



LeetCode

STRIVER'S

SDE

SHEET



Day - 1

① Set Matrix Zeroes :- [Medium]

Given an ' $m \times n$ ' integer matrix, if an element is '0' set the entire row and column to $\Rightarrow 0$.

You must do it in place:

Input :-

1	1	1
1	0	1
1	1	1

\Rightarrow

Output

1	0	1
0	0	0
1	0	1

Brute-force approach :-

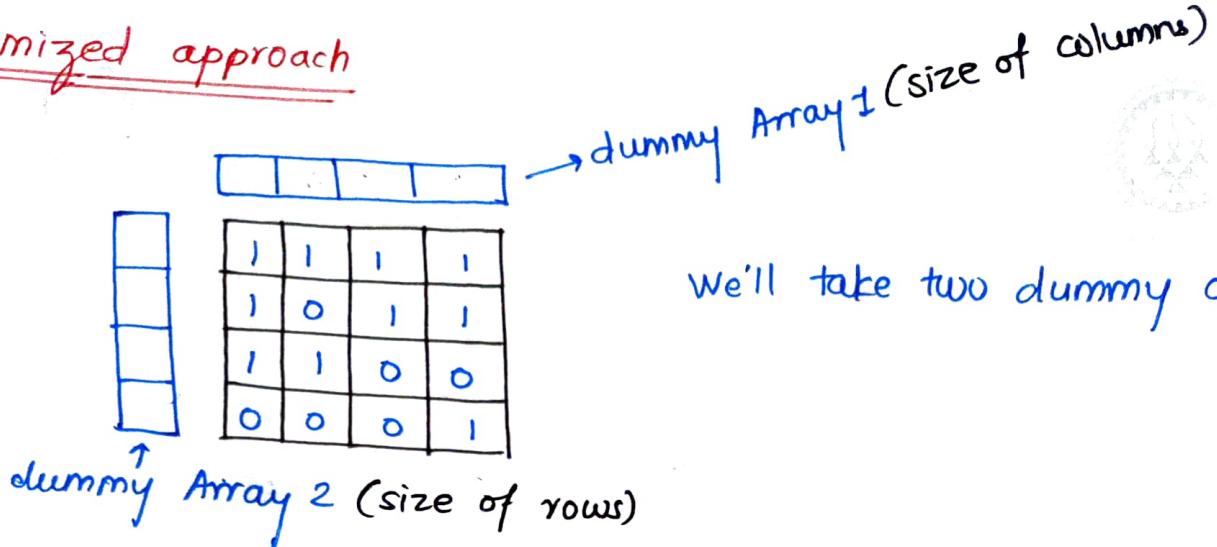
Whenever we find "0" \rightarrow then go through its row and make all elements $\Rightarrow -1$. and same, go through column and make all elements $\Rightarrow -1$

After checking the whole 2D array, then change the -1 element \Rightarrow to "0" and here we have got our answer.

Complexity :- $(N \times m) \times (N + m)$

Space complexity $\Rightarrow O(1)$

Optimized approach

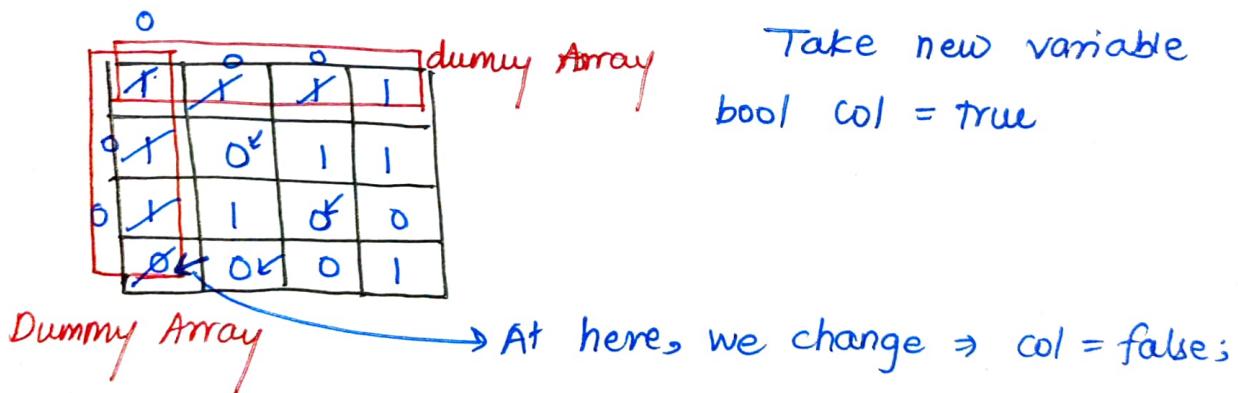


⇒ linearly traverse ⇒ Whenever you find $\Rightarrow 0$ then make
 $0 \Rightarrow$ in the columnth index of
 $0 \Rightarrow$ in the rowth index

Complexity $\Rightarrow O(N \times m + N \times m)$

Space Complexity $\Rightarrow O(N) + O(m)$

Most Optimized Approach :-



Now traverse from back & check whether for that particular element, zero is present in the dummy column array or dummy row array if yes then convert that element to zero (0).

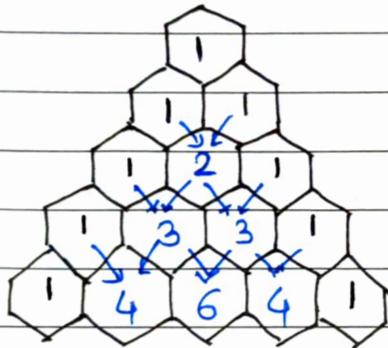
Time complexity $= 2 * (N \times m)$

Space Complexity $\Rightarrow O(1)$

②

Pascal's Triangle :-

Given an integer "numRows", return the first numRows of pascal triangle.



numRows = 5
 Output = $\begin{bmatrix} [1], \\ [1, 1], \\ [1, 2, 1], \\ [1, 3, 3, 1], \\ [1, 4, 6, 4, 1] \end{bmatrix}$

Approach :-

Another subproblem

print only one of the row from
pascals triangle

let's suppose 5th row should be
printed then

```
for(i=0; i<k; ++i){  
    res *= (n-i);  
    res /= (n+i);
```

If in interview, they
ask what is the value
present at r^{th} row & c^{th} column
i.e 5th row & 3rd column \Rightarrow 6
then formula $\binom{r-1}{c-1}$

Now for the original
problem.

We can resize the vector to $(i+1)$,
then for ($i=0$; $i < \text{numRows}$; $i++$)

$\text{ans}[i][0] = \text{ans}[i][i] = 1$

then

$\text{for}(j=1; j < i; ++j) \leftarrow$

\uparrow
first column
element

\downarrow
last column
element

$\text{ans}[i][j] = \text{ans}[i-1][j-1] + \text{ans}[i-1][j];$

return ans.

③ Next Permutation :-

Array = [1, 2, 3] then its permutations are

[1, 2, 3]

[1, 3, 2] then next permutation

[3, 1, 2] for [1, 2, 3] \Rightarrow [1, 3, 2]

[2, 3, 1]



Brute Approach

Generate All possible combos (permutations)
then find the nums array
return its next permutation

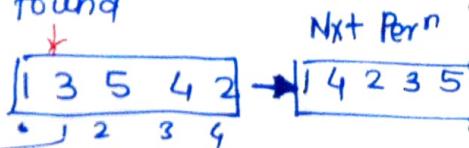
and if last nums is found then the first permutation
will be its next permutation

Optimal Approach:-

linearly traverse from backwards
and we have to traverse till we found

$\text{arr}[i] < \text{arr}[i+1]$

index 1 = 1



IInd step

Again traverse

linear traversal from back and find element
which is actually greater than the value at index = 1

then we have got 4

index 2 = 3

Swap(index1)

IIIrd step :-

Swap($\text{arr}[\text{index1}], \text{arr}[\text{index2}]$)

↳ 1 4 5 3 2

IVth step :-

reverse(index1+1, last);

Time Complexity $\Rightarrow O(n)$



⑤

Maximum Subarray [Kadane's Algorithm] :-

Given an integer array `nums`, find the contiguous Subarray which has the largest sum. and returns its sum.

