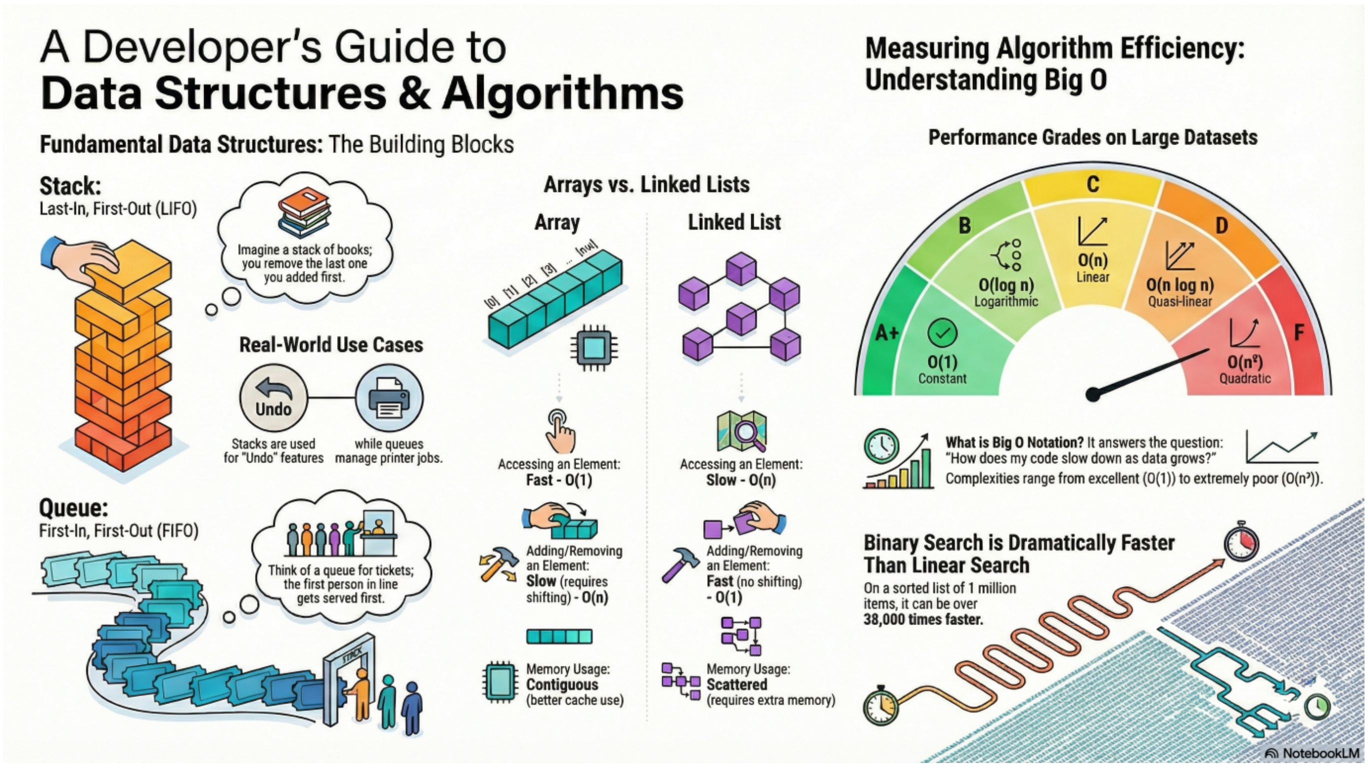
kintsugi-stack-dsa-cpp: COMPETITIVE_PROGRAMMING

> "Talk is cheap. Show me the time complexity."

- Author: Kintsugi-Programmer


A Developer's Guide to
Data Structures & Algorithms
Fundamental Data Structures: The Building Blocks
Stack:
Last-In, First-Out (LIFO)
Imagine a stack of books; you remove the last one you added first.
Real-World Use Cases
Undo
Stacks are used for "Undo" features
while queues manage printer jobs.
Queue:
First-In, First-Out (FIFO)
Think of a queue for tickets; the first person in line gets served first.
Arrays vs. Linked Lists
Array
Linked List
[0] [1] [2] [3] ... [n-1]
Accessing an Element: Fast - O(1)
Accessing an Element: Slow - O(n)
Adding/Removing an Element: Slow (requires shifting) - O(n)
Adding/Removing an Element: Fast (no shifting) - O(1)
Memory Usage: Contiguous (better cache use)
Memory Usage: Scattered (requires extra memory)
Measuring Algorithm Efficiency: Understanding Big O
Performance Grades on Large Datasets
A+
O(1) Constant
B
O(log n) Logarithmic
C
O(n) Linear
D
O(n log n) Quasi-linear
F
O(n²) Quadratic
What is Big O Notation? It answers the question: "How does my code slow down as data grows?" Complexities range from excellent (O(1)) to extremely poor (O(n²)).
Binary Search is Dramatically Faster Than Linear Search
On a sorted list of 1 million items, it can be over 38,000 times faster.
NotebookLM

> Disclaimer: The content presented here is a curated blend of my personal learning journey, experiences, open-source documentation, and invaluable knowledge gained from diverse sources. I do not claim sole ownership over all the material; this is a community-driven effort to learn, share, and grow together.

- https://codeforces.com/profile/kintsugi-programmer
- https://www.tle-eliminators.com/cp-sheet

Table of Contents

- kintsugi-stack-dsa-cpp: COMPETITIVE_PROGRAMMING
    - Table of Contents
- R800
    - 01 A Halloumi Boxes
    - 02 A Line Trip
    - 03 A Cover in Water
    - 04 A Game with Integers
    - 05 A Jagged Swaps
    - 06 A Doremy's Paint 3
    - 07 A Don't Try to Count

  - 08 A How Much Does Daytona Cost?
  - 09 Goals of Victory
  - 10 Target Practice
  - 11 Ambitious Kid
  - 12 Sequence Game
- TipsCollectedFromExperiences
- Array Coloring [ONSIGHT]

R800

01 A Halloumi Boxes

- https://codeforces.com/problemset/problem/1903/A
- brute force, greedy, sortings, *800
- Analysis
  - n boxes/array a1 a2 ... an
  - a = {a0, a1, a2 ... an-1}
  - subarray = subsegment = segment taken out of array not manipulated ,no change in order
    - eg: {a0, a1}, {a1,a2,a3}, etc
  - He wants to sort them in non-decreasing order based on their number
  - non-decreasing = increasing
  - s is atmost k , means : s<=k
  - however, his machine works in a strange way. It can only reverse any subarray of boxes with length `at most k`
  - subarrsize<=k
  - Find if it's possible to sort the boxes using any number of reverses.
  - So, if K>=2 ,Machine's sort is 100%possible at `any number of reverses` `ANY_TIMES`
    - if k=2 atleast => i have power to shift any element anywhere
  - eg:
    - 6421
      - 6421 rev 2 nos sub array my initial thought
      - 6412 rev 2 nos sub array
      - 6142 rev 2 nos sub array
      - 1642 rev 2 nos sub array
      - 1624 rev 2 nos sub array
      - 1264 rev 2 nos sub array
      - 1246 rev 2 nos sub array
      - sorting done :0
    - 6421
      - 1246 rev 4 nos sub array optimal from tuts
  - atq : according to question
  - tl per test = 1sec atq
    - 1sec = 10^8 Operations = per test operations
    - 1 <=k <= n (minitests)<= 100 acc.to ques (atq)
    - consider n=100 upperbound
    - tl per mini test = 1sec /100

        - per mini test operations = 10^8 / 100 = 10^6
        - if tc per mini test = O(n^3)
            - so n=100, then operation = O(n^3) = O(100^6) = per mini test operations
            - so O(n^3) is the upper bound
            - even sol. can have O(n^2), O(n), O(nlogn) etc. anything below O(n^3), but not above O(n^3)
        - Expected TC = O(n^3)
    - ml per test = 256mB atq
    - at k=1, no sorting is possible
        - because the foundation of reverse is actually swap any atleast 2 stuff
        - if stuff is only one then it wont make sense to reverse as we lost power to shift any element
- Approach
    - Passing Condition where return YES
        - K>=2
        - or given array is already sorted
    - else, return False

```
#include<bits/stdc++.h>
using namespace std;
int main(){
    // at extreme proof case use :
    // long long t;
    int t;
    cin>>t;
    while(t--){
        int n,k;
        cin>>n>>k;
        vector<int> v(n);
        int i=0;
        //input
        while(i<n){
            cin>>v[i]; // n order
            i++;
        }
        vector<int> v2=v; // copy // n order
        sort(v2.begin(), v2.end());  // nlogn order
        if ((v2==v)or(k>=2)){ // to check whether initial array is sorted
or not // n order
            cout<<"YES\n";
        } else {
            cout<<"NO\n";
        }
    }
    return 0;
}
// tc O(nlogn) // highest order here
// at n = 100 , tc = 100log100 = 100*7 = 700
// 2^7 ~ 100
// log2(n) = ln n / ln 2
// sc O(n)
```

