

Algorithms Tasks

Grading and Policies

1. Students who use the Internet to plagiarize the task, or copy from his/her colleagues, will take zero.
2. The task grade is 10. **Deliverables**
 1. **Implementation** of at least two algorithms without using built-in function. Algorithms can be recursive and non-recursive algorithms
 2. **Documentation** includes pseudo-code of the used algorithms, analysis of the used algorithm and computing its time complexity with comparison between them.

Projects Ideas

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1- Max Product of Three

A non-empty zero-indexed array A consisting of N integers is given. The *product* of triplet (P, Q, R) equates to $A[P] * A[Q] * A[R]$ ($0 \leq P < Q < R < N$).

For example, array A such that:

$A[0] = -3$ $A[1] = 1$ $A[2] = 2$ $A[3] = -2$ $A[4] = 5$ $A[5] = 6$

contains the following example triplets:

- (0, 1, 2), product is $-3 * 1 * 2 = -6$
- (1, 2, 4), product is $1 * 2 * 5 = 10$
- (2, 4, 5), product is $2 * 5 * 6 = 60$

Your goal is to find the maximal product of any triplet. Write a function that given a non-empty zero-indexed array A, returns the value of the maximal product of any triplet.

Example 1:

Input: `nums = [1,2,3]`

Output: 6

Example 2:

Input: `nums = [1,2,3,4]`

Output: 24

2- Triangle

A zero-indexed array A consisting of N integers is given. A triplet (P, Q, R) is *triangular* if $0 \leq P < Q < R < N$ and:

1. $A[P] + A[Q] > A[R]$, 2.
- $A[Q] + A[R] > A[P]$, 3.
- $A[R] + A[P] > A[Q]$.

For example, consider array A such that:

$A[0] = 10$ $A[1] = 2$ $A[2] = 5$ $A[3] = 1$ $A[4] = 8$ $A[5] = 20$ Triplet $(0, 2, 4)$ is triangular.

Write a function that, given a zero-indexed array A consisting of N integers, returns 1 if there exists a triangular triplet for this array and returns 0 otherwise.

Consider the following constraints:

1. **Count all unique triangular triplets:**
 - Instead of just returning 1 or 0 based on whether a triangular triplet exists, the function should return the total count of unique triangular triplets in the array.
2. **Allow custom indices for triplet search:**
 - Add an optional parameter that allows the user to specify a range $[start, end]$ within the array to look for triangular triplets. This way, users can search for triangular triplets in a specific subset of the array.
3. **Return the triplets themselves if a flag is set:**
 - Add a flag parameter `return_triplets` that, when set to `True`, will return the list of all valid triangular triplets and their count.

Example 1:

Input: `nums = [10, 50, 1]`

Output: `(0, [])`

Example 2:

Input: `nums = [10, 2, 5, 1, 8, 20]`

Output: `(5, [(8, 16, 20), (10, 16, 20), (5, 16, 20), (5, 8, 10), (8, 10, 16)])`

3- balanced string

A string is balanced if it consists of exactly two different characters and both of those characters appear exactly the same number of times.

For example: "aabbab" is balanced (both 'a' and 'b' occur three times) but "aabba" is not balanced ('a' occurs three times, 'b' occurs two times).

String "aabbcc" is also not balanced (it contains three different letters).

A substring of string S is a string that consists of consecutive letters in S. For example: "ompu" is a substring of "computer" but "cmpttr" is not.

Examples:

1. Given S = "cabbacc", the function should return 4 ("abba" is the longest balanced substring).
2. Given S = "abababa", the function should return 6 ("ababab" and "bababa" are the longest balanced substrings).
3. Given S = "aaaaaaa", the function should return 0 (S does not contain a balanced substring).

Write an efficient algorithm to get the length of the longest balanced substring of given string S.

4- Birthday Cake Candles

You are in charge of the cake for a child's birthday. You have decided the cake will have one candle for each year of their total age. They will only be able to blow out the tallest of the candles. Count how many candles are tallest, Determine if the tallest candles are placed symmetrically around the center of the array. If they are, return True; otherwise, return change the positions of element to make it symmetric.

Example

Candles = [4,4,1,3]

The maximum height candles are 4 units high. There are 2 of them, so return 2.

Function Description

Write a function `birthdayCakeCandles` that has the following parameter(s):

- Returns**
- `int candles[n]`: the candle heights
 - `int`: the tallest candle.
 - `int`: the number of candles that are tallest.
 - `boolean`: Is symmetric:

Example:

Input:

4
4 4 1 3

Output:

Max height: 4
Number of tallest candles: 2
Is symmetric: False

5- Diagonal Difference

Given a square matrix, calculate the absolute difference between the sums of its diagonals.