Example :-

Input: `nums = [-2, 1, -3, 4, -1, 2, 1, -5, 4]`
Output = 6 $\rightarrow \text{max. sum} = 6$

Solution :-

`int mx = INT_MIN;`

Take one Traverse through array compute sum
and take `mx = max(sum, mx)`
then whenever sum will be < 0
then set `sum = 0`
return `mx`.

Time complexity = $O(n)$

⑥ Sort an array of 0's, 1's & 2's :-

Sort colors [leetcode]

Sort colors [Leetcode]

Given an array of 'nums' with n colored objects as red, white or blue sort them in-place so that objects of the same color are adjacent with the colors in the order red, white & blue

Ex

TOPWT :- RUMS = [2,0,2,1,1,0]

output = [0,0,1,1,2,2]

Approach : This problem can be solved by using

Dutch National Flag Algorithm

Now shift mid pointer

if mid pointer $\Rightarrow 0$ → then [swap $\Rightarrow (\text{arr}[low], \text{arr}[mid])$
 points
 $low++;$
 $mid++;$

if mid pointer
points \Rightarrow j \rightarrow then mid++;



Day 2

⑦ Rotate Image [medium]

You are given an ~~an~~ $n \times n$ 2D matrix representing an Image
rotate the image by 90 degree clockwise.

You have to rotate the image in-place, which means you
have to modify the input 2D matrix directly.

* Do not allocate another 2D matrix and do the rotation

Example :-

Input \Rightarrow

1	2	3
4	5	6
7	8	9

\Rightarrow

7	4	1
8	5	2
9	6	3

Approach :-

Take transpose of the matrix

$$A = \begin{array}{|c|c|c|} \hline 1 & 2 & 3 \\ \hline 4 & 5 & 6 \\ \hline 7 & 8 & 9 \\ \hline \end{array} \Rightarrow A^T = \begin{array}{|c|c|c|} \hline 1 & 4 & 7 \\ \hline 2 & 5 & 8 \\ \hline 3 & 6 & 9 \\ \hline \end{array}$$

then

reverse each row of the transpose matrix

Resultant matrix =

7	4	1
8	5	2
9	6	3

ANSWER

⑧ Merge Intervals [Medium]

Given an array of intervals where $\text{intervals}[i] = [\text{start}_i, \text{end}_i]$, merge all overlapping intervals and return an array of the non-overlapping intervals that cover all the intervals in the input.

Example :-

$$\text{Intervals} = [[1,3], [2,6], [8,10], [15,18]]$$

$$\text{Output} = [[1,6], [8,10], [15,18]]$$

Approach :-

① **Brute-force**

sort all the given intervals.

then check if the interval is merging or not
if yes \Rightarrow then add to the DS.

$$T.C = O(n \log n)$$

② **Optimized Approach**

Sort	1,3	2,6	8,10	8,9	9,11	15,18	2,4	16,17
	1,3	2,4	2,6	8,9	8,10	9,11	15,18	16,17

linearly iterate. and check $\begin{bmatrix} 1,3 \\ 1,3 \end{bmatrix}$ are merging or not if yes ~~then add in DS.~~

move pointer on next index, Now $\begin{bmatrix} 1,3 \\ 2,4 \end{bmatrix}$ then $\Rightarrow [1,4]$

$$\text{Now } \begin{bmatrix} 1,4 \\ 2,6 \end{bmatrix} \Rightarrow [1,6]$$

then $[1,6]$ & $[8,9]$ they are not merging \Rightarrow At this point

$$\text{Now } \begin{bmatrix} 8,9 \\ 8,10 \end{bmatrix} \Rightarrow [8,10] \quad \left| \begin{array}{l} \text{Again} \\ [8,10] \Rightarrow [8,11] \\ [9,11] \end{array} \right. \Rightarrow [8,11] \Rightarrow [8,11] \Rightarrow [15,18]$$

~~add [1,6] to our DS.~~

Sorting

$$\text{Now } [15,18] \Rightarrow [15,17]$$

Add to DS

$$TC = O(N \log N) + O(N)$$

for traversing

$$\text{Answer} = [1,6], [8,11], [15,17]$$



(9) Merge- sorted Array in O(1) space :-

You are given two integer arrays 'num1' & 'num2' sorted in non-decreasing order, and two integers m & n representing the number of elements in num1 & num2 respectively.

Merge num1 & num2 into a single array sorted in non-decreasing order.

Example :-

$$a_1[] = \boxed{1 \ 4 \ 7 \ 8 \ 10} \quad \text{size} = m$$

$$a_2[] = \boxed{2 \ 3 \ 9} \quad \text{size} = n$$

Approach :-

Take one more array a_3 of size $(m+n)$ and then add a_1 elements & a_2 elements in the a_3 array.

↓

Sort it

↓

Take out ~~the~~ m elements from a_3 put in a_1 , then take n elements from a_3 put in a_2 .

$$\begin{aligned} \text{T.C.} &= O(n\log n) + O(n) + O(n) \\ &\approx O(n) \end{aligned}$$

$$\text{S.C.} = O(n)$$

Approach:- 2

You can't take extra Space

arr1 =

1	4	7	8	10
---	---	---	---	----

arr2 =

2	3	9
---	---	---

Traverse linearly in arr1 & check if arr1[i] > arr2[i]

1	4	7	8	10
2	3	9		

if yes then
swap(arr2[i], arr1[i])

1	2	7	8	10
4	3	9		

$$T.C = O(n_1 \times m_1)$$

$$S.C = O(1)$$

Sort

1	2	7	8	10
3	4	9		

1	2	3	8	10
7	4	9		

⇒

1	2	3	8	10
4	7	9		

1	2	3	4	10
8	7	9		

1	2	3	4	10
7	8	9		

1	2	3	4	7
10	8	9		

Sort

1	2	3	4	7
8	9	10		



Answer

⑩ Find the duplicate Number:

Given an array of integers 'nums' containing ' $n+1$ ' integers where each integer is in range $[1, n]$ inclusive.

There is only 'one repeated number' in nums, return its repeated number.

Example :- $\text{nums} = [1, 3, 4, 2, 2]$
 output = 2

Approach :-

- ① Sort the nums array,
then we can iterate through nums array

```
for(i=1 to n)
if (nums[i] == nums[i-1])
    return nums[i];
```

$\Rightarrow O(n \log n)$
space = $O(1)$
Complexity

- ② Using the frequency array .

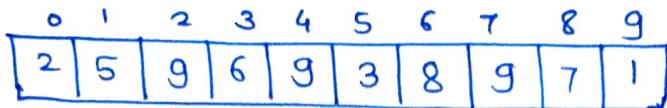
Count the frequency of each element in the array & check if the frequency of any element is ≥ 1 , return that element

