Department of Electrical and Computer Engineering
North South University
CSE 373 : Design and Analysis of Algorithms
Section 2
Midterm Examination
Summer 2020

Total Marks: 35

Start time: 2:50 PM

End Time: 3:50 PM

Instruction: Write ALL answers in handwriting. Take snapshots of your answers and then compile all pages in one pdf document. **You are also required to write your name and ID in each of the pages**. Upload your document via Google Classroom.

1.   Solve the following recurrence relation:

     $T(n) = 2T(n-1) + c$, $n > 1$ 10 marks
   and
     $T(n) = c$, $n = 1$

2   This question is about the max-heap data structure

a)   Consider that a set of keys are added in an array A such that it maintains   4 + 1 = 5
   the heap-order property. Infact, A is a max-heap. Write down an   marks
   algorithm **isLeaf(A, i, n)** that returns a *true* if the ith element in the array
   A is a leaf. If that is not the case, it should return a *false*. The heap-size
   is n. What is the time complexity of your algorithm.

b)   Figure 1 shows a tree-based and the corresponding array-based   4 + 1 = 5
   representation of keys stored in a max-heap data structure. You need to   marks
   write down an algorithm, **ithMax(A, i, n)**, that will return the ith largest
   element in a max-heap. Here, A is the array and n is the heap-size. In
   the example, given in figure 1, if i were 2, it would return 30 since 30 is
   the 2nd largest number in the Array A. What should be the worst case
   time complexity for your algorithm. Your objective must be to come with
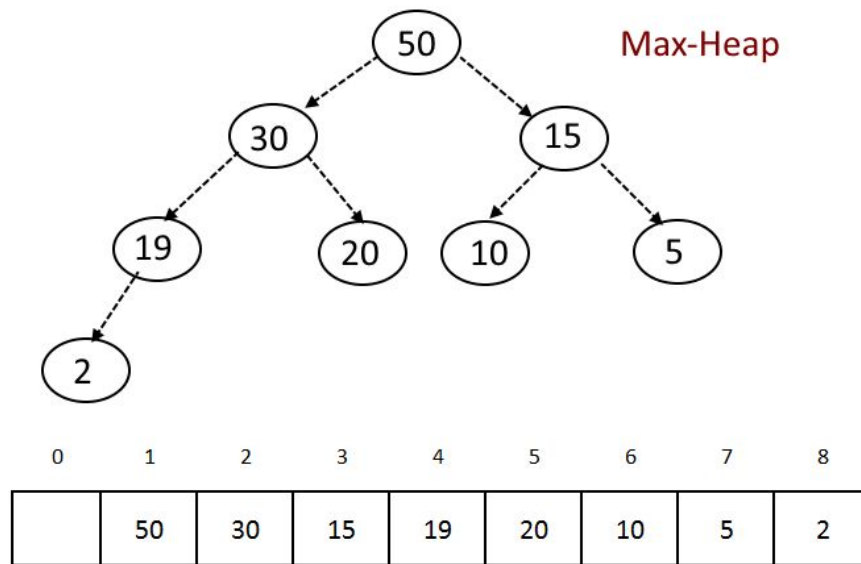   a time and space efficient algorithm.

Figure 1: The array and tree-based representation of a max-heap

3. Quicksort is often a pragmatic choice for sorting an array compared to   5 marks
    other choices such as mergesort, insertion sort and heapsort. Quicksort
    uses the divide and conquer approach to sort an unsorted array of size
    n. It uses the **Partition** algorithm in the divide phase of the divide and
    conquer approach. Imagine you want to sort an array containing unique
    integers as keys into **decreasing order**. Write down the partition
    algorithm that will take the last element as the pivot to partition around it.

4. Mergesort and Heapsort are often referred to as optimal time sorting   3 marks
    algorithms but the same cannot be said about insertion sort. Explain
    briefly why that is so.

5. Imagine data (items) is stored in a complete binary tree of height 20.   7 marks
    What is the maximum number of items stored in this data structure?
    Show your workings. **You should not use any calculator**.