02 A Line Trip

- https://codeforces.com/problemset/problem/1901/A
- greedy, math, *800
- Analysis
  - location&road on number line
    - 0 , a1 , a2 , ... , x
    - Round Trip i.e. total path => 0, a1, ... an, x, an, ..., a1,0
    - a1,a2 ... Gas station for Tanki Full/ Refill
    - 0 start point
    - if stop at non-station location due to gas empty = gameover
    - no refuel at dest x
  - In this ques, we have to find the capacity of gas tank car should take it for journey, efficiently without stopping
  - tl per test = 2secs
    - 2secs = 2*(10^8) operations
    - t=1000 atq
    - time/testcase = O(2* 10^5)
    - n=50 max atq
    - then at O(n^3) = O(125000) = O(1.25 * 10^5) <= O(2* 10^5)
    - TC for minitest = Expected TC = O(n^3) upper bound
  - tlpt = time limit per test
  - mlpt = 256mB
  - in test case 1
    - n=3
    - x=7
    - a{1,2,5}
    - `0-1-2-5-7-5-2-1-0`
    - output = 4
    - gaschanges=
      - 4 start
      - 3 at 1
      - 4 refill
      - 3 at 2
      - 4 refill
      - 1 at 5
      - 4 refill
      - 2 at 7
      - NO Refill at dest x
      - 0 at 5 ,biggest gas consumption, 5->7->5 , 4 units distance
      - 4 refill
      - 1 at 2
      - 4 refill

            - 3 at 1
            - 4 refill
            - 3 end, fully reached ,gas still remaining
        - biggest gas consumption, 5->7->5 , 4 units distance
        - thus min threshold gas capacity is 4 units ,as below it , car would stop at 5->7->5
    - now the max capacity of gas tank in any journey = max distance of any 2 gas stations throughout journey
    - througout journey means a round trip
        - so, after lastGasStation, car will go to x(dest), and find lastGasStation first in return journey
        - so, that distance is (lastGasStation - x)*2
- Approach
    - C1= cal. firstGasStation-0
    - C2= max(allDistances(cal. dist b/w eachGasStation))
    - C3= cal. (lastGasStation - x)*2
    - return max(C1,C2,C3)

```
#include<bits/stdc++.h>
using namespace std;
int main(){
    long long t;
    cin>>t;
    while(t--){
        long long n,x;
        cin>>n>>x;
        long long i=1;
        long long smax=0;
        vector<long long> v1(n+1,0); //initialize safety //O(n)
        v1[0]=0;
        while(i<=n){// O(n)
            cin>>v1[i];
            // cout<<v1[i];
            long long buff=smax;
            smax=max(buff,(v1[i]-v1[i-1]));
            i++;
        }
        long long smax2=(x-v1[n])*2; // O(1)
        cout<< max(smax,smax2)<<endl;
        // cout<< smax<<" "<<v1[n-1]<<" "<<smax2<<endl;

    }return 0;
}
// Time Complexity: O(n)
// Space Complexity: O(n)

//  max(a, b); O(1) // just checks (a < b)
//  min(a, b); O(1) // just checks (a < b)
// max_element(v.begin(), v.end()) O(n)
// min_element(v.begin(), v.end()) O(n)
```

- my code is more optimal than tut ;0

03 A Cover in Water

- https://codeforces.com/problemset/problem/1900/A
- constructive algorithms, greedy, implementation, strings, *800
- Analysis
    - Filip has a row of cells, some of which are blocked, and some are empty.
    - He wants all empty cells to have water in them.
    - He has two actions at his disposal
        - 1. place water in an empty cell. `FINITE_TIMES`
        - 2. remove water from a cell and place it in any other empty cell. `ANY_TIMES`
    - autoOperation
        - if at some moment cell i (2≤i≤n−1) is empty and both cells i−1 and i+1 contains water, then it becomes filled with water. `ANY_TIMES`
        - magic autofill
    - N => s = s1,s2,s3....,sn
        - = ...##.#....##
        - now in ...
            - if we just w.w (w=water) => www
            - then we can transfer the middle water to other cells one by one
            - w.w sill it get refill=> www
        - ...##.#....##
            - w.w##.#....## 2times fill water manual
            - www##.#....## autofill
            - w.w##.#w...## swap water
            - www##.#w...## autofill
            - w.w##w#w...## swap water
            - www##w#w...## autofill
            - w.w##w#ww..## swap water
            - www##w#ww..## autofill
            - w.w##w#www.## swap water
            - www##w#www.## autofill
            - w.w##w#wwww## swap water
            - www##w#wwww## auto fill
            - all buckets filled ;0, count=2 operation 1
    - C1: if no. of Consecutive dots(emptyBoxes) >= 3
        - then we only need 1 operation only 2TIMES as we could fill at corner of 3 boxes and middle box will autoOperationAutoFillWater and we can transfer that water to other cells `ANY_TIMES` 2 operation, and regenerate autoOperationAutoFillWater
    - C2: else we need to fill all boxes by 1 operation only as here autoOperationAutoFillWater fails
    - Expected TC
        - tlpt 1sec atq
            - mt = t max= 100 atq
            - tlpmt = 10^8 / 100 = 10^6
            - n = 100 atq
            - TCpmt = O(n^3) upperbound

            - as O(100^3) = O(10^6) = order of tlpmt
        - mlpt 256mB atq
- Approach
    - count no. of dots(emptyBoxes)
    - count no. of Consecutive dots(emptyBoxes)
    - if no. of Consecutive dots(emptyBoxes) >= 3
        - return 2
    - else
        - return no. of dots(emptyBoxes)
- AnotherApproach
    - if i have 3 contineous empty cell, answer is 2 else ,answer is count of all empty cells
    - similar
    - ... => (i-1), (i), (i+1)
        - just fill i-1, i+1
    - if `(s[i]=="." && i+1<n && s[i+1]=="." && i+2<n && s[i+2]=="."`
        - return 2
    - else
        - return no. of dots(emptyBoxes)

```
#include<bits/stdc++.h>
using namespace std;
int main(){
    long long t;
    cin>>t;
    while (t--)
    {

        long long n;
        cin>>n;

        string s;
        cin>>s;

        int sum=0;
        int i=0;
        int dot=0;

        while(i<s.size()){
            if (s[i]=='.'& sum!=3)
            {
                sum++;
                dot++;
            }
            else if (s[i]=='#' & sum!=3)
            {
                sum=0;
            }
            i++;
        }
        if (sum>=3)
        {
            cout<<2<<endl;
        }
        else
        {
            cout<<dot<<endl;
        }


    }
    return 0;

}
// TC O(n)
// SC O(n)
```

04 A Game with Integers

- https://codeforces.com/problemset/problem/1899/A
- games, math, number theory, *800
- Analysis
  - Vanya and Vova are playing a game. Players are given an integer n. On their turn, the player can add 1 to the current integer or subtract 1
  - Operations any ne
    - n=n-1
    - n=n+1
  - The players take turns; Vanya starts. If after Vanya's move the integer is divisible by 3, then he wins. If 10 moves have passed and Vanya has not won, then Vova wins.
  - if both players play optimally
    - then in each of player turn he/she will try move to make other one lose
  - eg: if nos is 5
    - nos = 5
    - 6 (vanya n++) OR 4 (vanya n--)
    - 5 (vova n--) or 7 (vova n++) OR 3 (vova n--) or 5 (vova n++)
    - 6 (vanya n++) OR 4 (vanya n--) or 6 (vanya n--) OR 8 (vanya n++) or 2 (vanya n--) OR 4 (vanya n++) or 4 (vanya n--) OR 6 (vanya n++)
    - basically she will counter , to remake it even, repetitive till 10
    - she won
  - Expected TC ?
    - tlpt = 1sec atq
    - mlpt = 256mB atq
    - t = 100 atq
    - n = 1000 atq
    - 1sec = 10^8 ops
    - tlpmt = 10^8 / t = 10^8 / 100 = 10^6
    - Expected TC = O(n^2)
      - not O(n^3)

