

Time Allowed: 1 hour 30 minutes.

Answer **SIX** questions, **ALL** questions in Section A and **TWO** questions from Section B.

Read carefully the instructions on the answer book and make sure the particulars required are entered on each answer book.

Calculators are **not** allowed.

Section A Answer **ALL** questions

1. (a) State formally what is meant by:

$f(n)$ is $\theta(g(n))$ [3 marks]

- (b) Determine whether each of the following statements is true or false, justifying your answers:

- i. $100n^3$ is $O(n^3)$
- ii. $n \log(n)$ is $\Omega(n)$
- iii. n^2 is $\theta(n^2 + n)$ [6 marks]

- (c) The following algorithm computes the determinant of a matrix of size 3. How many basic operations will be required to complete the calculation? State clearly any assumptions you make.

Algorithm *determinant*(X)
// Input array X of size 3
// Output an integer d which is the determinant of X

```
 $d \leftarrow 0$ 
for  $i \leftarrow 0$  to 2 do
     $d \leftarrow d + X[i,0] * (X[i+1 \% 2, 1] * X[i+2 \% 2, 2] -$ 
         $X[i+2 \% 2, 1] * X[i+1 \% 2, 2])$ 
return  $d$ 
```

[4 marks]

2. (a) What is an abstract data type (ADT)? [3 marks]
- (b) What is the relationship between an ADT and a data type? [2 marks]
- (c) Define an ADT to represent a list. [4 marks]
- (d) State one problem which would occur if a list were to be implemented using an array, and explain how this problem might be solved. [4 marks]
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3. (a) Using pseudocode, or a fragment of Java, describe the algorithm *selection sort*. [7 marks]
- (b) Illustrate your answer for part (a) by tracing **all** the successive steps of selection sort applied to the list (9, 1, 8, 2, 7, 3). [6 marks]
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4. (a) What is the *JCF* (*Java Collections Framework*)? [3 marks]
- (b) In the package `java.util`, the declaration for `Queue` is
- ```
public interface Queue<E> extends Collection
```
- (i) Why is `Queue` declared as an interface? [2 marks]
- (ii) Why does `Queue` extend `Collection`? [2 marks]
- (iii) What does the Java syntax `<E>` mean? [1 mark]
- (c) Why might a programmer choose to use `java.util.Queue` rather than write their own `Queue` class? [5 marks]
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**Section B** Answer **TWO** questions

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5. (a) Define the ADT *stack*. [5 marks]
- (b) Draw a binary tree which represents the arithmetic expression  $(1 + 9) * ((6 - 2) / (3 * 4))$  [4 marks]
- (c) Rewrite the expression in (b) using postfix (Reverse Polish) notation. [4 marks]
- (d) With reference to your answer to (c), explain how a stack can be used to evaluate an arithmetic expression. Why is the use of a stack desirable in this instance? [7 marks]
- (e) State **two** other situations where you might encounter the use of a stack within a computer system, and for each one explain briefly why a stack would be used. [4 marks]
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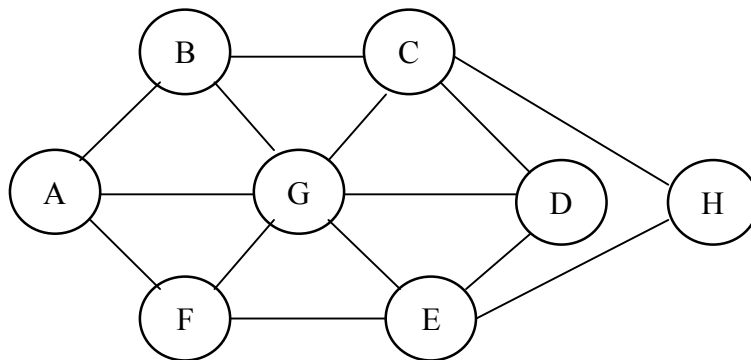
6. (a) Using pseudo-code, describe the sorting algorithm *mergesort*. Illustrate your description by showing the intermediate lists produced while applying mergesort to the following values:

3 8 1 0 5 2 4 9

[7 marks]

- (b) What is the *worst-case* running time for mergesort? Justify your answer. [4 marks]
- (c) Using pseudo-code, describe the sorting algorithm *quicksort*. Illustrate your description by showing the intermediate lists produced while applying quicksort to the same values as in (a). [7 marks]
- (d) What is the *worst-case* running time for quicksort? Justify your answer. [4 marks]
- (e) How might you improve the running time for quicksort? [2 marks]

7. Consider the following undirected graph G.



- (a) Assuming node A is the root, list the sequence in which vertices of G are visited by a *depth-first* search algorithm. [2 marks]
- (b) Assuming node A is the root, list the sequence in which vertices of G are visited by a *breadth-first* search algorithm. [2 marks]
- (c) Using pseudocode or otherwise, describe *Dijkstra's algorithm* for finding a shortest path between two nodes in a weighted connected graph. [10 marks]
- (d) Traveller Chris wishes to travel from London to Sydney. His journey involves several legs, and each leg is costed separately by his airline, as follows:

London-Amsterdam: £70  
London-Paris: £60  
Amsterdam-Dubai: £300  
Amsterdam-Kuala Lumpur: £580  
Amsterdam-Hong Kong: £450  
Paris-Dubai: £320  
Paris-Kuala Lumpur: £570  
Dubai-Kuala Lumpur: £250

Dubai-Hong Kong: £280  
Kuala Lumpur-Sydney: £310  
Hong Kong-Sydney: £400

The price for the travelling any of the legs in the reverse direction is the same.  
Which route should Chris travel to minimise his cost? Justify your answer.

[7 marks]

- (e) Suppose Dijkstra's algorithm is applied to a graph containing  $e$  edges and  $v$  vertices. What is the worst-case time complexity for the algorithm? Justify your answer.

[3 marks]

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8. (a) In the context of the object-oriented programming language Java, explain the meaning of each of the following terms, and give a **short** example of the use of each one. Note that you will not be penalised for minor syntactical errors in your examples.

- |       |                |           |
|-------|----------------|-----------|
| (i)   | Class          | [3 marks] |
| (ii)  | Abstract class | [3 marks] |
| (iii) | Interface      | [3 marks] |
| (iv)  | Constructor    | [3 marks] |
| (v)   | Signature      | [3 marks] |
| (vi)  | Polymorphism   | [4 marks] |

- (b) Describe the role of an Interface in implementing an ADT using Java. Illustrate your description with an example.

[5 marks]

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