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# Introduction

This answer sheet is written for answering assignment questions.

For the first three questions, answer will be provided in both Plain English form and Pseudo Code form for clarity, they describe the same algorithm while Plain English contains more detailed description of the algorithm and analysation of complexity.

# Question 1

## Question Part

You’re given an array A of n integers, and must answer a series of m questions, each of the form: “Given two integers, Xi and Yi, how many elements a of the array A satisfy ”. Design an expected algorithm that answers all these queries.

## Plain English Answer

First create an array to record the number of occurrences of each number by scanning , storing value in as an integer and incrementing the element of occ whose initial value is zero (existence of n is only for the purpose of clearness of explanation, we don’t actually need it). Say, is where 5 occurs 2 times, then . It takes steps to linear iterate and set the corresponding value in .

Secondly answer the question by using an if statement to handle different condition:

For each question Qi, IF is not zero, then there is no integer that satisfies , answer is 0.

Else, IF equals zero, that implies that can be divided by with quotient . We can easily get the number of elements a of the array by getting the value in array with index , that means, answer is .

As the complexity of dividing and finding the index is , it costs linear time to answer all question, then the complexity for answering questions is .

The overall expected complexity is the sum of pre-treatment and question part:

Due to the limitation of space of memory, the solution is based on the assumption of the space of is available for the given array .

## Pseudo Code Answer

# Question 2

## Question Part

You are given an array of integers and another integer .

a) Describe an algorithm that determines whether or not there exist two elements in whose absolute diﬀerence is exactly .

b) Describe an algorithm that acomplishes the same task, but runs in expected time.

## Plain English Answer

1. We devise a function using **divide and Conquer** method that **extends Merge sort** to solve this problem with two parameters implying is the array that is required to be examined whether or not there exist two elements in which whose absolute difference is exactly . This function can sort the given array in ascending order and return whether there is a pair of elements that satisfies the requirement.

For the simplicity of describing, implies the array and the of the and elements : Full version should be .

First the function divides into to equal parts, and and then runs functions and .

If the return values of the two functions **are not both zero**, that means there exist two elements in higher part or lower part of S namely, there exists a pair satisfying the requirement.

If **both of them are zero**, the function then merge the two sub arrays by counting from the least elements int them and moves the smaller element into a new array. Then, it compares two of the latest elements to decide if the absolute difference is exactly , if it’s true, return immediately (In the case of the new array has less than two elements, skip this process). After merging process, replace with the new array then return .

The terminating condition of this function is (the sub array doesn’t exists).

Complexity is (explained in the pseudo code part).

## Pseudo Code Answer



If l <r: