Submission Deadline: Will be announced later

You have to submit both hard and soft copies.

Softcopy submission:

- Please write your answers in A4 papers and scan your answer script.
- Rename the file with your student id (e.g "21201123.pdf").
- Submit the pdf file.
- Maximum file size is 10MB.
- The filename should contain your student id only.
- **Failing to follow the submission format will lead to a deduction in marks.**
- **Any sort of plagiarism will not only result in 0 in this assignment but will also result in a 0 in assignment portion.**
- Submission link: **Will be posted later**

Hardcopy submission:

- Submit your assignment in the theory class **following the softcopy submission deadline**. The assignment must be written in A4 papers and must include your student id at the top.

1. Modify the following binary search algorithm to find the first occurrence of the Key (T) in an ascendingly sorted input list (A).

Index	0	1	2	3	4	5	6	7
Number	2	4	4	4	4	6	7	9

key(T) = 4, so the first occurrence is in index 1.

```
function binary_search(A, n, T) is
    L := 0
    R := n - 1
    while L ≤ R do
        m := floor((L + R) / 2)
        if A[m] < T then
            L := m + 1
        else if A[m] > T then
            R := m - 1
        else:
            return m
    return unsuccessful
```

2. Calculate the time complexity of the following recurrence relations.
   [Any method is acceptable as long as steps are shown]
   A. $T(n) = 2T(n/2) + 1/n$
   B. $T(n) = 2T(n/3) + n$
   C. $T(n) = T(n/2) + T(n/5) + n$
   D. $T(n) = 2T(n/4) + n^2$

3. Take a look at the following recursive algorithm which determines if a string is palindrome or not. **Write the time complexity of this algorithm.**

```
def isPalindrome(s, l, r):
    if l >= r:
        return True

    if s[l] != s[r]:
        return False

    return isPalindrome(s, l+1, r-1)
```

4. Imagine you're a farmer named Sam who grows different types of vegetables in several continuous fields. Each field can grow a specific type of vegetable, and based on the market value of that vegetable, each field will bring a certain profit (positive integer) or loss (negative integer). The profit or loss is estimated and noted for each field.

Sam can start farming from any field, but once he starts, he must continue farming the next fields in sequence without skipping any, until he decides to stop, because his tractor can only move to the next adjacent field and cannot skip fields.

Sam needs to choose which sequence of fields to farm to maximize his profits. The following array represents the estimated profits or losses for ten consecutive fields on Sam's farm, based on the types of vegetables that can be grown in each field and their respective market values.

[4, -18, -8, -2, 16, -14, 12, -1, 3, 15]

a) Can you help Sam decide which sequence of fields to farm for maximum profit using an **efficient algorithm**? What would the profit amount be? **Show a simulation of your proposed algorithm. You must show which sequence of fields he needs to select in order to achieve this maximum profit.** **[6]**

b) Calculate the time complexity of your algorithm using proper mathematical logic. An efficient algorithm should have time complexity less than or equal to O(n log n).

5. Is $f(n) = O(g(n))$ or is $g(n) = O(f(n))$? **Answer** for the following scenario. **Show** your calculations.

i. $f(n) = 4^n$, $g(n) = 16^{log2(n)}$

ii. $f(n) = (\sqrt{n} + n)\sqrt{n}$, $g(n) = n^2$

6. Consider the following functions.

$$f_1(n) = (log\ n)^{2023}$$

$$f_2(n) = n^2\ log_n(n^n)$$

$$f_3(n) = n^3 + 7n^2$$

$$f_4(n) = 2.023^n$$

$$f_5(n) = n\ log\ n$$

$$f_6(n) = n * \sqrt[3]{n^2}$$

Now do the followings:

a. Write a correct asymptotic upper bound for each of the above.
b. Sort the functions in ascending order of their growth rate, assuming n is significantly large. Just write the sorted order, no need to show any simulation.

7. Given a sorted array of distinct non-negative integers, find the smallest missing element from the sequence. The array is sorted in increasing order, and the missing element should be the smallest number that does not appear in the sequence but is expected in the natural order.

Example 1

Input: A=[0,1,2,3,6,7,9] **Output:** 4

Example 2

Input: A=[0,1,2,3,4,5,6,7] **Output:** 8

8. Renowned Progressive Rock band ‘Porcupine Tree’ released an album called 'Closure/Continuation' after about 13 years. Now as a Progressive Rock Music fan you are going to listen to the tracks of the album but in the order of their Youtube views (highest one at first, lowest one at last) instead of the order of the album tracklist.

You have chosen an Algorithm to order them as per your preference. If multiple tracks have the same views, you are going to listen to any of them the Algorithm puts first in the list after ordering. This algorithm also solves your concern about the issues regarding space that your device is facing. Porcupine Tree made the fans wait for 13 years for a new album and so you think you have the patience to wait as much time as the Algorithm may take to order the tracks.

The following table contains the list of the tracks and their Youtube views (in thousand) :

Track	Harridan	Of The New Day	Rats Return	Dignity	Herd Culling	Walk the Plank	Chimera's Wreck	Population Three
Views	15	8	11	112	33	39	88	41

Now write the name of the algorithm and also the step-by-step solution/pseudocode/flowchart/code how this algorithm would solve the above list.