$T(n) = O(n)$
 $S(n) = O(n)$

```
vector<int> freq(n+1)
for(i=0 to n)
    if (freq[nums[i]] == 0) → freq[nums[i]]++;
    else → return nums[i];
```

most-optimized method :-

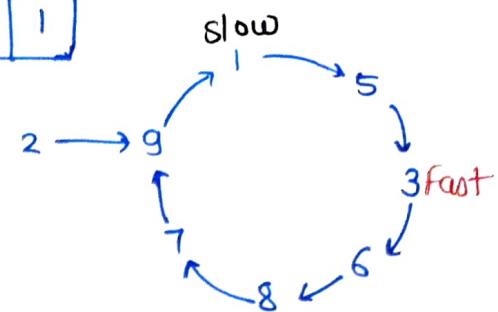
Linked-List Cycle method



2 → then we take element present at index → 2
→ 9

2 → 9

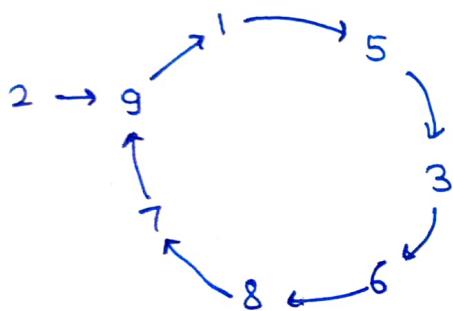
then take element of 9th index



this process takes place again & again

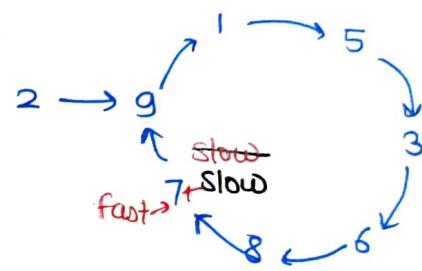
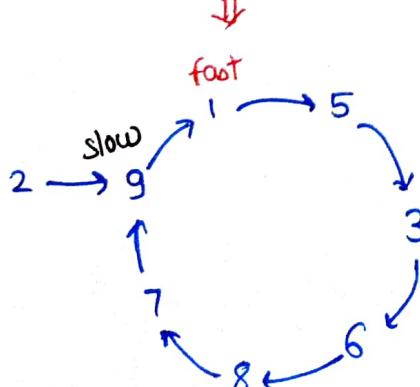
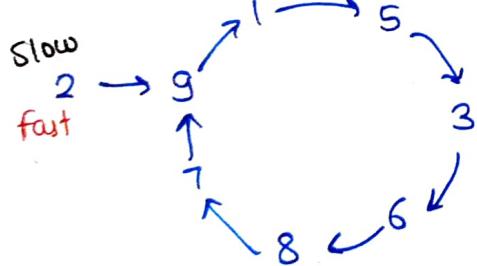
2 → 9 → 1

like wise

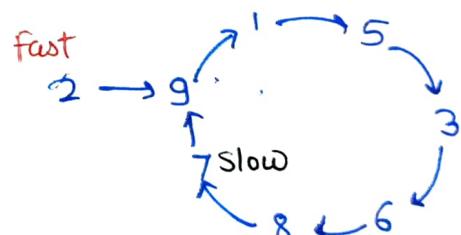


Now, we will apply tortoise-method

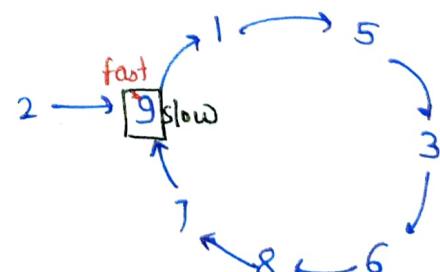
slow → it moves 1 step
pointer → it moves 2 step



Now we will place the fast pointer at first



Move slow & fast pointer by +1



Return 9

$Tc = O(N)$
$Sc = O(1)$



```
slow = nums[0] ;
```

```
fast = nums[0] ;
```

```
while ( slow != fast ) {
```

```
    slow = nums[slow] ;
```

```
    fast = nums[nums[fast]] ;
```

```
}
```

```
Fast = nums[0] ;
```

```
while ( slow != fast ) {
```

```
    slow = nums[slow] ;
```

```
    fast = nums[fast] ;
```

```
}
```

```
return slow;
```

11) Find the repeating and missing numbers:-

You are given an array of N integers with the values in the range $[1, n]$ both inclusive. Each integer appears exactly once except A which appears twice & B which is missing.

Find the repeating no. & the missing no.

Example:-

nums = [3, 1, 2, 5, 3]

Result = {3, 4}

Brute force:-

Take one substitute Array of size $(N+1)$ and initialize it with 0 then add the values to the substitute array (frequency) and find if the frequency $= 0 \rightarrow$ missing No. $\&$ frequency $> 1 \rightarrow$ Repeating no.

```
for (i=0 to n)
{
    Substitute[Array[i]]++;
}
for (i to n)
{
    if (Substitute[i] == 0 || Substitute[i] > 1)
    {
        ans.push-back(i);
    }
}
```

Time Complexity = $O(N) + O(N) \approx O(N)$

Space Complexity = $O(N)$



Approach 2 :-

Using Maths

let the missing no. $\rightarrow x$
& the repeating no. $\rightarrow y$

S = Sum of Natural no. from 1 to n

$$S = \frac{n(n+1)}{2} \quad \text{--- (i)}$$

P = Sum of Squares of natural no.

$$P = \frac{n(n+1)(2n+1)}{6} \quad \text{--- (ii)}$$

Now for Array, also calculate sum $\Rightarrow S_1$, (iii)

& sum of Squares $\Rightarrow P_1$, (iv)

then Subtract the

$$\left[\frac{\text{Sum of elements of Array}}{S_1} - \frac{\text{Sum of natural No. from 1 to } N}{S} \right] \quad \text{--- (v)}$$

Now

$$x - y = S_1$$

$$x + y = P_1 / S_1$$

$$2x = S_1 \left(1 + \frac{1}{P_1} \right)$$

$$x = \frac{S_1}{2} \left(1 + \frac{1}{P_1} \right)$$

and find y
also

gives

$$(x - y) = S - S_1 = S'$$

$$x^2 - y^2 = P_1 - P_1 = P_1$$

$$(x+y)(x-y) = P_1$$

$$(x+y) * S' = P_1$$

$$x+y = \frac{P_1}{S'}$$

$$\begin{cases} T.C = O(N) \\ S.C = O(1) \end{cases}$$

SOLUTION :-

(12) Inversion of Array :-

for a given integer array of size 'n' containing all distinct values, find the total no. of inversions that may exist

A pair $(\text{arr}[i], \text{arr}[j])$ \Rightarrow said to be an inversion when

a) $\boxed{\text{arr}[i] > \text{arr}[j]}$

and $\boxed{i < j}$

EX:-

$$\text{nums} = \{5, 3, 2, 1, 4\}$$

There are 7 pairs

$$(5,1), (5,3), (5,2), (5,4), (3,2), (3,1), (2,1)$$

* For the Array which is sorted in decreasing order, the

$$\text{maximum inversions} = \frac{n*(n-1)}{2}$$

Approach

Brute force :-

Traverse through array with two loops
and check if $(\text{arr}[i] > \text{arr}[j] \text{ } \& \& \text{ } i < j)$
 $\text{count}++;$

$\text{TC} = O(n^2)$
$\text{SC.} = O(1)$

(13) Search in a Sorted 2D matrix:-

Given a ' $m \times n$ ' 2D matrix and an integer write a program to find the particular integer exists.

Input :-

$$\text{matrix} = \begin{bmatrix} [1, 3, 5, 7], \\ [10, 11, 16, 20], \\ [23, 30, 34, 60] \end{bmatrix} \quad \text{target} = 3$$

Output = TrueApproach

(1) Brute force:- We can traverse through the 2D matrix if we found the target element, return true.

$$\begin{array}{l} TC = O(m \times n) \\ SC = O(1) \end{array}$$

```
for (i=0 ; i<mat.size(); i++)
    for (j=0 ; j<mat[0].size(); j++)
        if (mat[i][j] == target)
            return true;
```

(2) Binary Search :-

	0	1	2	3
0	1	3	5	7
1	10	11	16	20
2	23	30	34	50
3	56	64	76	86

target = 30

low
0high
15

$$\text{mid} = \frac{0+15}{2} = 7 \quad \text{so}$$

$$\begin{aligned} \text{P/Column} &= 7/4 = 1 \Rightarrow (1, 3) \\ \text{P/Row} &= 7/3 = 2 \end{aligned}$$



so it will present in the right part ($20 < \text{target}$)

low

8

high

15

$$\text{mid} = \frac{8+15}{2} = 12 \rightarrow \textcircled{56} \text{ element}$$

$$\frac{12}{4} = 3$$



56 present at (3,0)

$$12 \% 4 = 0$$

But our target element present at left part

low

8

high

11

$$\text{mid} = \frac{8+11}{2} = \frac{19}{2} = \textcircled{9} \rightarrow \text{element} = 30$$

