Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

Faculty of Engineering, Mathematics & Science

School of Computer Science and Statistics

Integrated Computer Science Programme   **Semester 1, 2020-21**
BA (Mod) CSLL
BA (Mod) Business & Computing
BA MSISS
Year 2 Annual Examinations

CS2011: Algorithms and Data Structures I (SAMPLE)

online exam   **2hr duration**

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Instructions to Candidates:

- Answer ALL questions.

Materials permitted for this examination:

- Open books exam.

Question 1   [0 marks]

In some of the following questions you will be asked to provide an answer which depends on the following numbers. Please calculate and write down these numbers.

(a) **R**: provide a 15-digit random number. This will be calculated during the exam and you will need a simple calculator for this.

(b) $d_1, d_2, d_3, d_4, d_5, d_6, d_7, d_8, d_9, d_{10}, d_{11}, d_{12}, d_{13}, d_{14}, d_{15}$: these are the fifteen digits of **R**, from left to right.

(c) $u_1, u_2, u_3, u_4, u_5, u_6, u_7, u_8, u_9, u_{10}$: these are the first 10 **unique** single-digit numbers of the d_i sequence, from left to right. If there are less than 10 unique numbers in your d_i sequence, you should complete the u_i sequence with single-digit numbers in ascending order. In the end, the u_i sequence should not contain duplicate numbers.

Question 2 [20 marks]

Consider the Abstract Data Type (ADT) `Example` with the following API:

```
public class Example<Key, Value>
```

Example()	Creates an object.
void put(Key key, Value val)	Adds key and value to the ADT.
Value get(Key key)	Gets the value for key.

The following program is a client of the `Example` ADT:

```java
public class Client
{
  public static void main(String[] args)
  {
    Example<String, Integer> st = new Example<String, Integer>();
    for (int i = 0; !StdIn.isEmpty(); i++)
    {
      String key = StdIn.readString();
      st.put(key, i);
    }
    for (String s : st.keys())
    StdOut.println(st.get(s));
  }
  }
```

Give the sequence of numbers printed by the command

```
java Client u1 u2 u3 u4 u5 u6 u7 u8 u9 u10
```

where ui is the corresponding single-digit number of the u_i sequence from Question 1 (c). *[20 marks]*

Question 3   [20 marks]

Give the logical representation of the **binary search tree** obtained by inserting the sequence $u_1, ..., u_{10}$ from Question 1 (c) to an empty tree.

Show the logical representation of the tree after every insertion.

For example inserting the sequence $0, 1, 2, 3, 4, 5, 6, 7, 8, 9$ produces the tree:
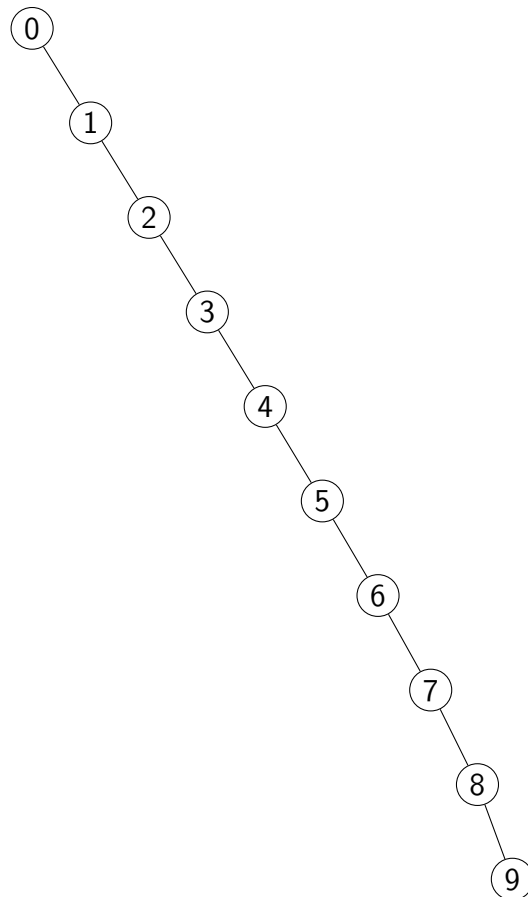
[20 marks]

Question 4   [10 marks]

A question similar to the above.   *[10 marks]*

Question 5   [20 marks]

A question similar to the above.   *[20 marks]*

Question 6 [10 marks]

Explain the intuition of amortised running time.   *[10 marks]*

Question 7 [20 marks]

Consider the standard API and implementation of the HashTable ADT. Also consider the following code.

```java
public int[] method(int[] A, int[] B) {
    int sa = 0, sb = 0;
    for (int x: A) sa += x;
    for (int x: B) sb += x;
    int delta = (sb - sa) / 2;

    Hashtable<Integer,Integer> setB = new Hashtable<Integer,Integer>();
    for (int x: B) setB.put(x,0);

    for (int x: A)
        if (setB.contains(x + delta))
            return new int[]{x, x + delta};

    throw null;
}
```

Analyse the performance of this code with respect to time and space. You are free to use any one of the analyses that have been covered in the module. You should clearly identify the analysis you use and sufficiently explain your answer.

[20 marks]