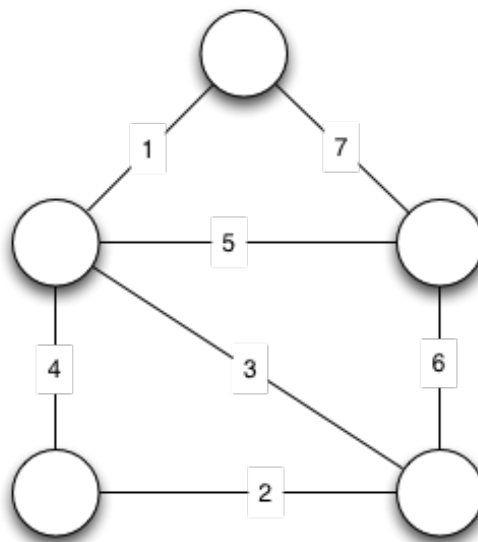
- a. Draw a directed graph with five vertices and seven edges. Exactly one of the edges should be a loop, and do not have any multiple edges.

(5 marks)

- b. Draw an undirected graph with four vertices and five edges. The vertices should be called v_1 , v_2 , v_3 and v_4 --and there must be a path of length three from v_1 to v_4 . Indicate the path from v_1 to v_4 .

(5 marks)

- c. A telephone company plans to connect its switching centres together using fibre optics. When connecting switching centres, it is required to have a path between every pair of them. The telephone company is looking for an interconnection topology that *minimizes* the amount of fibre required to connect its switching centres. The switching centres are connected by pipelines along which the fibre can be laid according to the diagram below:



- i. Which algorithm can be used to help the telephone company find the optimal topology?

(1 mark)

- ii. Using the algorithm from a) calculate the **minimal length** of fibre required. Your answer must include also a diagram that shows the connections along which the fibre should be laid. You should show every step of your working required to produce the final answer.

(10 marks)

- iii. Explain what the most time-consuming step of the algorithm you have described is, and give its complexity using Big O notation.

(4 marks)

[Total 25 marks]

END OF EXAM