

**Special information for invigilators:**

Students may bring any written or printed aids into the examination.

**Information for candidates:**

Marks may be deducted for answers that use unnecessarily complicated algorithms.

## The Questions

1. a) Figure 1.1 shows a C++ function that calculates the value of the function described in equation (1.1), for any non-negative integer  $n$  (e.g.  $f(0) = 0$ ).

$$f(n) = \begin{cases} 0 & n = 0 \\ f(n-1) + n & n \geq 1 \end{cases} \quad (1.1)$$

Identify six errors in the C++ code shown in Figure 1.1.

```
void calculateF (N) {  
    int result = 0;  
    for (i=0; i <= n; i++) {  
        result = result + n;  
        return result;  
    }  
}
```

Figure 1.1 calculateF() function.

[ 6 ]

- b) Write a recursive C++ function that performs the calculation described in part (a).

[ 6 ]

[continued on the following page]

- c) i) A set of numbers is inserted in an ordered binary tree (ascending ordered tree). Draw a tree for the following set assuming that the elements in the set are inserted in the order shown.

{20, 12, 25, 15}

[ 2 ]

- ii) State whether the tree from part (i) is balanced or not, and justify your answer. If the tree is currently unbalanced, then balance it using single and/or double rotations and draw the resulting tree.

[ 2 ]

- iii) Insert the number 14 into the balanced tree resulting from part (ii) and draw the new tree.

[ 2 ]

- iv) State whether the tree from part (iii) is balanced or not, and justify your answer. If the tree is currently unbalanced, then balance it using single and/or double rotations and draw the resulting tree.

[ 2 ]

- v) What is the height of the tree resulting from part (iv)?

[ 2 ]

- vi) The same set of numbers as in part (i) is inserted into a chained hash table structure with three entries and the following hash function:

$$H(x) = x \bmod 3$$

Draw the resulting hash table without any ordering imposed, assuming that the numbers in the set are inserted in the order shown.

[ 2 ]

- d) Draw a parse tree for the following expressions, assuming the normal priorities of the operators:

i)  $10/12 + 3 + 4 * 6$

[ 2 ]

ii)  $3 * (2 + 6) + 9$

[ 2 ]

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- e) Consider the C++ code segment in Figure 1.2. With justification, state the values of variables  $x$ ,  $y$  at points A and B of the code. With justification, state whether this code segment has a memory leak or not.

```
int x=20;
int y=5;
int *p1 = new int;
int *p2 = &y;
*p1 = *p1 + x;
y= *p1;
A
p1 = &x;
p2 = p1;
x = *p1 + *p2;
y = *p2;
B
```

Figure 1.2 Code segment.

[ 5 ]

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- f) Figure 1.3 shows the type declaration for a dynamic linked list, where each node stores an *id*, which is unique to each node, and *data*. Both take positive integer values. An empty list is a valid instance of the data structure.

```
struct Node {  
    int id;  
    int data;  
    Node * next;  
};  
  
typedef Node * NodePtr;  
NodePtr hdList = NULL;
```

Figure 1.3 Linked list declaration.

- i) Write a C++ function/procedure that takes as input the *hdList* pointer and returns a pointer that points to the first element of the list that has its *data* field greater or equal to 10. If the list is empty or no such node exists, the function/procedure should return NULL.

[ 3 ]

- ii) Write a C++ function/procedure that takes as input the *hdList* pointer, and increments by 1 the *data* field of all the nodes in the list.

[ 4 ]

2. Figure 2.1 illustrates the structure of a company. Each node represents an employee in the company and stores information regarding his/her salary and age. Every arrow in the figure corresponds to a employee-manager relationship. You can assume that every node has a unique number (id), each manager can supervise at most two people, and each employee has only one manager.

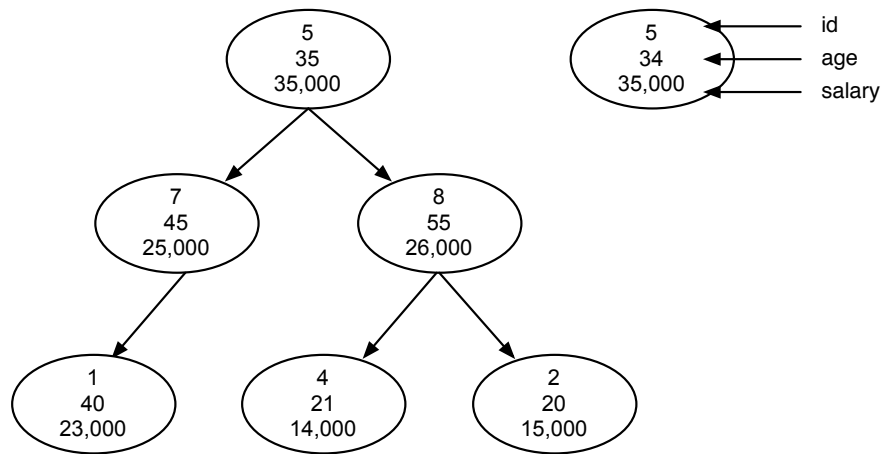


Figure 2.1 Binary tree structure.

- a) Define a structure *treeNode* capable of representing a node of the tree.
- [ 5 ]
- b) Write a recursive function/procedure that takes as input the pointer to the root of the tree and returns the number of people that work in that company. Show how your recursive function/procedure will be invoked. You can always pass more input arguments in your function/procedure.
- [ 5 ]
- c) Write a recursive function/procedure that takes as input a pointer to the root of the tree, and returns the number of managers that supervise directly only one person. For example, for the given instance of the tree, the function/procedure should return 1. Show how your recursive function/procedure will be invoked. You can always pass more input arguments in your function/procedure.
- [ 10 ]
- d) Write a recursive function/procedure that takes as input a pointer to the root of the tree and returns the average salary of the people that work in that company. Show how your recursive function/procedure will be invoked. You can always pass more input arguments in your function/procedure.

[ 20 ]

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- e) Write a recursive function/procedure that takes as inputs a pointer to the root of the tree and an *id* value, and returns the number of people that work under the manager with the given *id*. For example, for the instance of the tree shown in Figure 2.1 and an input *id* of 5, the function/procedure should return 5. Show how your recursive function/procedure will be invoked. You can always pass more input arguments in your function/procedure.

[ 20 ]