For example, the square matrix is shown below:

1 2 3

4 5 6

9 8 9

The left-to-right diagonal = $1+5+9=15$. The right to left diagonal = $3+5+9=17$. Their absolute difference is $|15-17|=2$.

Input Format

The first line contains a single integer, n , the number of rows and columns in the square matrix `arr`.

Each of the next n lines describes a row, `arr[i]`, and consists of n space-separated integers `arr[i][j]` .

Constraints

$-100 < arr[i][j] < 100$

Output Format

Return the absolute difference between the sums of the matrix's two diagonals as a single integer. Then check if the absolute difference between these sums is zero return true else return false.

Sample Input

3

11 2 4

4 5 6

10 8 -12

Sample Output :

15 # difference between the sums of the matrix's two diagonals

false #returned of the check

6- Wiggle Sort

Given an integer array `nums`, reorder it such that:

$$\text{nums}[0] < \text{nums}[1] > \text{nums}[2] < \text{nums}[3] \dots$$

You may assume the input array always has a valid answer.

Example 1:

Input: `nums = [1,5,1,1,6,4]`

Output: `[1,6,1,5,1,4]` OR `[1,4,1,5,1,6]`

Example 2:

Input: `nums = [1,3,2,2,3,1]`

Output: `[2,3,1,3,1,2]` OR `[1, 3, 2, 3, 1, 2]`

Constraints:

- `1 <= nums.length <= 5 * 104`
- `0 <= nums[i] <= 5000`
- It is guaranteed that there will be an answer for the given input `nums`.

7- K-th Element of Two Sorted Arrays

Given two sorted arrays of size m and n respectively, you are tasked with finding the element that would be at the k'th position of the final sorted array.

Example 1:

Input: Array 1 = { 2 ,3, 6, 7, 9} Array 2 = {1, 4, 8, 10}

 k = 5

Output: 6

Explanation: The final sorted array would be – {1, 2, 3, 4, 6, 7, 8, 9, 10 }
 The 5th element of this array is 6.

Example 2:

Input: Array 1 = { 100, 112 ,256 ,349 ,770} Array 2 = {72, 86 ,113 ,119 ,265 ,445 ,892}

 k = 7

Output: 256

8- Dominator

An array A consisting of N integers is given. The dominator of array A is the value that occurs in more than half of the elements of A.

For example, consider array A such that

A[0] = 3 A[1] = 4 A[2] = 3 A[3] = 2 A[4] = 3 A[5] = -1 A[6] = 3
A[7] = 3

The dominator of A is 3 because it occurs in 5 out of 8 elements of A (namely in those with indices 0, 2, 4, 6 and 7) and 5 is more than half of 8.

Write an efficient algorithm for the following assumptions:

- given an array A consisting of N integers, returns index of any element of array A in which the dominator of A occurs. The function should return -1 if array A does not have a dominator.
- N is an integer within the range [0..100,000];
- each element of array A is an integer within the range [-2,147,483,648 ... 2,147,483,647]

Sample Input:

A[0] = 3
A[1] = 4
A[2] = 3
A[3] = 2
A[4] = 3
A[5] = -1
A[6] = 3
A[7] = 3

Sample Output:

0, 2, 4, 6 and 7 # this is the position of the most repeated value

9- Distinct

Write a function that, given a zero-indexed array A consisting of N integers, returns the number of distinct values in array A but with the following constraints:

1. **Memory Constraints:** You have limited memory, and you cannot store the entire array in memory at once.
2. **Stream Processing:** The array is too large to fit in memory and is processed sequentially, one element at a time.

Assume that:

- N is an integer within the range $[0..100,000]$;
- each element of array A is an integer within the range $[-1,000,000..1,000,000]$.

For example, given array A consisting of six elements such that:

$A[0] = 2$

$A[1] = 1$

$A[2] = 1$

$A[3] = 2$

$A[4] = 3$

$A[5] = 1$

the function should return 3, because there are 3 distinct values appearing in array A, namely 1, 2 and 3.

10- Median of Two Sorted Arrays

Problem Statement:

Given two sorted arrays `nums1` and `nums2` of size `m` and `n` respectively, return the median of the two sorted arrays.

Example 1:

Input:

`nums1 = [1, 3]`

`nums2 = [2]`

Output: 2

Example 2:

Input:

`nums1 = [1, 2]`

`nums2 = [3, 4]`

Output: 2.5

Constraints:

- `nums1.length == m`
- `nums2.length == n`
- $0 \leq m \leq 1000$
- $0 \leq n \leq 1000$
- $1 \leq m + n \leq 2000$
- $-10^6 \leq \text{nums1}[i], \text{nums2}[i] \leq 10^6$