            - as 1000^3 = 10^9 < tlpmt
          - as putting n in mt O(n^2)
          - = 1000^2
          - = 10^6
          - = tlpmt
    - NOW , if both play most optimal, then they will reverse each other operations and exhause the turns
        - eg: n=6 => 7 (vanya n++) => 6 (vova n--) => infinite loop
        - n%3 == 0
            - if True, divisible before vanya move
                - even vanya could +1/ -1
                - it will not be divisible by 3
                - & vova will cancel the effect -1/ +1 of vanya till 10rounds
                - ultimate vova win
            - if False, not divisible before vanya move
                - vanya could +1/ -1
                - it will be divisible by 3 after vanya move
                - & vova will do something
                - & vova will cancel the effect -1/ +1 of vova
                - and still it will be divisible by 3 after vanya move till 10rounds
                - ultimate vanya win
    - numbers
        - 0 DIV
        - 1 (-1=0)
        - 2 (+1=3)
        - 3 DIV
        - 4 (-1)
        - 5 (+1)
        - 6 DIV
        - 7
        - 8
        - 9 DIV
    - Eg: 6
        - => 7 => 8 => 9 => .... vanya win
        - => 7 => 6 => 7 => 6 ... vova win if played optimaly
- Approach
    - if n%3 == 0
        - vova win, return Second
    - else if n%3 != 0
        - vanya win, return Second

```
#include<bits/stdc++.h>
using namespace std;
int main(){
    long long t=0;
    cin>>t;
    while(t--){
        long long n=0;
        cin>>n;
        if (n%3==0){cout<<"Second\n";}
        else{cout<<"First\n";}
    }
    return 0;
}
// TC O(1)
// SC O(1)
```

05 A Jagged Swaps

- https://codeforces.com/problemset/problem/1896/A
- sortings, *800
- Analysis
    - here, permutation is an array
        - of unique elements
        - if array of `n` integers, then integet exists of all 1,..to.,n
        - => ORDER DOES NOT MATTER
    - we want to check if we could sort the permutation with special operation `ANY_TIMES`
    - special operation
        - if `a[i-1] < a[i] > a[i+1]`
            - then swap a[i], a[i+1]
    - eg: 1 3 2 5 4
        - target: 1 2 3 4 5
        - now
            - 1 3 2 5 4
            - 1<3>2 5 4 satisfies spec ops
            - 1 2 3 5 4 swap :0
            - 1 2 3<5>4 satisfies spec ops
            - 1 2 3 4 5 swap :0
            - = target
    - Expected TC
        - tlpt 1sec atq
            - t max 5000 atq
            - n max 10 atq
            - 1 sec = 10^8 ops
            - tlpmt = 10^8 / 5* 10^3
                - = 10^5/ 5
                - = 2* 10^4 ops
            - O(10^4)< tlpmt
            - O(n^4) = Expected TC = tcpmt
        - mlpt 256mB atq
- Approach optimal
    - IF THE FIRST NUMBER IN THE INITIAL ARRAY IS 1, THEN ANSWER IS YES , ELSE ANSWER IS NO
    - if not 1st element is 1 ,then that element can never shift towards its desired side

    - this is technically bubble sort
    - as if a number is largest, then it would be `a[i-1] < a[i] > a[i+1]` obviously
    - our input arrays are already a permutation perfect, so no need to crosscheck

```cpp
#include<bits/stdc++.h>
using namespace std;

int main(){

    long long t;
    cin>>t;
    while(t--){
        int n;
        cin>>n;
        vector<int> arr(n,0);
        for (int i=0; i<n; i++) cin>>arr[i];
        if (arr[0]==1) cout<<"YES\n";
        else cout<<"NO\n";

    }

    return 0;
}
// TC O(n)
// SC O(n)
```

- Approach Brute Force
    - if this is permution
        - if permutation is already sorted
            - return "YES"
        - else
            - try sort by special operation n times
            - if sorted
                - return "YES"
            - else
                - return "NO"
    - else
        - return "NO"
        - TTYL

```cpp
#include<bits/stdc++.h>
using namespace std;

string checkSort(vector<int> arr,vector<int> arr2, int n){
    for ( int faltu=0; faltu<n; faltu++){
    for ( int idx=0; idx<n; idx++){
        if (
            arr[idx]<arr[idx+1] &&
            arr[idx+1]>arr[idx+2] &&
            idx+2<n
        ){
            int temp= arr[idx+1];
            arr[idx+1]= arr[idx+2];
            arr[idx+2]=temp;

        }
    }
    if(arr2==arr) { return "YES"; }
}
    return "NO";
}


// NO NEED
string checkPert(int n){
    vector<int> arr(n);
    for (int i=0; i<n; i++) cin>>arr[i];

    vector<int> arr2=arr;
    sort(arr2.begin(),arr2.end());

    for ( int idx=0; idx<n; idx++){if (arr2[idx]!=idx+1) {return "NO";}}
    if(arr2==arr) { return "YES"; } // already sorted
    return checkSort(arr,arr2, n);// we dont feed data types as arguements
}


int main(){

    long long t;
    cin>>t;
    while(t--){
        int n;
        cin>>n;
        cout<<checkPert(n)<<"\n";

    }

    return 0;
}
```

06 A Doremy's Paint 3

- https://codeforces.com/problemset/problem/1890/A
- constructive algorithms, *800
- Analysis
    - array a = { a1,a2,a3...an}
    - n sized array
    - you want equality among the adjacent sums

- array is good for this ques as
- there exists a k such that a1+a2=a2+a3=…=an−1+an=k
- Can you reorder the elements such that the condition becomes true ???
- `permute its element` = change its order
- eg : {1,1,2}
  - 1,2,1 permute done
  - now 1+2 = 2+1 = 3 :0 Done
  - "YES"
- Expected TC?
  - tlpt = 1sec atq
  - = 10^8 ops
  - t max=100 = mt atq
  - tlmt = 10^8 / 100 = 10^6
  - n = 100
  - O(n^3) = 100^3 = 10^6 = tlmt
  - Expected TC = O(n^3)
  - mlpt = 256mB atq
  - if Expected TC = O(n^3) ,then
    - O(n^4) NO ABOVE UPPER BOUND
    - O(n^3) YES UPPER BOUND
    - O(n^2) YES BELOW UPPER BOUND
    - O(n) YES BELOW UPPER BOUND
    - O(nlog2(n)) YES BELOW UPPER BOUND
    - O(n1) YES BELOW UPPER BOUND
    - this helps in thinking solution limits and optimisation
    - solution can be minimal, not exact O(n^3)
    - but still we got to know our limits

- Approach optimal
  - => Generalise the condition
    - a1 + a2 = a2 + a3 = ... = an-1 = an atq
    - => ai-1 + ai = ai + ai+1
    - => ai-1 + ai(cancelled) = ai(cancelled) + ai+1
    - => `ai-1 = ai+1` !!!
    - i.e. a1=a3=a4=a5=.... && a2=a4=a6=....
  - odd index positions should have same nos && even index positions should have same nos
  - NO when i have more than or equal to 3 distinct integers in my array, eg: 1 1 2 3 => no, you cant create any fair ordering
    - => Case of 3 Distinct Integers
  - ELSE NOW if we have N1 & N2, freq. f1, f2
    - we want either of both cases in n=6
      - { N1 N2 N1 N2 N1 N2 }
      - { N2 N1 N2 N1 N2 N1 }
      - => f1=f2 AT ODD N
      - YES
    - n=7
      - { N1 N2 N1 N2 N1 N2 N1 }

        - { N2 N1 N2 N1 N2 N1 N2 }
        - => f1= f2 +1
        - => f2= f1 +1
        - => abs(f1-f2) = 1 AT EVEN N
      - if not then we cant achieve our `ai-1 = ai+1` !!!, then NO
      - => Case of 2 Distinct Integers
  - => Case of 1 Distinct Integers
      - N1 , any n
      - then N1 N1 N1 N1 ...
      - whole array same
      - direct YES
  - else NO

```
#include<bits/stdc++.h>
using namespace std;
int main(){

    // t
    // mini tests
    int t;
    cin>> t;
    while (t--){
        long long n;
        cin>>n;
        vector<long long> a(n,0);
        // vector input
        for (long long i=0; i<n; i++) {cin>>a[i];} //n

        // freq map
        map<long long, long long> freq_map;
        for (long long i =0; i<n; i++){//n
            freq_map[a[i]]++;//logn
        }
        //nlogn


        if (freq_map.size()>=3) cout<<"No"<<endl;
        else {

            // begin- first element
            // rbegin- last element

            long long freq1 = freq_map.begin()->second;
            long long freq2 = freq_map.rbegin()->second;

            //odd size array
            if (freq1==freq2) cout<<"Yes"<<endl;
            else if ( n%2 ==1 && abs(freq1-freq2)==1) cout<<"Yes"<<endl;
            else cout<<"No"<<endl;
        }
    }
    return 0;
}

// TC O(nlog2n) = O(100*log2(100)) = O(100*7) = O(700)
// SC O(n+n)= O(2n) = O(200)

// this problem is imp to teach map,begin,rbegin iterators
```

