CSE221
Lab Assignment 03
Summer 2023

Submission Guidelines:

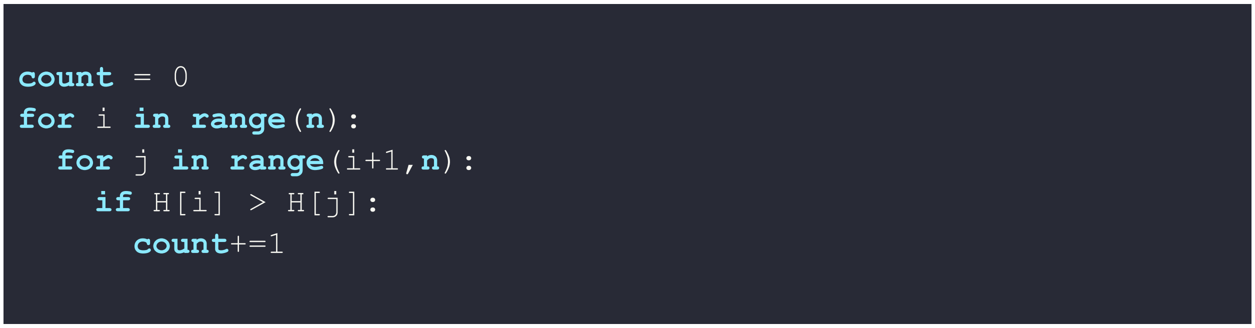
1. You can code all of them either in Python, CPP, or Java. But you should choose a specific language for all tasks.
2. For each task write separate python files like task1.py, task2.py, and so on.
3. For each problem, take input from files called **"inputX.txt"** and output at **"outputX.txt"**, where X is the task number.
4. Add a hand written explanation of 3-4 lines for each of your solutions in a separate document. You may compile all of your explanations in a single file.
5. Finally zip all the files and rename this zip file as per this format:**LabSectionNo_ID_CSE221LabAssignmentNo_Summer2023.zip** [Example:**LabSection01_21101XXX_CSE221LabAssignment03_Summer2023.zip**]
6. Don't copy from your friends.
7. You MUST follow all the guidelines, naming/file/zipping convention stated above.
   Failure to follow instructions will result in a straight 50% mark deduction.

Task 01 [15 Points]:

Somewhere in the universe, the Biannual Regional Alien Competition is taking place.

There are **N** aliens standing in a line. You will be given a permutation of N, which denotes the height of each alien. A sequence of N numbers is called a permutation if it contains all integers from 1 to N exactly once. For example, the sequences [3,1,4,2], [1] and [2,1] are permutations, but [1,2,1], [0,1] and [1,3,4] — are not.

In the competition, for each alien, the judge wants to count how many aliens are standing on its right side with a strictly smaller height. Then the judge wants to add up all the counts. To do this, the judge writes the following piece of code.



```
count = 0
for i in range(n):
  for j in range(i+1,n):
    if H[i] > H[j]:
      count+=1
```

However, their algorithm wasn’t efficient at all. Hence, the alien calls you to write a better solution for the program.

More formally, you have to count how many pairs of aliens are standing in the line such that H[i] > H[j] and i < j. Here, A is a permutation of the aliens’ heights. And i,j denote the Aliens’ positions.

Input

The first line contains a single integer $1 <= N <= 10^6$ - the number of total aliens.

The next line contains N integers $H_1, H_2, \ldots\ldots\ldots, H_n$**($1 \le H_i \le N$)– the height of the i–th alien. It is guaranteed that the given heights will be a permutation of N.**

Output

Print a single integer, which denotes the total number of pairs (i, j) such that i < j and $H_i > H_j$.

Sample Input/Output:

Sample Input 1	Sample Output 1

5 1 2 3 4 5	0
Sample Input 2	Sample Output 2
5 5 4 3 2 1	10
Sample Input 3	Sample Output 3
8 2 7 4 1 5 6 8 3	11

Sample Input 3 Explanation:

In the sample input 3, the following pairs on alien’s heights satisfy the condition: (2,1), (7,4), (7,1), (7,5), (7,6), (7,3), (4,1), (4,3), (5,3), (6,3), (8,3)

Task 02 [15 points]

You are given a list A of N integers. You have to choose two indices i and j such that 1 <= i < j <= N and $A[i] + A[j]^2$ is maximum possible. Here, we are considering 1-based indexing.

