Problem 5 (50 marks)

Answer the following questions in one or two sentences:

1. How can we construct a tree where all nodes have the same degree? [4]

**5a)**

It is impossible to construct a tree that has a number of nodes with the same degree N, except the trivial case N = 0.

1. What is the difference between l-value and r-value references? [6]

**5b)**

"l-value” illustrate the location in memory of an object, while “r-value” evaluate the value stored in memory.

1. What is a key concept of an abstract data types? [4]

**5c)**

Abstract data types mainly hide the detail information, showing only necessary data to users. To elaborate, it only mentions what to execute (function... etc.) but not how those executions process step-by-step.

1. How do we define mutual dependent classes in C++? [4]

**5d)**

Mutual dependant classes can be recognized when the code in one class mention the other classes.

For instance, two class A and B and in class A if we see a variable crated based on class B, those classes are mutually dependant.

1. What must a value-based data type define in C++? [2]

**5e)**

A value-based data type element directly contains a data value within its own memory space.

1. What is an object adapter? [6]

**5f)**

Object adapter allows an object with interface to collaborate with another incompatible interface.

1. What is the difference between copy constructor and assignment operator and how do we guarantee safe operation? [8]

**5g)**

The copy constructor separate a space of memory for new objects, while assignment operator does not make new memory space for objects.

1. What is the best-case, average-case, and worse-case for a lookup in a binary tree? [6]

**5h)**

Best-case (Lower Bound): O(1), if the element is the first

Worst-case (Upper Bound): 0(n), if the element is the last in array Average-case: O(log n), in an array of size n takes on average n/2

1. What are reference data members and how do we initialize them? [2]

**5i)**

Reference data members is kind of an object with a specific data type. In order to initialize reference data members, we initialize the object's "l-value" or "r-value".

1. You are given n-1 numbers out of n numbers. How do we find the missing number nk, 1 ≤ k ≤ n, in linear time? [8]

**5j)**

On this condition, by using the algorithm of calculating all the numbers in an array (such as n\*(n+1)/2 for the first n number), we can calculate the sum of all the first n natural numbers. Then subtract it with the sum of all n-1 numbers above, and we will be able to find the missing number.

Time complexity: O(n)