- this problem is imp to teach map,begin,rbegin iterators

```
// freq map
map<long long, long long> freq_map;
for (long long i =0; i<n; i++){//n
freq_map[a[i]]++;//logn
}
```

```
if (freq_map.size()>=3) cout<<"No"<<endl;
```

```


// begin- first element
// rbegin- last element

long long freq1 = freq_map.begin()->second;
long long freq2 = freq_map.rbegin()->second;
```

- Approach Brute force
  - Similar thinking but not organised enough at first try out of clue
  - Read number of test cases `t`
  - For each test case:
    - Read array size `x`
    - Read `x` elements into array `v1`
    - Make a copy `v2` and sort it
    - Make a copy `v3` from `v2` and remove duplicates from `v3`
    - If `v3.size() > 2`, return `"NO"`
    - If all elements are equal, return `"YES"`
    - If array size is even:
      - If frequency of smallest and largest elements is equal, return `"YES"`
    - If array size is odd:
      - If the frequency difference between smallest and largest elements is exactly 1, return `"YES"`
    - If array size is 2, return `"YES"`
    - Else, return `"NO"`

```
#include<bits/stdc++.h>
using namespace std;
string goodAPCheck(int x){
    vector<int> v1(x);
    for ( int i=0; i<x; i++) cin>>v1[i];
    vector<int> v2=v1;
    sort(v2.begin(),v2.end());

    vector<int> v3=v2;
    // remove duplicates
    v3.erase(unique(v3.begin(),v3.end()),v3.end());
    if (v3.size()>2 ) return "NO";

    if (count(v1.begin(), v1.end(),v2[0])==x) return "YES";
    if (x%2==0 && count(v1.begin(), v1.end(),v2[0])==count(v1.begin(),
v1.end(),v2[x-1])) return "YES";
    if(x%2!=0 && (count(v1.begin(), v1.end(),v2[0])==count(v1.begin(),
v1.end(),v2[x-1])+1 ||count(v1.begin(),
v1.end(),v2[0])+1==count(v1.begin(), v1.end(),v2[x-1])  )) return "YES";
    if(x==2) return "YES";
    else return "NO";



}
int main(){

    long long t;
    cin>>t;
    while(t--) {
        int x = 0;
        cin>>x;
        cout<<goodAPCheck(x)<<"\n";
    }
    return 0;
}
```

07 A Don't Try to Count

- https://codeforces.com/problemset/problem/1881/A
- brute force, strings, *800
- Analysis
    - string x, len n
    - string s, len m
    - n*m <=25
        - 1, 25
        - 5, 5
        - 25, 1
    - operation `ANY_TIMES`

        - if x= "abc"
        - x= x+x "abcabc"
    - Find
        - min. no of operation by which
        - s is substring of x
    - Expected TC?
        - tlpt 2sec atq
            - t 10^4 max atq
            - 1sec = 2*10^8 ops per test
            - ops/minitests = 2*10^8 / 10^4 = 2*10^4 ops = 20000 ops = 25*10^2 ops
            - n*m 25 max atq
            - O(n*m*10^2) Upper bound Expected TC
        - mlpt 256mB atq
- Approach Brute Force Tuts
    - where do i finally say ,this is the end ?
        - x-> x+x -> x+x + x+x -> ... -> not infinity but a upperbound
        - arguement = upper bound is 5
        - should not go beyond 5
        - n-> x, m-> s
        - worst, n=1, m=25
        - eg : x='a', s='aa...25times...a'
        - x.size()< s.size(), till this condition is true, you can never find s within x
        - a => aa => aaaa => a.8..a => a..16..a => a..32..a
        - 1=> 2=> 4=> 8 => 16 => 32(its enough ,more than 25 to become super set), these changes done within 5 operation
        - if not done in even 5 operations then ,at 6, x=a...64..a
        - if couldnt find str in 25 ,then you can't find in 64 or more ... .answer is impossible => -1

```
#include<bits/stdc++.h>
using namespace std;
bool check(string s,string x)
{
    if (x.size()<s.size()) return false;
    for (int i=0; i<x.size()- s.size()+1; i++) if (x.substr(i,s.size())==s) return true; //x.substr(i,s.size())==s substring extract
    return false;
}// O((n-m+1)*m)=O(n*m)
int main(){
    int t;
    cin>>t;
    while (t--){
        long long n,m;
        cin>>n>>m;
        string x,s;
        cin>>x>>s;

        string x0 = x;
        string x1 = x0+x0;
        string x2 = x1+x1;
        string x3 = x2+x2;
        string x4 = x3+x3;
        string x5 = x4+x4;

        long long ans = -1;
        if(check(s,x0)) ans=0;
        else if (check(s,x1)) ans=1;
        else if (check(s,x2)) ans=2;
        else if (check(s,x3)) ans=3;
        else if (check(s,x4)) ans=4;
        else if (check(s,x5)) ans=5;
        cout<<ans<<endl;



    }return 0;
}
//187 ms    100 KB
// TC O(2^5 *n*m) = O(32*n*m)
// SC O(2^5*n) = O(32*n)
```

- Approach optimal Mine
  - SAME
  - input t testcases
  - each test cases
    - input n,m
    - Wrong, as babb,bbb ,its not -1
      - check if x is substring of s+s
        - if no
          - then x ,even mul by infinite can't be superset or in any combination of s
          - and we took s+s as maybe x="mara", s="rama"
          - return -1
        - if yes
          - then its posible
  - counter=0
  - while counter<=5
    - concatnate till s is substring of x
      - counter++
  - return counter
  - why counter =5 ??
    - counter=m*n
    - NO, Memory limit exceeded on test 2 1734 ms 262100 KB

```
#include<bits/stdc++.h>
using namespace std;
int checkCount(string x,string s){
    int counter = 0;

    while (counter<=5){
        if ((x).find(s) != string::npos){
            return counter;
        }
        counter++;
        x=x+x;


    }
    return -1;

};

int main(){
    long long t;
    cin >> t;
    while(t--){
        int n=0, m=0;
        string x="",s="";
        cin>>n>>m>>x>>s;

        // if ((s+s).find(x) == string::npos){
        //     cout<<-1<<"\n";
        // }
        // else{
            cout<<checkCount(x,s)<<"\n";
        // }


    }

    return 0;
}

// passed 58 tests containing test cases :)
// 109 ms   100 KB
// Time Complexity: O(n * m)
// Space Complexity: O(n + m) (worst case 32n + m).
```

08 A How Much Does Daytona Cost?

- https://codeforces.com/problemset/problem/1878/A
- greedy, *800
- Analysis
  - array a
  - size n
  - int k
  - Find?
    - if exists subsegment(sub array) of a where k is most common element

  - a = { a0,a1,... an-1}
  - n,k
  - subarray
    - {a1,a2,a3}
    - {a1}
    - {a1 ,a2}
    - {a3,a4}
  - eg: n=5,k=4, a={1,4,3,4,1}
    - => {4,3,4}
    - => YES
  - Expected TC?
    - tlpt 1sec atq
    - mlpt 256mB atq
    - t max 1000 atq
    - n max 100 atq
    - 1 sec = 10^8 ops
    - tlpmt = 10^8 / 1000 = 10^5
    - O(100^3) = 10^6 NO
    - O(100^2) = 10^4 YES
    - Expected TC = tcpmt = O(n^2)
- Approach optimal
  - IF k is present in array anywhere, then answer is YES, else no
  - a = { a0,a1,a2,k,a4...an}
  - we haven't told lenght of subarray
  - we can take length =1 , {k} is correct too , now in this subarray, k is the highest occurance as k is only

```
#include<bits/stdc++.h>
using namespace std;
int main(){
    int t;cin>>t;while(t--){long long n,k;cin>>n>>k;
    long long a[n];for (int i=0; i<n; i++) cin>>a[i];
    long long number_is_present =0;
    for (int i=0; i<n; i++){if (a[i]==k) {number_is_present=1;break;}}
    if(number_is_present) cout<<"YES"<<endl;
    else cout<<"NO"<<endl;}return 0;
}
// TC O(n)
// SC O(n)
```

