GRIFFITH COLLEGE DUBLIN

NATIONAL COUNCIL FOR EDUCATIONAL AWARDS SAMPLE EXAM

GRADUATE DIPLOMA IN COMPUTING SCIENCE

SAMPLE SAMPLE SAMPLE

Programming and Data Structures

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THIS PAPER CONSISTS OF SIX QUESTIONS. SECTION A – <u>COMPULSORY</u> SECTION B – <u>FOUR</u> QUESTIONS TO BE ATTEMPTED

SECTION A – <u>COMPULSORY</u>

Question 1

(a) Describe a non- linear data structure. Give examples and operations in which you might perform on such a structure.

(4 marks)

(b) Briefly describe the difference between the Dynamic Programming and the Greedy solution paradigm. Give an example of a problem that may use a Dynamic Programming approach and one that may use a Greedy approach.

(4 marks)

(c) What is recursion and why is the concept important in computer science? Demonstrate your understanding of recursion by giving a recursive algorithm for finding the factorial of a number n.

Reminder :

The factorial of a number n (i.e. n!) is the solution to the product :

n*(n-1)*(n-2)*....*3*2*1

Expressed mathematically :

$$n! = \begin{cases} 1 & \text{if } n = 0 \\ n^*(n-1)! & \text{If } n > 0 \end{cases}$$

(4 marks)

(d) Describe pre-order traversal of a binary search tree. Show the output of a preorder traversal of the following binary search tree.



(4 marks)

(e) In complexity theory what do we mean when we say a class of problem is P? What do we mean when we say a class of problem is NP? Give an example of a problem in each class.

(4 marks)

(f) In Graph theory what is the difference between a Hamiltonian Cycle and a Hamiltonian Path?

(4 marks)

(g) Name 3 $O(n^2)$ sorting algorithms. Describe the algorithm for either one of the $O(n^2)$ sorting algorithms that you have named.

(4 marks)

(h) Use the iteration method to solve the following recurrence relation:

T(1) = 1	for	Ν	=	1
T(N) = T(N-1) + N	for $N \ge 2$			

What is the big O complexity?

(4 marks)

(i) What is a Minimum Spanning Tree? Why is the concept of a MST useful?

(4 marks)

(j) In terms of sorting algorithms what do we mean when we say the algorithm is a stable sort? Support your answer by an example.

(4 marks) (Total 40 marks)

SECTION B – <u>ANSWER 4</u> QUESTIONS ONLY Question 2

(a) Describe the elements of the Divide and Conquer paradigm. Further demonstrate your understanding of this paradigm by describing the Quicksort algorithm and showing how these are present in the algorithm.

(6 marks)

(b) Merge sort can use a procedure called "Abstract In-place Merge" when merging together two sorted lists into the one sorted list. What is "Abstract Inplace Merge"? Support your answer by showing how the following two lists will be merged together using Abstract In-place Merge.

10 35 4	1 52	22	37 40	56
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(4 marks)

(c) Describe the Binary Search algorithm and demonstrate how Binary Search would work on the following list of numbers given that we want to find number 9.

2 4 6 9 14 15 19 25 29 32

What is the main disadvantage of Binary Search?

(5 marks) (Total 15 marks)

Question 3

(a) What is an Abstract Data Type?

(3 marks)

(b) In terms of data structures, what is a Stack and a Queue? What are the main difference between the two. Describe the abstract data type for both a Stack and Queue. Give example uses of a Stack and Queue (If you can give example uses in the area of computer science the better).

(6 marks)

(c) What is a doubly linked list? Describe an Abstract Data Type for a doubly linked list data structure. Given a doubly linked list with only 3 nodes, show how we might go about adding a node after the second node in the list. You must describe the algorithm involved as well as use diagrams to show the operations involved.

(6 marks) (Total 15 marks)

Question 4

(a) What is a Heap? Give an example. We can build a Heap using a "Heapify" operation. Outline the algorithm for Heapify. Give an illustrated example of this operation.

(6 marks)

(b) What is a Priority Queue? Using diagrams, illustrate what happens in a Priority Queue when something is added to the Queue and when something is removed from the Queue. Describe a data structure which can use to implement a Priority Queue. Give an example where in computer science a Priority Queue can be useful.

(5 marks)

(c) What is the difference between a Complete Binary Tree and a Heap? Support your answer with illustrations.

(4 marks) (Total 15 marks)

Question 5

(a) What do we mean by Asymptotic analysis? What is the difference between the Big O notation, the Big Theta notation and the Big Omega notation?

Show that the following time complexity function $2n^2 + 5n + 2$ is $O(n^2)$.

Is the above time complexity function also $\Omega(n^2)$? Why?

(6 marks)

(b) Roger, Laura, Brenda, and Mark work in the city as a singer, stockbroker, salesperson, and cook, but not necessarily in that order. The salesperson and the singer car pool with Laura. Mark plays tennis with the salesperson and the cook. The cook drives to work alone. Roger envies the salesperson.

Which person has which career? How did you come to this conclusion? What problem solving method did you use?

(4 marks)

(c) What is the Travelling Salesman Problem? Why is this problem important in computer science? Give an approximation algorithm for the Travelling Salesman Problem.

(5 marks) (Total Marks 15)

Question 6

(a) In graph theory, what is the difference between an Adjacency List and an Adjacency Matrix? What advantages and disadvantages does each have?

(4 marks)

(b) One way of searching a graph is by Depth First search. Name the other way and describe the algorithm for this other method. Give a situation in which we may use this other search method to help us in resolving a problem.

(5 marks)

(c) Explain what we mean by a Minimum Spanning Tree and give an example of when such a structure may be useful? Describe Prim's algorithm for building a MST from a given graph.

(6 marks) (Total Marks 15)