④

matches with the target element
return true.

```
int n = matrix.size();  
int m = matrix[0].size();
```

T.C = $O(\log(m*n))$
S.C = $O(1)$

```
int low = 0, high = (n*m) - 1;  
while (low <= high) {
```

~~if (matrix[~~

~~int mid = (low + (high - low)) / 2;~~

~~if (matrix[mid/m][mid%m] == target) → return true~~

~~else if (matrix[mid/m][mid%m] < target)~~

~~low = mid + 1;~~

~~else → high = mid - 1;~~

~~return false;~~

(14) Pow(x,n)

Given a double 'x' & integer 'n', calculate x raised to power ' n ' basically implement $\text{pow}(x,n)$;

Input :-

$$x = 2.00000$$

$$n = 10$$

$$\text{Output} = 1024.00000$$

Approach

① Brute force :-

```
double ans = 1.0  
for (int i=0 ; i<n ; i++)  
    ans = ans * x;  
}  
return ans;
```

Time Complexity = $O(n)$

S.C. = $O(1)$

② Optimized Approach :-

* Using Binary Exponentiation

$n =$ +ve
 -ve

$$2^{10} = (2 \times 2)^5 = 4^5$$

$$4^5 = 4 \times 4^4$$

$$4^4 = (4 \times 4)^2 = 16^2$$

$$16^2 = (16 \times 16)^1 = 256^1$$

$$256^1 = 256 \times \frac{(256)^0}{1}$$

$$= 256$$

$$= 4 \times 256 = \underline{\underline{1024}}$$

if($n \cdot .2 == 0$)

$$x = x * x$$

$$n = n/2$$

($n \cdot .2 == 1$)

$$\text{ans} = \text{ans} * x$$

$$n = n - 1;$$

```
double ans = 1.0
```

```
long long nn = n
```

```
if(nn < 0)
```

```
    nn = -1 * nn;
```

```
while(nn > 0)
```

```
    if(nn % 2 == 1) {
```

```
        ans = ans * x;
```

```
        nn = nn - 1;
```

```
}
```

```
else {
```

```
    x = x * x;
```

```
    nn = nn / 2;
```

```
}
```

```
}
```

```
if(n < 0)
```

```
ans = double(1.0) / (double)(ans);
```

```
return ans;
```

T.C = O(logn)

S.C = O(1)

15) Find the majority element that occurs more than $(N/2)$ times
Given an array of N integers, write a program to return an element that occurs more than $(N/2)$ times.

Input $N=3$ $\text{nums} = [3, 2, 3]$

3 occurs more than $3/2 = 1$ time so
result = 3

Solution

① Brute force :-

Check the count of occurrences of all elements of the array one by one.

Start from the first element of the array and if $\text{count} > \text{floor}(N/2)$ then return that element as the answer.

If not, proceed with the next element in the array & repeat the process.

Time complexity = $O(N^2)$
Space Complexity = $O(1)$

② Using Hashmap :-

Hashmap (key, value)

↓
(element, No. of occurrence of)
element

```
map<int, int> mp
for (int i=0 ; i<arr.size() ; i++)
    mp[arr[i]]++;
```

```
for (auto i : arrmp)
    if (i.second > (n/2))
        return i.first;
```

T.C = $O(n \log n)$
S.C = $O(n)$



Why this intuition worked!

there are 4 partitions

7 7 5 7 5 1

5 7

5 5 7 7

→

→ Majority Ele = minority Ele

$\rightarrow 7 = 3 \text{ times}$

$\rightarrow 5 = 2 \text{ times}$

$\rightarrow 1 = 1 \text{ time}$

$\rightarrow 2 + 1 = 3$

5 5 5 5

→ majority Ele = 5 (4 times appeared)

RAISONI GROUP
a vision beyond

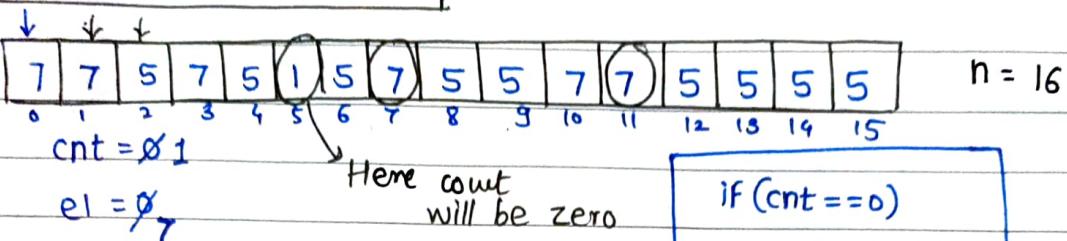
③ Most Optimal Solution

This is the ans.

T.C = $O(N)$

S.C = $O(1)$

Moore's Voting Algorithm



Now $i++$; $i=1 \Rightarrow cnt = 1$
 $a[1]=7$ $el=7$

```

if (cnt == 0)
    el = a[i];
if (el == a[i])
    cnt++;
else
    cnt--;

```

Now $i++$; $i=2 \Rightarrow cnt = 1$
 $a[2]=5$ $el=7$

$i=9, a[9]=5$ $el=5$
 $cum=2$

Now $i++$; $i=3 \Rightarrow cnt = 2$
 $a[3]=7$ $el=7$

$i=10, a[10]=7$ $cnt = 1$
 $el=5$

$i++$, $i=4 \Rightarrow cnt = 1$
 $a[4]=5$ $el=7$

$i=11, a[11]=7$ $cnt = 0$
 $el=5$

$i=5, a[5]=5 \Rightarrow cnt = 0$
 $el=7$

$count=0$
 $i=12, a[12]=5$ $cnt = 1$
 $el=5$

$i++$, $i=6 \Rightarrow cnt = 1$
 $a[6]=5$ $el=5$

$i=13, a[13]=5$ $cnt = 2$
 $el=5$

$i=7 \Rightarrow cnt = 0$
 $a[7]=7$ $el=5$

$i=14, a[14]=5 \Rightarrow cnt = 3$
 $el=5$

$i=8 \Rightarrow cnt = 0$
 $a[8]=5$ $el=5$

$i=15, a[15]=5 \Rightarrow cnt = 4$
 $el=5$

$el = 5 \Rightarrow$ This is the answer.

⑯ Majority Elements ($> N/3$ times)

Given an array of N integers. Find the elements that appears more than $(N/3)$ times in the array. If no such element exists, return an empty vector.

Approach :-

- ① Brute force :- Simply count the no. of appearance for each element using nested loops and whenever you find the count of an element greater than $N/3$ times , that element will be your ans.

```
for (int i=0 ; i<n ; i++)
    cnt=1
    for (int j= i+1 ; j<n ; j++)
        if (arr[i] == arr[j])
            cnt++
    if (cnt > (n/3))
        ans.push_back (arr[i]);
```

Time complexity = $O(N^2)$

Space complexity = $O(N)$

- ② Using Hashmap :-

```
unordered_map<int, int> mp
for (int i=0 ; i<n ; i++)
    mp[arr[i]]++;
for (auto i : mp)
    if (i.second > (n/3))
        ans.push_back (i.first);
```

T.C = $O(n \log n)$
S.C = $O(n)$



③ Extended Boyer Moore's Voting Algorithm

num1 = -1

1	1	1	3	3	2	2	2
---	---	---	---	---	---	---	---

num2 = -1

c1 = 0

c2 = 0

vector<int> ans

count1 = count2 = 0;

if ($i=0$; $i < sz$; $i++$) {

 if ($\text{nums}[i] == \text{num1}$)
 count1++;

 else if ($\text{nums}[i] == \text{num2}$)
 count2++;

}

if ($\text{count1} > (sz/3)$)

 ans.push_back(num1);

if ($\text{count2} > (sz/3)$)

 ans.push_back(num2);

return ans;

for(int el = nums)

{

 if ($el == \text{num1}$) c1++;

 else if ($el == \text{num2}$) c2++;

 else if ($c1 == 0$)

 num1 = el;

 c1 = 1;

 else if ($c2 == 0$)

 num2 = el;

 c2 = 1;

 else

 c1--;

 c2--;

T.C = O(n)

S.C = O(1)

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Unique Grid paths :-

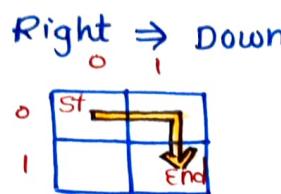
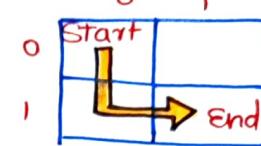
Given a matrix 'mxn', count paths from left-top to the right bottom of a matrix with the constraints that from each cell you can either only move to the rightward direction or to the downward direction.