- Approach Brute Force
  - SAME nearly
  - One sec,
    - if number exists
      - if array size is 2 or 1
      - or if anywhere a[i]=a[i+1]=k

            - or if its>2
                - if in array bw that 1st occur and last occur ,that number the most occur
    - return yes if any satisfy, else no :0
    - FREAKING, the the limits, loopholes are hidden
    - functions returns>if else with breaks
    - if number exists
        - then its largest at subarray len = 1

```
// template miniTests int1 int2 vectorArrayInt1
#include<bits/stdc++.h>
using namespace std;
string mainGame(int x1, int x2, vector<int> v1){
    // code here
    // x1 n
    // x2 k
    // v1 a
    for ( int i =0; i<x1; i++ ){
        if (x2==v1[i]) {return "YES";}
    }
    return "NO";

}

void eachMiniTest(){
    int x1=0, x2=0;// factor1 factor2
        cin>>x1>>x2;
    vector<int> v1(x1);

    for (int i=0; i<x1; i++ ) cin>>v1[i];
    cout<< mainGame(x1,x2,v1)<<"\n";

}

int main(){
    long long t; //mini test cases
    cin>>t;
    while(t--){
        eachMiniTest();
    }

    return 0;
}
```

09 Goals of Victory

- https://codeforces.com/problemset/problem/1877/A
- math, *800
- Analysis
    - Expected TC ?
        - tlpt 1sec atq

        - mlpt 256 mB atq
        - t max 500 atq = 5*100
        - n max 100 atq
        - 1sec = 10^8 ops
        - tlpmt = 10^8 / 500
- Approach
    - given
        - n teams in tournament
        - each match
            - each pair of teams match up once
            - after every match
                - 2 int, as result of match, 2 goals of 2 teams
        - efficiency of team = total no. of goals in each of its matches. - total opponents score in each of its matches.
    - to find
        - effiency array of each team, one missing
        - a1, a2, a3, ... ,an-1
        - n-1 teams
        - efficiency of missing team?
            - it can be uniquely determined
    - input
        - t(tests)
        - n(teams) 1
        - effiencies of n-1 teams 1
        - n(teams) 2
        - effiencies of n-1 teams 2
        - ...
    - output
        - missing effiency 1
        - missing effiency 2
        - ...
- Approach 1 -- brute force -- optimal
    - suppose 4 teams
        - n1 n2 n3 n4 teams
            - matches (in pairs)
                - n1 n2 => scores a1 b1
                - n1 n3 a2 c1
                - n1 n4 a3 d1
                - n2 n3 b2 c2
                - n2 n4 b3 d2
                - n3 n4 d3 c3
        - e1 e2 e3 e4 eff.s
    - so
        - e1 = a1 + a2 + a3 - b1 - c1 - d1 = 3
        - e2 = b1 + b2 + b3 - a1 - c2 - d2 = -4
        - e3 = c1 + c2 + c3 - a2 - b2 - d3 = 5

        - e4 = d1 + d2 + d3 - a3 - b3 - c3
        - e1 + e2 + e3 + e4 = 0 (oh, just found out !!!)
            - e4 = -(e1+e2+e3) (SOLVED!!!)
            - e4 = -(3-4+5) = -4
- Formalised
    - Problem Insight
        - Each goal scored by a team increases its own efficiency by 1.
        - The same goal decreases the opponent's efficiency by 1.
        - So for every goal, the total sum of efficiencies changes by +1 and -1.
        - Net change in total efficiency is always 0.
    - Key Observation
        - Initially, before any match, all teams have efficiency 0.
        - So the total sum of efficiencies starts at 0.
        - Since the sum never changes, the final sum of efficiencies is also 0.
    - Given
        - There are n teams.
        - Efficiencies of n – 1 teams are given.
        - One team's efficiency is missing.
    - Logic to Find Missing Efficiency
        - Let the given efficiencies be: A1, A2, A3, ..., A(n−1)
        - Let the missing efficiency be An.
        - Since total sum is 0: A1 + A2 + A3 + ... + A(n−1) + An = 0
        - Therefore: An = −(A1 + A2 + A3 + ... + A(n−1))
    - Algorithm
        - Read n.
        - Read the n – 1 efficiencies.
        - Compute their sum.
        - Output the negative of this sum.
    - Complexity
        - Time complexity: O(n)
        - Space complexity: O(1)

```
#include<bits/stdc++.h>
using namespace std;
int main(){
    // Read Question and Analyse it Bit-by-bit
    // write all pts in depth, leave no missing dots
    // then dots will connect easily and will give you answer
    ios::sync_with_stdio(0);
    cin.tie(0);
    int t=0;// safe ,no to garbage entry
    cin>>t;
    while(t--){
        int n=0;// safe ,no to garbage entry
        cin>>n;
        n--; // we have n-1 entries
        int res=0;// safe ,no to garbage entry
        while(n--){
            int buff=0;// safe ,no to garbage entry
            cin>>buff;
            res+=buff;
        }
        res=res*(-1);
        cout<<res<<"\n";

    }
    return 0;
}
```

```
#include <bits/stdc++.h>
using namespace std;

int main()
{
    int t; // Variable to store the number of test cases
    cin >> t; // Read the number of test cases
    while (t--) // Loop through each test case
    {
        long long n; // Variable to store the number of teams
        cin >> n; // Read the number of teams
        long long a[n]; // Array to store the efficiency of n-1 teams
        for (long long i = 0; i < n - 1; i++) // Loop to read the
efficiency of n-1 teams
            cin >> a[i]; // Read efficiency of each team
        // inputs

        long long sum = 0; // Variable to store the sum of efficiencies of
n-1 teams
        for (long long i = 0; i < n - 1; i++) // Loop to calculate the sum
of efficiencies
            sum += a[i]; // Add each team's efficiency to the sum

        cout << -1 * sum << endl; // Output the efficiency of the missing
team, which is the negative of the sum
    }
    return 0; // Return 0 to indicate successful execution
}

// Time Complexity (TC): O(n) = O(100)
// Space Complexity (SC): O(n) = O(100)
```

10 Target Practice

- https://codeforces.com/problemset/problem/1873/C
- implementationmath, *800
- Analysis
  - tc and sc

        - 1sec = 10^8 ops
        - tlpt = 1sec
        - 1 test = 10^8 ops
        - 1 test = 1000 mtest
        - => tlpmt = 10^8 / 10^3 = 10^5 ops = O(n^5) max allowed and n = 10 (10x10matrix)
        - mlpt = 256mb
    - given board
    - 10x10
    - each ring deeper, more points, outermost is 1, innermost is 5
    - person shot "X" in grid of 10x10 "."
    - Find?
        - Scores
    - technically

    ```
    0123456789

    1111111111 0
    1222222221 1
    1233333321 2
    1234444321 3
    1234554321 4
    1234554321 5
    1234444321 6
    1233333321 7
    1222222221 8
    1111111111 9

    0 1234 5678 9

    1 1111 1111 1 0

    1 2222 2222 1 1
    1 2333 3332 1 2
    1 2344 4432 1 3
    1 2345 5432 1 4

    1 2345 5432 1 5
    1 2344 4432 1 6
    1 2333 3332 1 7
    1 2222 2222 1 8

    1 1111 1111 1 9
    ```

    - condtion of scoring
        - 1
            - 0,0 to 9,0 L 00 10 20 30 40 50 60 70 80 90
            - 0,9 to 9,9 R 09 19 29 39 49 59 69 79 89 99
            -
            - 0,0 to 0,9 T 00 01 02 03 04 05 06 07 08 09