Write a code which will find the maximum value of $A[i] + A[j]^2$ in O(N) or O(N log N).

Input

The first line contains a single integer 1 <= N <= 10^6 - the length of the list.

The next line contains N integers $A_1, A_2, \ldots\ldots, A_n$ ($-10^8 \leq A_i \leq 10^8$) separated by a space.

Output

Print a single integer - which denotes the maximum possible value of A[i] + A[j]^2.

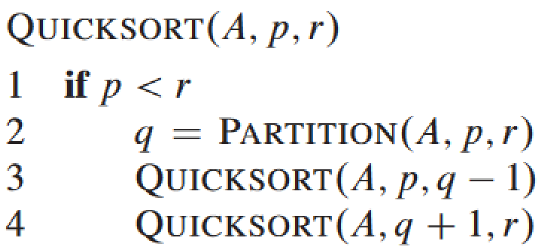
Sample Input/Output:

Sample Input 1	Sample Output 1
5 9 6 5 8 2	73
Sample Input 2	Sample Output 2
8 5 10 4 -3 1 6 -10 2	110
Sample Input 3	Sample Output 3
7 -5 -2 -6 -7 -1 8 2	63

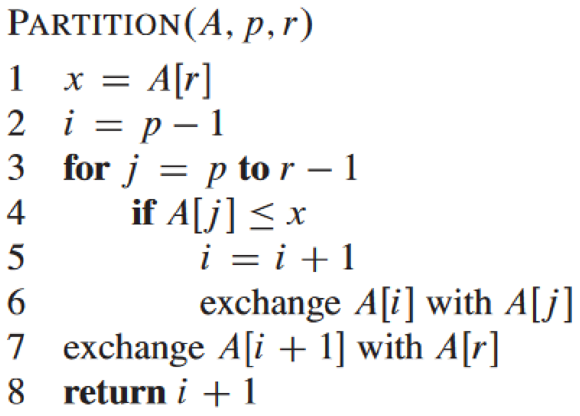
Task 03 [10 Points]

In this problem, you will be given a list of numbers. You have to sort the list using the Quick Sort algorithm in ascending order.

Pseudocode of Quick Sort Algorithm:



```
QUICKSORT($A, p, r$)
if $p < r$
    $q$ = PARTITION($A, p, r$)
    QUICKSORT($A, p, q - 1$)
    QUICKSORT($A, q + 1, r$)
```



```
PARTITION$(A, p, r)$
$x = A[r]$
$i = p - 1$
for $j = p$ to $r - 1$
    if $A[j] \le x$
        $i = i + 1$
        exchange $A[i]$ with $A[j]$
exchange $A[i + 1]$ with $A[r]$
return $i + 1$
```

[The code snippet has been taken from the book: Introduction to Algorithms]

Input

The first line contains an integer N (1 <= N <= 10^5), denoting the length of Alice’s list. In the next line, there will be N integers separated by space.

Output:

You have to sort the number using the Quick Sort algorithm in ascending order and show the sorted list.

Sample Input/Output:

Sample Input 1	Sample Output 1
8 9 5 4 6 1 3 2 9	1 2 3 4 5 6 9 9
Sample Input 2	Sample Output 2
1 10	10
Sample Input 3	Sample Output 3
6 8 1 4 2 1 3	1 1 2 3 4 8

Sample Input 4	Sample Output 4
7 7 6 5 4 3 2 1	1 2 3 4 5 6 7

Task 04 [10 Points]

In this problem, you will be given a list of numbers. You have to find the **k**-th smallest value from the list without sorting using the Partition function of Quick sort.

We will consider the 1-based indexing of the list.

Input

The first line contains an integer N (1 <= N <= 10^6), denoting the length of the list.

The next line contains N integers A_1,A_2,…………,A_n($1 \le A_i \le 10^6$) separated by a space.

The third line contains a single integer Q (1 <= Q <= 100) - which denotes the number of queries you have to answer.

Each of the next Q lines will contain a single integer K ($1 \le K \le N$).

Output:

For each query, you have to find the K-th smallest number from the given list.

Sample Input/Output:

Sample Input 1	Sample Output 1
9 // Total Elements 10 11 10 6 7 9 8 15 2 4 // Total queries	9 7 6

5 3 2 7	10