Example

Input = m: 2 n: 2
output = 2

Explanation :-

①

② Down \Rightarrow right

Total ② ways

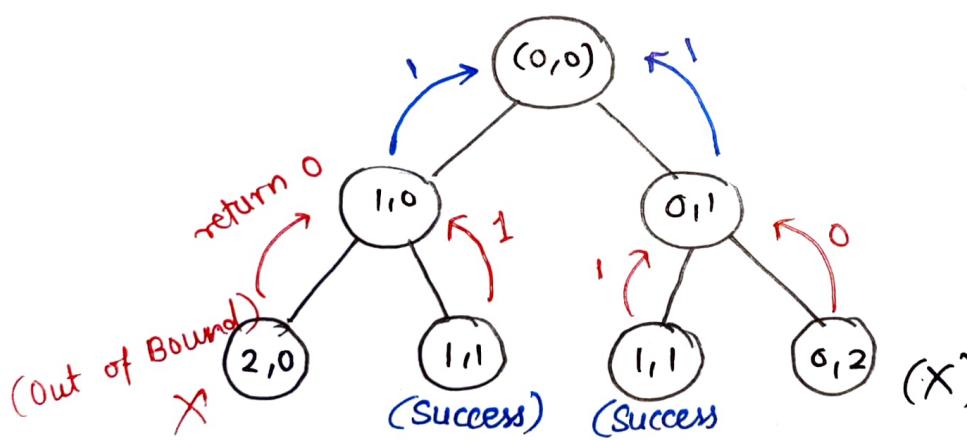
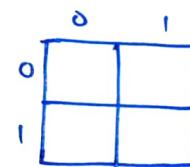
Approach

① Brute Recursive Approach :-

Initially we are at (0,0)

from here we can go to the right as well as bottom

and we will move until the base case hits



Ans = 2

Time & Space Complexity will be exponential

countPaths(int i, int j, int n, int m)

{ if(i == (n-1) && j == (m-1))

return 1;

if(i >= n || j >= m) return 0

else

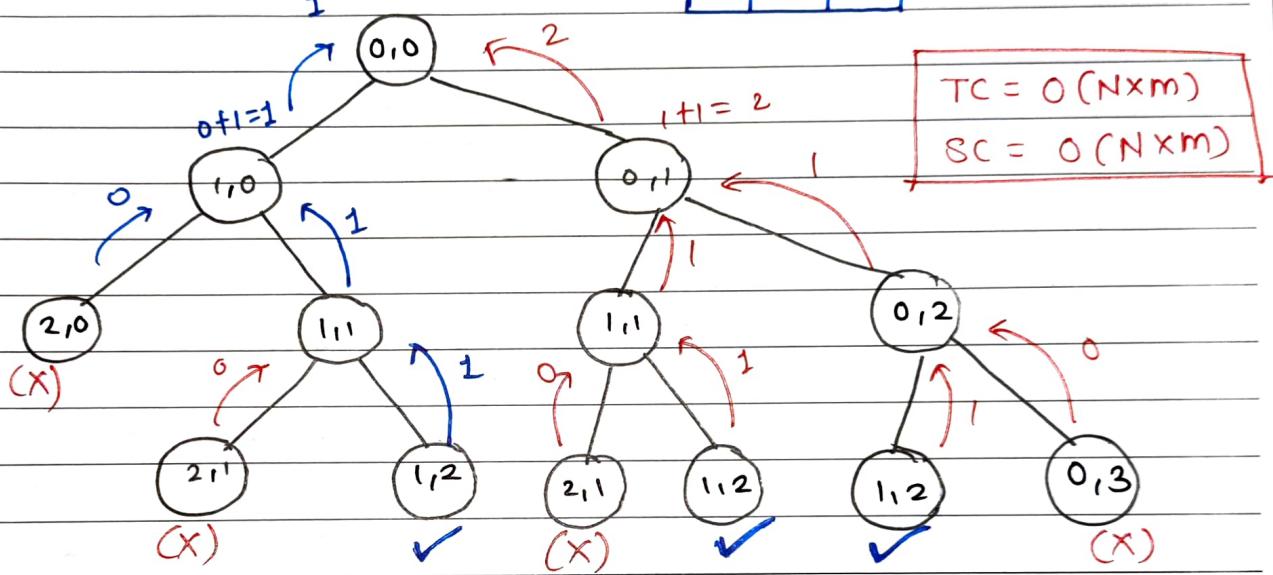
return countPaths(i+1, j, n, m)
+ countPaths(i, j+1, n, m);

② Dynamic Programming Solution

① Take a dummy matrix $A[m][n]$ and initialize it with " -1 ".

$$A[][] \quad \begin{matrix} 0 & 1 & 2 \\ 0 & -1 & -1 & -1 \\ 1 & -1 & -1 & -1 \end{matrix}$$

$\text{Ans} = 1+2=3$



```

int countPaths (int i, int j, int n, int m, vector<vector<int>> dp)
{
    if (i == (n-1) && j == (m-1)) return 1;
    if (i >= n || j >= m) return 0;
    if (dp[i][j] != -1) return dp[i][j];
    else
        return dp[i][j] = countPaths(i+1, j, n, m, dp)
                    +
                    countPaths (i, j+1, n, m, dp);
}

```

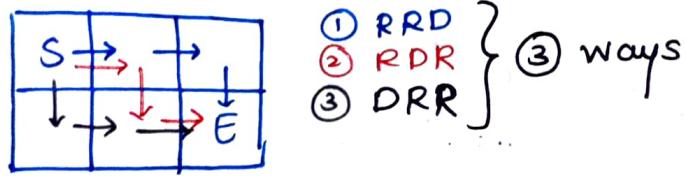
```

int uniquePaths (int m, int n) {
    vector<vector<int>> dp(m+1, vector<int> (n+1, -1));
    int num = countPaths (0,0, m, n, dp);
    if (m == 1 && n == 1) return num;
    else return dp[0][0];
}

```

③ Most Optimal Approach :-

Combinatorics method :-



① To reach the destination we must have to take certain number of steps to the right & certain number of steps to bottom.

so

$$\text{possible moves to the right} = m-1$$

$$\text{possible moves to the down} = n-1$$

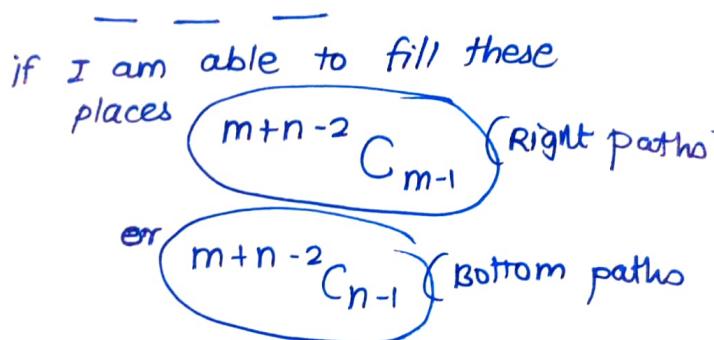
$$\begin{aligned}\text{Total moves} &= (m-1 + n-1) \\ &= \boxed{m+n-2} \text{ moves}\end{aligned}$$

for given Example

$$\begin{cases} m=2 \\ n=3 \end{cases}$$

$$\text{So } m+n-2 = 2+3-2 = \boxed{3} \text{ places}$$

so



9.

$$10C_3 = \frac{8 \times 9 \times 10}{3 \times 2 \times 1}$$

$T.C = O(m-1) \text{ or } O(n-1)$
 $S.C = O(1)$

```

int Total = m+n - 2;
int right = m-1;
double ans = 1;
for (int i=1 ; i<=right ; i++)
    ans = ans * (total-right+i) / i ;
return (int)ans;

```

(18)

Count Reverse Pairs :- (HARD)

Given an array of numbers, you need to return the count of reverse pairs.