      - 9,0 to 9,9 B 90 91 92 93 94 95 96 97 98 99
      - relation
        - i =0 or 9
        - j =0 or 9
        - 1 = 0+1 == 10-9
    - 2
      - 1,1 to 8,1 L 11 21 31 41 51 61 71 81
      - 1,8 to 8,8 R 18 28 38 48 58 68 78 88
      -
      - 1,1 to 1,8 T 11 12 13 14 15 16 17 18
      - 8,1 to 8,8 B 81 82 83 84 85 86 87 88
      - relation
        - i,j = 1 or 8
        - 1 = 1+1 == 10-8
    - 5
      - 4,4
      - 4,5
      - 5,4
      - 5,5
  - this not 2D Array
  - this is char incoming
- Approach 1 -- brute force
  - The grid is fixed at 10×10 and consists of 5 concentric square rings, where the outermost ring gives 1 point and each inner ring gives one more point, up to 5 at the center
    - For every test case, we scan the grid cell by cell
      - When a cell contains `'X'`, we must determine which ring it belongs to
        - We simulate rings using two boundaries: `bound1` starting at 0 and `bound2` starting at 9
          - Ring 1 checks the outer boundary (row or column equal to 0 or 9)
          - Ring 2 checks the next inner boundary (1 or 8)
          - This continues until ring 5
        - If the current cell lies on any side of the current boundary square
          - `(row == bound1 || row == bound2 || col == bound1 || col == bound2)`
          - The current ring number is returned as the score
        - After each ring check, the boundaries are moved inward (`bound1++`, `bound2--`)
      - The returned ring score is added to the total score
    - After processing all cells, the accumulated score is printed
  - The idea works because each cell belongs to exactly one concentric square ring, and shrinking boundaries correctly model these rings without needing an extra 2D scoring array

```
#include<bits/stdc++.h>
using namespace std;
// 1
/*
```

```
00 01 02 03 04 05 06 07 08 09
10 19
20 29
30 39
40 49
50 59
60 69
70 79
80 89
90 91 92 93 94 95 96 97 98 99
*/
// 2
/*
11 12 13 14 15 16 17 18
21 28
31 38
41 48
51 58
61 68
71 78
81 82 83 84 85 86 87 88
*/

int calScore(int row, int col, char c){
    int bound1 =0;
    int bound2 =9;

    for ( int ring =1; ring<=5; ring++){
        if ( (row==bound1) || (row==bound2) ){ return ring;}
        else if ((col==bound1) || (col==bound2)) {return ring;}

        bound1++;bound2--;
    }
    return 0; // fallback

}
void miniTest(){
    int finalScore=0;
    for (int row=0; row<10; row++){
        for (int col=0; col<10; col++){
            char c;
            cin>>c;
            if (c=='X') finalScore+=calScore(row,col,c);
        }

    }
    cout<<finalScore<<"\n";
}
int main(){
    ios::sync_with_stdio(0);
    cin.tie(0);;
    int t;
    cin>>t;
    while(t--){
        miniTest();
    }
    return 0;
}
// Approach 1: Time complexity is O(1) per test case (100 cells × 5 rings,
all constants) and space complexity is O(1).
```

- Approach 2 -- optimal
  - The grid is fixed at 10×10 and forms 5 concentric square rings with scores from 1 (outermost) to 5 (innermost)
    - For each test case, the grid is read cell by cell
      - When a cell contains `'X'`, its score depends only on how close it is to the nearest border
        - Compute the distance from the cell to all four edges:
          - top → `i`
          - left → `j`
          - bottom → `9 - i`
          - right → `9 - j`
        - The minimum of these four values gives the ring index (0-based)
          - `0 → outer ring`, `1 → second ring`, ..., `4 → center`
        - Add `1` to convert the index into the actual score
          - `score += min({i, j, 9 - i, 9 - j}) + 1`
      - Repeat for all 100 cells
    - After processing the grid, output the total score
  - The intuition is that every step away from the border moves one ring inward, so the closest border uniquely determines the ring of any cell

```
#include<bits/stdc++.h>
using namespace std;

int calScore(int row, int col, char c){
    int top = row;
    int left = col;
    int bottom = 9- row;
    int right = 9-col;
    return min({top,bottom,left,right})+1; // fallback

}
void miniTest(){
    int finalScore=0;
    for (int row=0; row<10; row++){
        for (int col=0; col<10; col++){
            char c;
            cin>>c;
            if (c=='X') finalScore+=calScore(row,col,c);
        }

    }
    cout<<finalScore<<"\n";
}
int main(){
    ios::sync_with_stdio(0);
    cin.tie(0);;
    int t;
    cin>>t;
    while(t--){
        miniTest();
    }
    return 0;
}

// Approach 2: Time complexity is O(1) per test case (100 cells, constant
work per cell) and space complexity is O(1).
```

```
#include <bits/stdc++.h>
using namespace std;

int main() {
    ios::sync_with_stdio(false);
    cin.tie(nullptr);

    int t;
    cin >> t;

    while (t--) {
        int score = 0;
        for (int i = 0; i < 10; i++) {
            for (int j = 0; j < 10; j++) {
                char c;
                cin >> c;
                if (c == 'X') {
                    score += min({i, j, 9 - i, 9 - j}) + 1;
                }
            }
        }
        cout << score << '\n';
    }
}
```

- Approach 3 -- optimal
  - A predefined 10×10 `score` matrix stores the score of each cell based on its concentric ring on the target
  - The number of test cases `t` is read, and each test case is processed independently
  - For each test case, a 10×10 character grid is read row by row and stored
  - The grid is scanned cell by cell to check for the presence of `'X'` (an arrow hit)
  - Whenever an `'X'` is found, the corresponding value from the `score` matrix is added to `total_score`
  - After scanning all 100 cells, the final accumulated score is printed for that test case

- Time complexity is O(1) per test case (fixed 10×10 grid), and space complexity is O(1) since all data structures are of constant size

```
#include<bits/stdc++.h>
using namespace std;

// Predefined score matrix representing the target's rings
// Each element represents the score for that position on the target
const int score[10][10] = {
    {1,1,1,1,1,1,1,1,1,1},
    {1,2,2,2,2,2,2,2,2,1},
    {1,2,3,3,3,3,3,3,2,1},
    {1,2,3,4,4,4,4,3,2,1},
    {1,2,3,4,5,5,4,3,2,1},
    {1,2,3,4,5,5,4,3,2,1},
    {1,2,3,4,4,4,4,3,2,1},
    {1,2,3,3,3,3,3,3,2,1},
    {1,2,2,2,2,2,2,2,2,1},
    {1,1,1,1,1,1,1,1,1,1}
};

int calScore(int row, int col, char c){
    return score[row][col];

}
void miniTest(){
    int finalScore=0;
    for (int row=0; row<10; row++){
        for (int col=0; col<10; col++){
            char c;
            cin>>c;
            if (c=='X') finalScore+=calScore(row,col,c);
        }

    }
    cout<<finalScore<<"\n";
}
int main(){
    ios::sync_with_stdio(0);
    cin.tie(0);;
    int t;
    cin>>t;
    while(t--){
        miniTest();
    }
    return 0;
}

// Time complexity is O(1) per test case (fixed 10×10 grid), and space
complexity is O(1) since all data structures are of constant size
```

11 Ambitious Kid

- https://codeforces.com/problemset/problem/1866/A
- math, *800
- Analysis
    - What the question gives:
        - An array of N integers (can be positive, negative, or zero)
        - One operation allows increasing or decreasing any single element by 1
        - Unlimited operations are allowed on any elements
    - What the question asks:
        - Find the minimum number of operations needed so that
            - the product of all elements in the array becomes 0
        - eg: [2,3,4] mul = 24
            - op1(-1): [1,3,4] mul = 12
            - op2(-1): [0,3,4] mul = 0 !!!
        - eg: [-2,3,4] mul = -24
            - op1(+1): [-1,3,4] mul = -12
            - op2(+1): [0,3,4] mul = 0 !!!
    - Key observation:
        - A product is 0 if and only if at least one element is 0
        - min(A1, A2 ... An) = solution
    - tc
        - tlpt 1sec
        - mlpt 256mb
        - 1sec = 10^8 ops
        - ops per testcase = 10^8 / 1 = 10^8
        - total minitests = 1
        - tlpmt = 10^8 ops
        - N = 10^5
        - O(N^2) => 10^10 => NO
        - O(N log2N) => YES
        - O(N) => YES
        - O(log2N) => YES
        - O(1) => YES
        - Expected TC => O(N^2)
- Approach 1 -- brute force -- optimal
    - To make the product of all elements equal to 0, at least one element must be 0
        - So we only need to convert one element to 0 with minimum operations
    - Each operation changes a number by +1 or -1
        - Therefore, converting any element Ai to 0 takes |Ai| steps
    - Intuition:
        - The element closest to 0 needs the fewest steps
            - For [2, 3, 4] → closest is 2 → 2 steps
            - For [-2, -3, -4] → take absolute values [2, 3, 4] → closest is 2 → 2 steps
    - Steps:
        - Read N

        - For each element:
            - Convert it to absolute value (represents steps needed to reach 0)
        - Find the minimum value among all absolute values
            - This value is the answer
    - Complexity:
        - Time Complexity: O(N)
        - Space Complexity: O(N)

```
#include<bits/stdc++.h>
using namespace std;
int main(){
    int n;
    cin >> n;
    vector<int> v1(n,0);
    for (int i=0; i<n;i++){
        int i1 =0;
        cin>>i1;
        v1[i]=(i1>=0) ? i1: (i1*-1); // or v1[i] = abs(i1);
    }
    cout<<*min_element(v1.begin(),v1.end());// min_element & max_element
return pointer
    // not sort then v1[1] as its nlogn
    return 0;
}
// TC O(n)
// SC O(n)
```

