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_CSE221LabAssignment02_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 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. The judge writes the following code to solve the problem.

```
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 the permutations of Alience's height. And i,j denotes the Alience's position.

Input

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

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

Output

Print a single integer, which denotes the total number of inversions of the given permutation of alien's heights as described in the problem statement.

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 of integers. You have to choose two indices i and j such that $A[i] + A[j]^2$ is maximum possible ($1 <= i < j <= N$, where N is the length of the given list). 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 $A_1, A_2, \ldots\ldots\ldots, A_n$ ($-10^8 \leq A_i \leq 10^8$) 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)
1  if p < r
2      q = PARTITION(A, p, r)
3      QUICKSORT(A, p, q − 1)
4      QUICKSORT(A, q + 1, r)
```

```
PARTITION(A, p, r)
1  x = A[r]
2  i = p − 1
3  for j = p to r − 1
4      if A[j] ≤ x
5          i = i + 1
6          exchange A[i] with A[j]
7  exchange A[i + 1] with A[r]
8  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 sorted 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 $A_1, A_2, \ldots\ldots\ldots, A_n$ ($\mathbf{1 \leq A_i \leq 10^6}$) 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 ≤ K ≤ 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 5 3 2 7	9 7 6 10