Reverse pairs :-

$$\text{arr}[i] > 2 * \text{arr}[j] \quad i < j$$

Approach :-

① Brute force :-

Two nested loops

```
for (i=0 to n)
    for (j=i+1 to n)
        if (arr[i] > 2 * arr[j])
            count++;
```

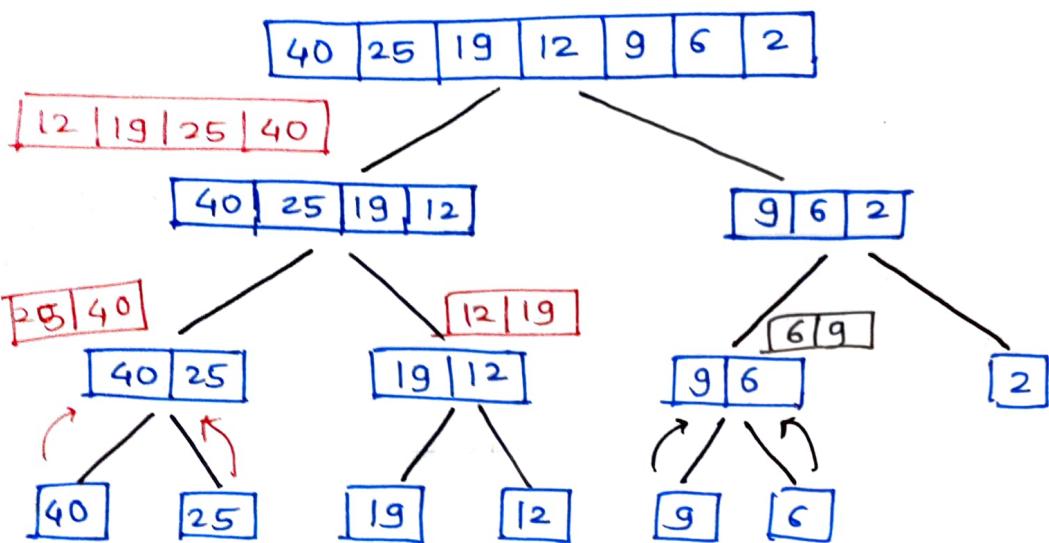
return count;

Time Complexity = $O(N^2)$

Space Complexity = $O(1)$

② Optimal Approach

We will use merge sort.



(i) $\rightarrow 40$ (j) $\downarrow 25$

Now, we will place the 'j' to such a index such
that $a[i] \leq 2 * a[j]$ (keeping 'i' constant)

$\Rightarrow j$ stays over there, so 25 will never contribute to our ans.

Now i move forward $\Rightarrow 19$

(i)

(j)

12 \Rightarrow This is also not
contributes to our
ans
perform merge

Now



$25 \leq 2 * 19$ (false)

move $j \Rightarrow j++ \Rightarrow 19$

$25 \leq 2 * 19$

} j moves by one step
so ans = 1

$40 \leq 2 * 19$ (false)

stop. (right array exhausted)

left array exhausted

ans
 $\Rightarrow + 2$

perform merge operation



(i) (j)
g 6 (No contribution)

perform merge step

(i) $j++$ (Right array exhausted)

6 9

$6 \leq 2 * 2$ (false) (No contribution)

ans

This is how we have to check.

6 9⁽ⁱ⁾ 2^(j) (Right array) Exhausted

and then add total no. of elements on the left so
add 1 more to the answer +1 ^{ans}

merge step

(i)

12 19 25 40

(j) (j)

2 6 9

$$12 <= 2 * 2$$

move j

$12 \leftarrow 2 * 6$ (✓) (odd no. of elements on left of
i) $\Rightarrow (+1)$

move $i \rightarrow 19$

$$19 \leq 2 * 6 (x)$$

move j

$lg \leq 2^k g(x)$ move j \Rightarrow Right array exhausted

Add #elements on left of j pointer

for (19) \Rightarrow +3 ans

move i to 25

$$25 \leq 2 * 2(x)$$

$$25 \leq 2^x 6 (X)$$

$$25 \leq 2^{\star}g(x)$$

} Right array exhausted
Add +3 ans

for 40 \Rightarrow +3

so ans = 1 + 2 + 1 + 1 + 1 + 3 + 3 + 3

ans = 15 \Rightarrow This is no. of pairs

Now merge & step

2	6	9	12	19	25	40
---	---	---	----	----	----	----

Time Complexity = $O(n \log n)$ + $O(n)$ + $O(n)$
Merge Sort merge operation count operation

Space Complexity = $O(n)$
Temp. array in merge sort

```
int reversePairs (vector<int>& nums)
    return mergeSort (nums, 0, nums.size() - 1);
int mergeSort (vector<int>& nums, int low, int high);
    if (low == high) return 0;
    int mid = (low + high) / 2;
    int inv = mergeSort (nums, low, mid); // left recursion
    inv += mergeSort (nums, mid + 1, high); // Right recursion
    inv += merge (nums, low, mid, high)  $\Rightarrow$  (merge function)
    return inv;
}
```



```
int merge(vector<int>& nums, int low, int mid, int high);  
int cut = 0; // store the total no. of pairs  
int j = mid + 1; // put the j index to the first index of  
// right half  
for (int i = low; i <= mid; i++) {  
    while (j <= high && nums[i] > 2LL * nums[j]) {  
        j++;  
    }  
    cnt += (j - (mid + 1)); // count the # elements placed  
    // to the left side of 'j'  
}  
// merge function  
vector<int> temp;  
int left = low, right = mid + 1;  
while (left <= mid && right <= high) {  
    if (nums[left] <= nums[right]) {  
        temp.push_back(nums[left++]);  
    }  
    else {  
        temp.push_back(nums[right++]);  
    }  
}  
// if any array exhausted, then:  
while (left <= mid) {  
    temp.push_back(nums[left++]);  
}  
// if left array  
// is left out.  
while (right <= high) {  
    temp.push_back(nums[right++]);  
}
```

// Copy back the temp array to nums array.

```
for(int i = low ; i <= high ; i++) {  
    nums[i] = temp[i - low];  
}  
  
return cnt;
```



Day - IV

19

Two-Sum-Problem

Given an array of integers "nums" and an integer "target" return indices of the two numbers such that they add up to "target".

