

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 $O(g(n))$ [3 marks]

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

- i. 2^n is $O(3^n)$
- ii. n is $\Omega(n^{-1})$
- iii. $n(\log n)^2$ is $\theta(n^2)$ [5 marks]

- (c) The following algorithm computes the geometric mean of n numbers, using an array as intermediate storage. How many basic operations will be required to complete the calculation? State clearly any assumptions you make.

Algorithm *geometricMean()*

$tmp \leftarrow 1$

for $i \leftarrow 0$ to $n-1$ do

$X[i] \leftarrow \text{read}()$

for $i \leftarrow 0$ to $n-1$ do

$tmp \leftarrow tmp * X[i]$

return tmp / n

[5 marks]

2. (a) When is a data type an *abstract data type* (ADT)? [2 marks]

- (b) Define an ADT to represent an *array of integers*. [7 marks]

- (c) State two reasons why an array which is part of a language such as Java may not faithfully implement your answer to (b). [4 marks]
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3. (a) Using pseudocode, or a fragment of Java, describe the algorithm *selection sort*. [6 marks]
- (b) Illustrate your answer for part (a) by tracing all the successive steps of selection sort applied to the list (9,0,8,1,7,2,5) [4 marks]
- (c) What is the worst-case time complexity of selection sort? Justify your answer. [3 marks]
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4. (a) What is the purpose of the interface `java.util.Iterator`? [2 marks]
- (b) Consider the following (hypothetical) Java class which stores an unordered set of objects:
- ```
import java.util.*;
public class MySet implements Collection { ...
```
- Explain why the class needs to use the `Iterator` interface, and using appropriate short code fragments, illustrate how the class would use `Iterator`. [8 marks]
- (c) Suppose `MySet` is implemented using a doubly linked list to store the objects. Describe how an `Iterator` for `MySet` might be coded. [3 marks]
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**Section B** Answer **TWO** questions

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5. (a) Describe (in words) the *binary search* algorithm. Are there any restrictions on the data which the algorithm can be used upon? [6 marks]
- (b) What is the *worst* case time complexity for binary search applied to a list of length  $n$ ? Justify your reasoning. [3 marks]
- (c) What is the *best* case time complexity for binary search applied to a list of length  $n$ ? Justify your reasoning. [3 marks]
- (d) Describe (in words) the *merge sort* algorithm. [5 marks]
- (e) What is the *worst* case time complexity for merge sort applied to a list of length  $n$ ? Justify your reasoning. [7 marks]
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6. (a) Define the ADT *stack*. [5 marks]

- (b) Draw a binary tree that represents the following arithmetic expression (using the usual rules of precedence of the operators):

$$x - (y * a / b - (z - d / e) + f) * c$$
 [4 marks]

- (c) Write down the postfix (or “reverse Polish”) expression that is equivalent to the expression given in part (b). [4 marks]

- (d) Explain how a Stack would be used to evaluate a postfix arithmetic expression. Illustrate your answer by drawing the successive states of the stack when  $a=10, b=2, c=5, d=12, e=4, f=1, x=100, y=3, z=11$  [5 marks]

- (e) The documentation for the Java API contains the statement:

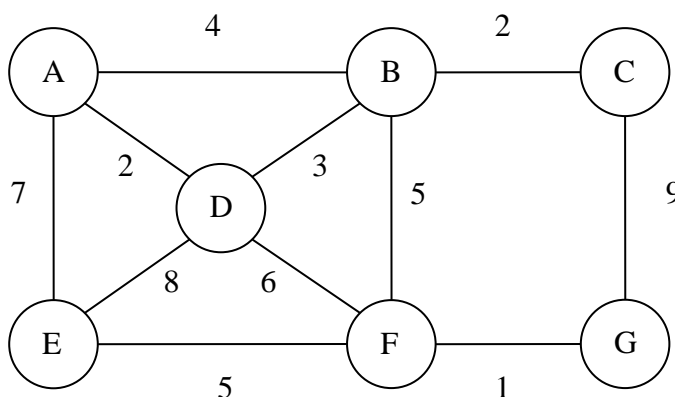
```
public class Stack extends Vector
```

Explain what `extends` means. With reference to your definition in (a), explain how this implementation of `Stack` allows the Java programmer to misuse a `Stack` object and why this would be regarded as misuse. [6 marks]

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7. (a) Describe, using words or pseudo-code, Dijkstra’s Algorithm for calculating the shortest path between two vertices in a weighted graph. State clearly any assumptions you make. [10 marks]

- (b) Using the following graph, find the shortest path from A to G using Dijkstra’s Algorithm. *Show your working clearly.* [8 marks]



- (c) For a graph with  $n$  nodes and  $m$  edges, what is the worst case time complexity for Dijkstra’s algorithm? Justify your answer. [6 marks]
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8. (a) What is the JCF? [3 marks]
- (b) State (with justification) *four* reasons why using the JCF might be beneficial to a programmer. [8 marks]
- (c) What are generics in Java? [3 marks]
- (d) What is the main benefit of using generics? [2 marks]
- (e) What are the differences between an interface and an abstract class in Java? [8 marks]
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