- Approach 2 -- optimal
    - Read integer N
    - Read the array of N integers
    - Initialize a variable min_ops to a very large value
        - This will store the minimum operations required
    - For each element in the array:
        - Compute the absolute value |Ai|
            - This represents the number of operations needed to make Ai equal to 0
        - Update min_ops with the minimum of current min_ops and |Ai|
    - Output min_ops
        - This is the minimum number of operations needed to make the product of the array equal to 0
    - Reasoning:
        - The product becomes 0 if at least one element is 0
        - Making the element closest to 0 reach 0 requires the fewest operations
    - Complexity:
        - Time Complexity: O(N)
        - Space Complexity: O(N)

```cpp
#include<bits/stdc++.h>
using namespace std;
int main()
{   long long n; cin>>n;
    long long a[n];
    for ( int i=0; i< n; i++){cin>> a[i];} //n
    long long min_ops = INT_MAX;
    for ( int i=0; i< n; i++){min_ops=min(min_ops,abs(a[i]));} //n
    cout<<min_ops;
    return 0;
}
// TC O(n)
// SC O(n)
```

12 Sequence Game

- https://codeforces.com/problemset/problem/1862/B
- constructive algorithms, *800
- Analysis
  - backcreate/guessback/reverse engineering!!!
  - tc
    - tlpt = 2 sec
    - 1sec = 10^8 ops
    - mlpt =256 mb
    - mt max = 10^4
    - n max = 2*10^5
    - Ques Line "The sum of the values of n over all test cases does not exceed 2*10^5"
      - this sum of minitest element length <= 2*10^5
      - its the main bottleneck
      - so we can assume not 10^4, but only 1 test case with n = 2*10^5
        - no need to cal tlpmt
    - 1 test = 2* 10^8 ops
    - O(n^2) => (2*10^5)^2 => 4*10^10 > 2*10^4
    - O(n^2) No (4*10^10 > 2*10^4)
    - O(nlog2n) Yes (< 2*10^4)
    - O(n) Yes
    - O(log2n) Yes
    - ... O(1) Yes
    - => so avoid making O(n^2) / 2 nested loops in code!!!
  - Ques
    - Tema and Vika Plays a game
    - Vika : a= +ve int, len m
    - b= new sequence, acc to rule
      - a1 as 1st element
      - then ai(2<= i <= m) such that ai-1 <= ai
      - length of this seq n
    - eg:

        - a=[4,3,2,6,3,3]
        - b=[4,6,3]
        - analysis

```
a 6 [4 3 2 6 3 3]
     Y N N Y N Y
b 3 [4     6   3]

4 1st element YES => b1
3>=4 => NO (ai-1 <= ai)
2>=3 => NO
6>=2 => YES => b2
3>=6 => NO
3>=3 => YES => b3
```

```
- then vika gives b to tema and tema tries to gues s seq a
- help vika to guess atleast 1 num.
```

- Note that the length of the sequence you output should not exceed the input sequence length by more than two times.
- Test Cases
    - input
        - t (1<=t<=10^4)
        - n
        - b1 b2 .. bn
        - The sum of the values of n over all test cases does not exceed 2*10^5
    - for each test, output gives 2 lines
        - m
        - a1 a2 ... am
    - mt1
        - 3
        - 4 6 3
        - out
        - 6
        - 4 3 2 6 3 3

          ```
          b [4 6 3]
          possibilities
          a [4 3 2 6 3 3] (as described in question)
          a [4 6 3 3] also possibilities
          ... so on , make/guess any, if fits the rule then good !!!
          ```
    - mt2
        - 3

    - 1 2 3
    - out
    - 3
    - 1 2 3
    - In the second sample, Vika could have chosen the original sequence.
  - mt3
    - 5
    - 1 7 9 5 7
    - out
    - 6
    - 1 7 9 3 5 7

      ```
      b 1 < 7 < 9 > 5 < 7
      a 1   7   9 ..5   7

      9 and 5 can't relate as b coming from a
      untill and unless there is unlikely element which exists in
      a which is <9 and <5

      possibilities

      1 7 9 3 5 7
      1 7 9 6 5 7
      1 7 9 5 5 7
      ... so on
      ```
  - mt4
    - 1
    - 144
    - out
    - 1
    - 144
  - mt5
    - 2
    - 1 1
    - out
    - 2
    - 1 1
  - mt6
    - 5
    - 1 2 2 1 1
    - out
    - 6
    - 1 2 2 1 1 1
  - If there are multiple suitable sequences, you can output any of them
- Approach 1 -- optimal

- Based on Hint
  - if `b[i-1]>b[i]`
  - append `b[i]` twice

  ```
  a1 a2 a3 a4 ... am
  to b1 b2 b3 b4 ... bn
  where generally b1<b2<b3<b4... ( as only ai-1 < ai are inserted
  in the array of b)

  there can be numerous possibilities ( a1>a2<a3)
  one of them can be like (a1>a2=a3), we are only considering this
  possibility and reverse enginner it..
  so if b1<b2>b3<b4 (where b3 dont make sense)
  then a would be b1<b2<b3=b3<b4 (to make sense)
  ```

- insert all mini test elements into arr b
- then traverse b to append into arr a
  - use the hint
- Reasoning
  - If there are multiple suitable sequences, you can output any of them. (in ques)
  - don't confused by inputs and outputs given, use what question demands and make your own outputs

```
#include<bits/stdc++.h>
using namespace std;
int main(){
    ios::sync_with_stdio(0);
    cin.tie(0);
    int mt=0;
    cin>>mt;
    while(mt--){
        int n=0;
        cin>>n;
        vector<int> b(n);
        for(int i=0; i<n; i++){ //n
            cin>>b[i];
        }
        // input done
        // main output
        vector<int> a;
        a.push_back(b[0]); //1
        for(int i=1; i<n; i++){ // n
            if(b[i-1]>b[i]){
                a.push_back(b[i]); //1
            }
            a.push_back(b[i]);
        }
        cout<<a.size()<<"\n";
        for(int i=0;i<a.size(); i++){ // n
```

```
            cout<<a[i]<<" ";
        }
        cout<<"\n";


    }
    return 0;
}

// Time Complexity (TC): O(n) = O(2*10^5)
// Space Complexity (SC): O(n) = O(2*10^5)
```

```
#include <bits/stdc++.h>
using namespace std;

int main()
{
    int t; // Number of test cases
    cin >> t;
    while (t--)
    {
        long long n; // Length of sequence b
        cin >> n;
        vector<long long> b(n), a; // Vector b to store input sequence,
vector a to store the reconstructed sequence
        for (int i = 0; i < n; i++) // Loop to read the sequence b
            cin >> b[i];
        // Initial input of sequence b is completed

        a.push_back(b[0]); // Always add the first element of b to a
        for (int i = 1; i < n; i++) // Loop through the rest of the
sequence b
        {
            if (b[i] >= b[i - 1])
                a.push_back(b[i]); // If current element is greater than or
equal to the previous, add it to a
            else
            {
                a.push_back(b[i]); // Add the current element to a
                a.push_back(b[i]); // Add the current element again to a to
ensure a[i-1] <= a[i]
            }
        }
        cout << a.size() << endl; // Output the size of the reconstructed
sequence a
        for (auto it : a) // Output each element of the sequence a
            cout << it << " ";
        cout << endl; // New line after each test case
    }
    return 0;
}
```

```
// Time Complexity (TC): O(n) = O(2*10^5)
// Space Complexity (SC): O(n) = O(2*10^5)
```

TipsCollectedFromExperiences

- Read Question and Analyse it Bit-by-bit
    - write all pts in depth, leave no missing dots
    - reconstruct the test cases with your written logic
        - test cases are misleading and full of confusion
    - then dots will connect easily and will give you answer
- when check TC& SC of program, don't consider TestCasesLoop&Spaces in counting
- 1sec = 10^8 Operations
- if 1sec = totalTests
    - operationsPerTestCase = 10^8 / totalTestCases
    - if totalTestCases = 100
        - operationsPerTestCase = 10^6 operations
        - O(n^3) is UpperLimit of the question's code
            - as O(n^3) = O(100^3) = 10^6 === operationsPerTestCase
- always think of extra testcases
- if Expected TC = O(n^3) ,then
    - O(n^4) NO ABOVE UPPER BOUND
    - O(n^3) YES UPPER BOUND
    - O(n^2) YES BELOW UPPER BOUND
    - O(n) YES BELOW UPPER BOUND
    - O(nlog2(n)) YES BELOW UPPER BOUND
    - O(n1) YES BELOW UPPER BOUND
    - this helps in thinking solution limits and optimisation
    - solution can be minimal, not exact O(n^3)
    - but still we got to know our limits
- and in cp submission , you can see testcases in ID :0
- FREAKING, the the limits, loopholes are hidden
- functions returns>if else with breaks
- => Generalise the condition in question 6R800
    - a1 + a2 = a2 + a3 = ... = an-1 = an atq
    - => ai-1 + ai = ai + ai+1
    - => ai-1 + ai(cancelled) = ai(cancelled) + ai+1

  - => `ai-1 = ai+1` !!!
  - i.e. a1=a3=a4=a5=.... && a2=a4=a6=....