Example :- Input : nums = [2, 7, 11, 15] . target = 9
output : [0, 1]

Solution :-

① Brute force:-

Simply traverse through the nums array

```
for (int i=0 ; i<n ; i++)  
    for (int j=i+1 ; j<n ; j++)  
        if (num[i] + nums[j] == target) {  
            ans.push-back(i);  
            ans.push-back(j);  
            break;  
        }  
    if (ans.size() == 2) break;  
return ans.
```

Time complexity = $O(n^2)$

Space Complexity = $O(1)$

② Two-pointer Approach

sort the array.
use two variables, each will start from one end of the array
and traverse in both direction to find the required sum.
for each element 'i', we try to find the second element
'target - i'

```
vector<int> ans, temp;  
temp = nums; → store the nums array in temp array  
sort(temp);  
int left = 0, right = n - 1;  
int x, y;  
while (left < right) {  
    if (temp[left] + temp[right] == target) {  
        x = temp[left];  
        y = temp[right];  
        break;  
    }  
    else if (temp[left] + temp[right] > target)  
        right--;  
    else  
        left++;  
}
```

// Now run one more loop to find the indices of x + y in
nums array.

```
for (int i = 0; i < nums.size(); i++) {  
    if (nums[i] == x)  
        ans.push_back(i);  
    else if (nums[i] == y)  
        ans.push_back(i);  
}  
return ans;
```

T.C = O(n log n)
S.C = O(n)



③ Hashing (Most Efficient)

We'll use the hashmap to see if there's a value ($\text{target} - i$) that can be added to the current array value (i) to get the sum equals to target.

If ($\text{target} - i$) found in the map we return the current index of index stored at ($\text{target} - \text{nums}[i]$) location in the map.

```
unordered_map<int, int> mp;  
  
for (i=0 ; i<n ; i++) {  
    if (mp.find (target - nums[i]) != mp.end ()) {  
        ans.push_back (i);  
        ans.push_back (mp[target - nums[i]]);  
        return ans;  
    }  
    mp[nums[i]] = i;  
}  
return ans.
```

Time complexity = $O(n)$
Space Complexity = $O(n)$

20

4-Sum problem

Given an array of nums.

return an array of unique quadruplets, such that

$$\text{nums}[a] + \text{nums}[b] + \text{nums}[c] + \text{nums}[d] == \text{target}$$

Example :- $\text{nums} = [1, 0, -1, 0, -2, 2]$, $\text{target} = 0$

output :- $\begin{bmatrix} [-2, -1, 1, 2], \\ [-2, 0, 0, 2], \\ [-1, 0, 0, 1] \end{bmatrix}$

• Solutions \Rightarrow

① Using 3 pointers & Binary Search:-

sort the array

Target = 9

Ex :-

Given array :-

4	3	3	4	4	4	2	1	2	1	1
---	---	---	---	---	---	---	---	---	---	---

sort it \Rightarrow

1	1	1	2	2	3	3	4	4	4
---	---	---	---	---	---	---	---	---	---

starts

$i=0$
 $j=i+1$
 $k=j+1$

\uparrow
 i
 j
 k

\uparrow

```
set <vector<int>> st;
for (i=0 to n)
    for (j=i+1 to n)
        for (k=j+1 to n) {
            int x = target - (nums[i] + nums[j] + nums[k])
            if (binary_Search(nums.begin() + k + 1, nums.end(), x))
                {
                    vector <int> quad;
                    quad.push_back(nums[i]);
                    quad.push_back(nums[j]);
                    quad.push_back(nums[k]);
                    quad.push_back(x);
                    quad sort(quad.begin(), quad.end());
                    st.insert(quad);
                }
        }
vector <vector <int>> ans {st.begin(), st.end()};
return ans;
```

② Optimal Approach (Two pointers)

Target = 9

$$\text{nums}[i] + \text{nums}[j] = 1 + 1 = 2$$

To find :- ⑦ \Rightarrow 2

d :- 7 ↗
and now $(\text{nums}[\text{left}] + \text{nums}[\text{right}])$
 $(1+4 < 7) \Rightarrow$ so no sol'n

so $\text{left}++$; $(2+4 < 7) \Rightarrow x$

Now

check for
this

1	1	1	2	2	3	3	4	4	4
---	---	---	---	---	---	---	---	---	---

We have checked for this

→ There is no need to check for this '2'

(`nums[left] + nums[right] == x`)

$$(3+4=7) \checkmark$$

quad \Rightarrow

1	1	3	4
---	---	---	---

 \Rightarrow

Now eliminating duplicates and shifting

left & right pointers

A diagram of a linked list with 11 nodes. The nodes are labeled 1 through 4. There are two skip pointers: one from node 2 to node 3, and another from node 3 to node 4.

left pointer crosses the right pointer

Now 'j' will jump j

1 1 1 2 2 3 3 4 4 4

↑
left right

Remaining value we are looking for = $9 - (1+2) = 6 \Rightarrow x$

($\text{nums}[\text{left}] + \text{nums}[\text{right}] == x$)

$$(2+4=6) \checkmark$$

1	2	2	4
1	1	3	9



Now skip the duplicates

i	j	left	right
	1	1 2 2 3 3 4 4 4	

$$(3+3=6) \checkmark$$

quad 1 2 3 3 \Rightarrow

1	2	3	3
1	2	2	4
1	1	3	4

likewise we can find

$$\boxed{\text{Time Complexity} = O(n^3)}$$
$$\boxed{\text{Space Complexity} = O(1)}$$

for ($i = 0$ to n)

target_3 = target - nums[i]

for ($j = i+1$ to n)

target_2 = ~~target~~ (target_3) - nums[j]

front = $j+1$ left = $j+1$;

back = right = $n-1$;

while (left < right)

if $x = \text{nums}[left] + \text{nums}[right]$

if ($x < \text{target}_2$) \Rightarrow left ++;

else if ($x > \text{target}_2$) \Rightarrow right --;

else {

vector<int> quad(64, 0)

push all elements (i, j, left, right)

Avoiding duplicates

while ($left < right$ && $\text{nums}[left] == \text{quad}[2]$) \Rightarrow left ++;

while ($left < right$ && $\text{nums}[right] == \text{quad}[3]$) \Rightarrow right --;

}

while ($j+1 < n$ && ~~nums[j+1]~~ $\text{nums}[j+1] == \text{nums}[j]$) \Rightarrow j++;

while ($i+1 < n$ && $\text{nums}[i+1] == \text{nums}[i]$) \Rightarrow i++;

(21)

Longest Consecutive Sequence in an Array

You are given an array of 'N' integers.
 You need to find the length of the longest sequence which contains the consecutive elements.

Ex:- $\text{nums} = [100, 200, \underbrace{1, 2, 3, 4}]$
 output = 4

* Solutions

① Brute force :-

```

sort the Array.
int prev = nums[0];
int ans = cur = 1;
for (i=1 to n)
    if (nums[i] == prev + 1) {
        cur++; (check if the next element
is just +1 to the previous)
    }
    else if (nums[i] != prev) {
        cur = 1; // set default
    }
    prev = nums[i];
    ans = max(ans, cur);
}
return ans;
  
```

$$\begin{aligned}\text{Time Complexity} &= O(n \log n) + O(n) \\ &\approx O(n \log n)\end{aligned}$$

$$\text{Space complexity} = O(1)$$



② Optimal Approach :- (using HashSet)

Insert all elements into HashSet;

Now traverse the ~~hashset~~^{nums}, and will check the $(num - 1)$ element is present or not

then we'll do $currentNum = num;$
 $currentStreak = 1$

then will increase ~~hi~~ the currentStreak until the $(currentNum + 1)$ element is present in the HashSet.

longestStreak = $\max(\text{longestStreak}, \text{currentStreak})$;

```
set<int> hashSet;  
for(int num : nums)  
    hashSet.insert(num);
```

T.C = O(N)
S.C = O(N)

```
longestStreak = 0;  
for(int num : hashSetnums) {  
    if(!hashSet.Count(num - 1)) {  
        currentNum = num;  
        currentStreak = 1;  
        while(hashSet.Count(currentNum + 1) == currentNum + 1) {  
            currentNum += 1;  
            currentStreak += 1;  
        }  
    }  
}
```

longestStreak = $\max(\text{longestStreak}, \text{currentStreak})$;

```
}  
return longestStreak;
```

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Length of the longest subarray with zero sum

Given an array containing both positive and negative integers, we have to find the length of the longest subarray with the sum of all elements equal to zero.

