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Topic: Searching (Data Structures)

Course: CSE 207 Data Structures
Instructor: Ahmed Abdal Shafi Rasel
Time: 1 Hour

Lab Objectives:

In this lab, students will:

1. **Understand Binary Search:** Learn its principles, time complexity, and advantages over linear search.
2. **Implement Binary Search Variations:** Find elements, determine insertion positions, and handle first/last occurrences.
3. **Apply Binary Search in Real-World Scenarios:** Insert elements into a sorted array efficiently.
4. **Enhance Problem-Solving Skills:** Optimize solutions and develop an intuition for when to use binary search.

By the end, students will be able to apply binary search effectively in algorithmic problems.

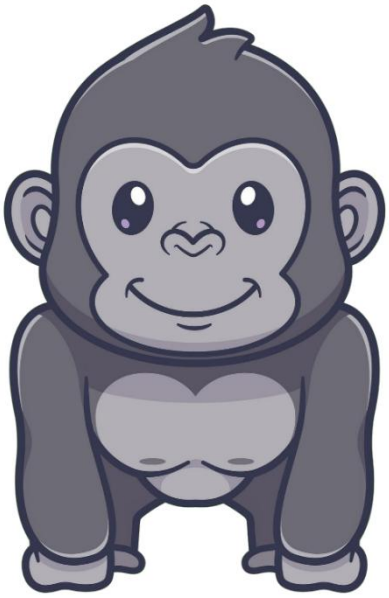
Lab Activities:

Here is a description of the binary search algorithm in pseudocode.

```
procedure binary search(x: integer, a1,a2,..., an: increasing integers)
 i := 1 {i is the left endpoint of interval}
 j := n {j is right endpoint of interval}
 while i < j
      m := ⌊(i + j)/2⌋
      if x > am then i := m + 1
      else j := m
 if x = ai then location := i
 else location := 0
 return location{location is the subscript i of the term ai equal to x,
                          or 0 if x is not found}
```

Lab Activities:

Problem 1



Once upon a time, there lived a chimpanzee called Ziggy (aka Tallest Chimp). Ziggy was known throughout the jungle for his height, agility and adventurous nature. Despite having many talents, Ziggy felt that something was missing. He had been visiting a forest clearing every morning where chimpanzees of all heights would gather, and each time, he felt a little disconnected from the others. Ziggy was tall and proud of it, but he often wondered if there were chimpanzees who were just the right match for his height to make friends. One day, Ziggy decided to find out. He visited a nearby meadow where all chimpanzees practiced their drills every morning. The chimpanzees were all arranged in a line, sorted by their height, the shortest one is in the front and the tallest one is at the back. Ziggy thought it was the perfect opportunity to find a perfect match — a chimpanzee whose height was just right for him. Your task is to help Ziggy on one particular day to find two chimpanzees: the tallest one shorter than he and the shortest one taller than he to make friends. However, any chimpanzee who happened to share the same height as Ziggy would not be considered a match, so he needed to make sure that the heights were distinct.

Input

There will be only one set of input for this problem. The first line of input gives you a number N ($1 \leq N \leq 50000$), the number of chimps on the line. In the next line you would have N integers (in the range 1 to 2^{31-1} giving the heights of the N chimps. There would be a single space after every number. You can assume that the chimps are ordered in non-decreasing order of their heights. In the next line you would have an integer Q ($1 \leq Q \leq 25000$) giving the number of queries. Then in the next line Q queries will follow. Then you would have Q numbers giving the height of Ziggy! Don't worry, Ziggy is from the land where people can have 3 birthdates; Q heights for a chimpanzee will make no difference here. The Q numbers are listed on a line and their range from 1 to 2^{31-1}, and as before you would find a single space after every query number. The query numbers are not supposed to come in any particular order.

Output

For each query height, print two numbers in one line. The first one would be the height of the tallest chimp that is shorter than Ziggy, and the next number would be the height of the shortest chimp that is taller than Ziggy. These two numbers are to be separated by a single

space. Whenever it is impossible to find any of these two heights, replace that height with an uppercase ‘X’.

Sample Input

4
1 4 5 7
4
4 6 8 10

Sample Output

1 5
5 7
7 X
7 X

Problem 2

You are given a sorted array of distinct integers and a target integer. Your task is to insert the target into the correct position in the array while maintaining the sorted order.

For example:
arr = [10, 20, 30, 40, 50]
target = 25
arr = [10, 20, 25, 30, 40, 50]

Constraints:

- The array consists of **distinct** integers.
- The function should run in **O(log n) time** for finding the correct position.