- put this at 1st line of main() code, to fix bug of compiler at running test cases, not interactive program

```
ios::sync_with_stdio(0);
cin.tie(0);
```

- templates

```
// template miniTests int1 int2 vectorArrayInt1
#include<bits/stdc++.h>
using namespace std;
void mainGame(int x1, int x2, vector<int> v1){
    // code here

}

void eachMiniTest(){
    int x1=0, x2=0;// factor1 factor2
    vector<int> v1;
    cin>>x1>>x2;
    for (int i=0; i<x1; i++ ) cin>>v1[i];
    mainGame(x1,x2,v1);

}

int main(){
    ios::sync_with_stdio(0);
    cin.tie(0);
    long long t; //mini test cases
    cin>>t;
    while(t--){
        eachMiniTest();
    }

    return 0;
}
```

```
// template miniTests int1 int2 string
#include<bits/stdc++.h>
using namespace std;
void mainGame(int x1, int x2, string s){
    // code here

}

void eachMiniTest(){
    int x1=0, x2=0;// factor1 factor2
    string s;
    cin>>x1>>x2>>s;
    mainGame(x1,x2,s);

}

int main(){
    ios::sync_with_stdio(0);
    cin.tie(0);
    long long t; //mini test cases
    cin>>t;
    while(t--){
        eachMiniTest();
    }

    return 0;
}
```

- Vectors CPP STL

```
vector<int> v1(n); // create ,with n elements mandatory
cin>>v1[0]; // insert
vector<int> v2 = v1; // copy
sort(v2.begin(),v2.end()); // sorting in stl, asc
bool compare= (v1==v2); // compare
```

```
#include<vector>
#include<iostream>
#include<algorithm>
```

- use `long long` instead of `int` for bigger stuff
- max/min : `max(var1 ,var2)`, `min(var1, var2)`
    - make sure var1,var2 has SAME DATATYPE
    - inbuilt
- subarray = sub segment =segment taken out of array not manipulated ,no change in order
    - eg of a = {a0, a1, a2 ... an-1}, subarrs : {a0, a1}, {a1,a2,a3}, etc
- non-decreasing = increasing
- s is atmost k , means : s<=k
- atq : according to question
- How to Calculate Expected TC? eg: in 1R800

  - tl per test = 1sec atq
    - 1sec = 10^8 Operations = per test operations
    - 1 <=k <= n (minitests)<= 100 acc.to ques (atq)
    - consider n=100 upperbound
    - tl per mini test = 1sec /100
    - per mini test operations = 10^8 / 100 = 10^6
    - if tc per mini test = O(n^3)
      - so n=100, then operation = O(n^3) = O(100^6) = per mini test operations
      - so O(n^3) is the upper bound
      - even sol. can have O(n^2), O(n), O(nlogn) etc. anything below O(n^3), but not above O(n^3)
    - Expected TC = O(n^3)

-
  ```
  // 1R800
  // at extreme proof case use :
  long long t;
  ```

-
  ```
  // 1R800
  // at n = 100 , tc = 100log100 = 100*7 = 700
  // 2^7 ~ 100
  // log2(n) = ln n / ln 2
  ```

-
  ```
  // 1R800
  // input, n order
  cin>>v[i]; // n order

  // vector copy, n order
  vector<int> v2=v; // copy // n order

  // sort stl func, n order
  sort(v2.begin(), v2.end());  // nlogn order

  // vector compare, n order
  if (v2==v) // vector compare // n order
  ```

- tlpt = time limit per test

- 2secs = 2*(10^8) operations

- at 2R800 , tl per test = 2secs

  - 2secs = 2*(10^8) operations
  - t=1000 atq
  - time/testcase = O(2* 10^5)
  - n=50 max atq

  - then at O(n^3) = O(125000) = O(1.25 * 10^5) <= O(2* 10^5)
  - TC for minitest = Expected TC = O(n^3) upper bound

-
  ```
  //  max(a, b); O(1) // just checks (a < b)
  //  min(a, b); O(1) // just checks (a < b)
  // max_element(v.begin(), v.end()) O(n)
  // min_element(v.begin(), v.end()) O(n)
  ```

- `vector<long long> v1(10,0);` initialize safety vector

- : What the Fish Ques

- Parity

  - Parity is simply whether a number is even or odd.
  - Even parity: divisible by 2 (like 2, 4, 6, 8...)
  - Odd parity: not divisible by 2 (like 1, 3, 5, 7...)

- 6R800 this problem is imp to teach map,begin,rbegin iterators

```
// freq map
map<long long, long long> freq_map;
for (long long i =0; i<n; i++){//n
freq_map[a[i]]++;//logn
}
```

```
if (freq_map.size()>=3) cout<<"No"<<endl;
```

```


// begin- first element
// rbegin- last element

long long freq1 = freq_map.begin()->second;
long long freq2 = freq_map.rbegin()->second;
```

- 11R800, you can use `INT_MAX` `INT_MIN` to initialise Extreme Value and compare as reference and play with it

```
    long long min_ops = INT_MAX;
    for ( int i=0; i< n; i++){min_ops=min(min_ops,abs(a[i]));} //n
```

Array Coloring [ONSIGHT]

- https://codeforces.com/problemset/problem/1857/A
- greedy, math, *800
- Analysis
    - given Array, n integers
    - to do
        - if you can
            - colour array elements in 2 groups/ 2 colors
            - parity of color 1 elements sum = parity of color 2 elements sum
            - print YES
        - else print NO
    - Parity
        - Parity is simply whether a number is even or odd.
        - Even parity: divisible by 2 (like 2, 4, 6, 8...)
        - Odd parity: not divisible by 2 (like 1, 3, 5, 7...)
    - eg: [1,2,4,3,2,3,5,4]
        - c1: [1,2,3] , c1 sum = even parity
        - c2: [4,2,3,5,4], c2 sum = odd parity
        - YES
    - eg: [4,7]
        - NO
    - eg: [3,9,8]
        - YES
        - c1: [3,9]
        - c2: [8]
        - both sum even parity
    - eg: [1,7]
        - YES
        - c1: [1]
        - c2: [7]
        - both sum odd parity
    - eg: [5,4,3,2,1]
        - NO
        - can't make 2color groups with same parity
- Approach
    - if no. of odds = no. of evens
        - YES
    - else if n=3 && no. of odds != 3 or !=1
        - YES
        - actually if [even,even,even] works YES
        - [odd,odd,odd] NO
        - [odd,odd,even] YES
        - [odd,even,even] NO
    - so iff n is odd && odd< even && abs(odd-even)!=1

        - YES
        - [odd,odd,odd,even,even] NO
        - [odd,odd,even,even,even] YES
        - [odd,odd,odd,even,even,even,even] NO

```
#include<bits/stdc++.h>
using namespace std;


int main(){
    ios::sync_with_stdio(0);
    cin.tie(0);
    int t;
    cin>> t;
    while (t--)
    {
        int n,odd=0,even=0;
        cin>>n;
        vector<int> v1(n,0);
        for (int i=0; i<n; i++){
            cin>>v1[i];
            if (v1[i]%2==0) {even++;}
            else {odd++;}
        }
        // cout<<odd<<" "<< even<<endl;
        if (odd==even && n>2) {
            cout<<"YES\n";
        }
        else if ((n==2 && odd!=even) || (n==3 && odd>even) || (n%2!=0 &&
odd<even && abs(odd-even)!=1) || even==1 || odd==1)
        {
            cout<<"YES\n";
        }
        else
        {
            cout<<"NO\n";
        }

    }

    return 0;
}
```

> Made with 💚 Kintsugi-Programmer