UNIVERSITY OF DUNDEE

BSc EXAMINATION
School of Computing
2 hours

December 2014

Multi-Paradigm Programming and Data Structures (AC21008)

This paper contains FOUR questions.
Answer ALL questions.

Only calculators approved by the School of Computing for exam use may be used in this exam.

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1. This question is on the following C++ code:

```
01  #include <iostream>
02  using namespace std;
03
04  int main()
05  {
06     int start, limit;
07     cin >> start;
08     cin >> limit;
09     for (int i=start; i<= limit; i++)
10     {
11       cout << i << ": ";
12       int current = 1;
13       for (int j=i; j>0; j--)
14       {
15          current = j * current;
16       }
17       cout << current << endl;
18     }
19     return 0;
20  }
```

  (a) Describe line-by-line how the C++ code works. **[10 marks]**

  (b) If the user was to input 1 and 5 into the code what would the output be? **[2 marks]**

  (c) Why might this be a difficult program for an end user to use? **[3 marks]**

  (d) Rewrite the code so that it only uses recursion. It must not use any `for` loops, `while` loops or `gotos` . It should also correct the error discussed in part (c). You may assume that the 2nd number the user enters is always larger than the first.

            [10 marks]

2. This question is on Vectors, Arrays and complexity theory.

(a) What is the difference between a Vector and an Array in C++? Your answer should include an example of when you would use both of these concepts. **[8 marks]**

(b) Give the code to create a two dimensional Vector of size 3 by 2 where every value is initialised to 0. **[3 marks]**

(c) Describe big O notation and explain how it is used in relation to Data Structures. **[4 marks]**

(d) Copy and complete the following complexity table for both Arrays and Vectors, where the operation cannot be undertaken you should indicate this:

Operation	Best Case	Worst Case
Indexing		
Addition		
Searching		
Deleting		
Emptying		

[10 marks]

3. This question should be answered using C.

(a) Give the prototypes for the following functions and describe their functionality in detail.

    i. malloc **[2 marks]**

    ii. free **[2 marks]**

(b) Write the following functions to implement a doubly linked list to store integers. Each node of this list will be the following structure:

```
struct Node
{
    struct Node* prev;
    struct Node* next;
    int data;
};
```

    i. The function `makeList` which creates a doubly linked list with a single element. The function prototype for this function is:

        `struct Node* makeList(int data)` **[6 marks]**

    ii. The function `addAfterNode` which adds `nextnode` directly after `node`, where `node` is already contained in a doubly linked list. The function prototype for this function is:

        `void addAfterNode(struct Node* node, struct Node* nextnode)`

        [5 marks]

    iii. The function `freeNode` which frees the memory of a `node` after removing it from any list it is contained in. The function prototype for this function is:

        `void freeNode(struct Node* node)` **[5 marks]**

    iv. The function `freeEntireList` which frees all `nodes` in the list which contains `node`, node may be at the beginning, contained in or at the end of the list. The function prototype for this function is:

        `void freeEntireList(struct Node* node)` **[5 marks]**

4. This question is on heaps and graphs.

(a) What is the heap property of a max heap? **[2 marks]**

(b) What is the difference between a max and min heap? **[2 marks]**

(c) What is the shape property in relation to a binary heap? **[3 marks]**

(d) Design a binary heap which is used to store the following girls names: Sophie, Emily, Olivia, Ava, Lucy and Isla . You should explain what key is being used.

[7 marks]

(e) Show how you would delete the root node of the binary heap constructed to answer part (d). **[4 marks]**

(f) Why are graphs a useful data structure? **[3 marks]**

(g) Explain the difference between directed and undirected graphs. Give an example as to when you would use each type. **[4 marks]**

End of examination paper