Ex:-

nums = [9, -3, 3, -1, 6, -5]

output = 5

subarrays with sum = 0

↓
[-3, 3] \Rightarrow len = 2[-1, 6, 5] \Rightarrow len = 3[-3, 3, -1, 6, -5] \Rightarrow len = 5
O/P

Solutions :-

① Naive Approach :-

① Initialize a variable maxlen = 0 (stores the maximum length of Subarray with sum 0)

② Traverse the array from start and initialise a variable sum = 0 which stores sum of subarray starting with currentIndex

③ Traverse from next element of currentIndex up to n

sum += nums[i]

if (sum == 0)

maxlen = max(maxlen, j - i + 1);

return maxlen.

```

int maxlen=0
for (int i=0 ; i<n ; ++i)
    sum=0
    for (int j=i ; j<n ; j++)
        sum+= nums[i];
        if (sum==0)
            maxlen = max(maxlen, j - i + 1);

```

return maxlen;

T.C = O(N²)
S.C = O(1)



② Optimized Approach :-

0	1	2	3	4	5	6	7	8	9	
nums = [1	-1	3	2	-2	-8	1	7	10	23]

Maintain (maxi) to store the max len of subarray.

Now linearly traverse through the array, and we'll store the prefix sum

At $i=0$

sum = 1 \rightarrow Add to hashmap with its index i.e. (1, 0)

(1, 0)

(key, Value)

At $i=1$

sum = 0

[1 | -1] \Rightarrow This subarray with sum = 0

maxi = 2

At $i=2$

sum = 3 \rightarrow Add to hashmap (3, 2)

(but before check if "3" exists in the hashmap or not)

(5, 3)
(3, 2)
(1, 0)

(if it does not exist then add).

At $i=3$

sum = 5 \rightarrow Add to hashmap (5, 3)

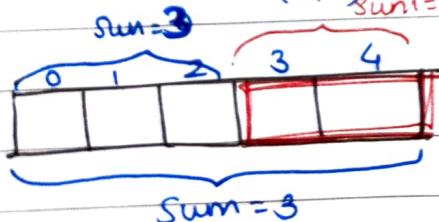
At $i=4$

sum = $5 - 2 = 3$ (It is exists in the hashmap)

so this means that till index $\Rightarrow 2$ we had sum = 3

(3, 2)

sum = 0 and till 4 we have sum = 3



\Rightarrow so this is one of the subarray.

its length = the index - the index at which we have got S=3 at which we have got S=3 (previous)

$$= 4 - 2$$

$$= 2$$

Now At i=5

$$\begin{aligned} \text{sum} &= 3 - 8 \\ &= -5 \end{aligned}$$

check if -5 is present in the hashmap or not
if not add it along with its index

(-4,6)
(-5,5)
(5,3)
(3,2)
(1,0)

At i=6

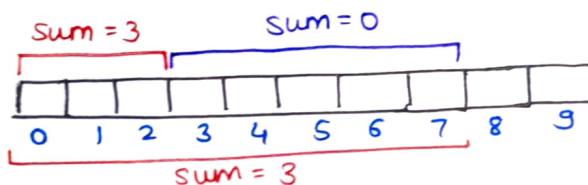
$$\begin{aligned} \text{sum} &= -5 + 1 \\ &= -4 \end{aligned}$$

Add (-4,6)

At i=7

$$\begin{aligned} \text{sum} &= -4 + 7 \\ &= 3 \end{aligned}$$

is present



$$\begin{aligned} \text{len} &= 7 - 2 \\ &= 5 \end{aligned}$$

$$\begin{aligned} \text{maxi} &= \\ \text{len} &= \max(\text{len}, \text{maxi}) \\ &= \max(5, 2) \end{aligned}$$

maxi = 5

At i=8

$$\begin{aligned} \text{sum} &= 3 + 10 \\ &= 13 \end{aligned}$$

→ Add (13,8) in hashmap

(36,9)
(13,8)
(-4,6)
(-5,5)
(5,3)
(3,2)
(1,0)

hashMap

At i=9

$$\begin{aligned} \text{sum} &= 13 + 23 \\ &= 36 \end{aligned}$$

→ Add (36,9)

So the {maximum length = 5}



```
unordered_map<int, int> mp;
int maxi = 0
int sum = 0
for (int i=0 ; i<n ; i++) {
    sum += nums[i];
    if (sum == 0) {
        maxi = i+1;
    }
    else {
        if (mp.find(sum) != mp.end()) {
            maxi = max(maxi, i - mp[sum]);
        }
        else {
            mp[sum] = i;
        }
    }
}
return maxi
```

Time Complexity = ~~O(nlogn)~~ O(n) + O(nlogn) $\approx O(nlogn)$
Space Complexity = O(n)

23

Count the number of Subarrays with given XOR k

Given an array of integers A and B an integer B, find the total number of subarrays having bitwise XOR of all elements equal to B.

Ex:- $A = [4, 2, 2, 6, 4]$ $B = 6$

O/P = 4

The subarrays having $\text{XOR} == B$

$[4, 2]$

$[4, 2, 2, 6, 4]$

$[2, 2, 6]$

$[6]$

• Solutions ⇒

① Brute force :-

```

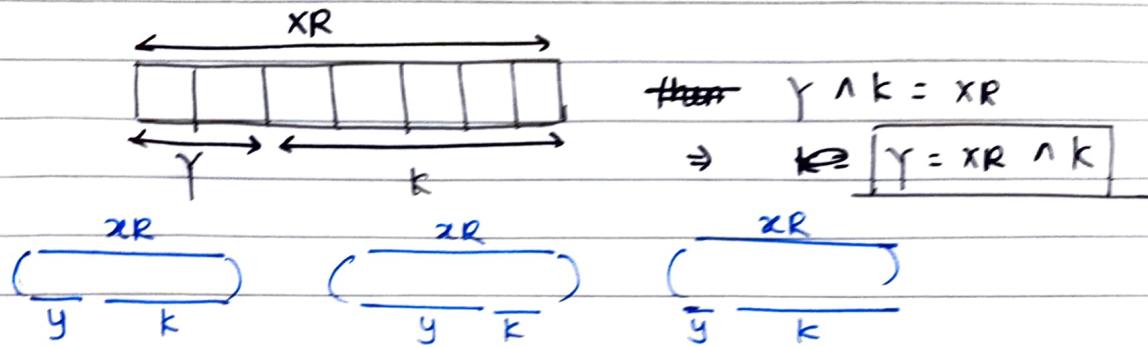
long long int count = 0
for(int i=0 ; i<n ; i++) {
    int curr_xor = 0;
    for(int j=i ; j<n ; j++) {
        curr_xor = curr_xor ^ A[i];
        if(curr_xor == B) {
            count++;
        }
    }
}
return count;
    
```

Time Complexity = $O(n^2)$

Space Complexity = $O(1)$



② Optimized Approach :-



there are multiple 'y's so

the $\boxed{\text{no. of } y\text{'s} = \text{no. of Subarrays}}$

Dry Run :-

nums =

0	1	2	3	4
4	2	2	6	4

 $K=6$

Assign $XOR = 0$, count = 0;

At i=0

$XOR = 0 \wedge 4 = 4 \rightarrow$ Does this give
 $k=6$ (X)

Add to hashmap with its count

$(4, 1)$

$(6, 1)$

$(4, 1)$

Hashmap

$(\text{prefix-XOR}, \text{count})$

At i=1

$XOR = 4 \wedge 2$

= 6 \Rightarrow Yes it is giving

4, 2, 2, 6, 4

increment count \Rightarrow count++

if it is present
then we will
increment the count

$$y = XOR \wedge K \\ = 6 \wedge K$$

$y = 0$

else
Add $(6, 1)$
to hashmap.

Check if '0' prefix-XOR is
present in the Hashmap or not.

At i=2

$$\text{XOR} = 6 \wedge 2$$

$$= 4$$

$$y = \text{XOR} \wedge k$$
$$= 4 \wedge 6$$

$y = 2$ → check in the hashmap

Add(4, 1) Add(4, cut)

But '4' is present already
so we'll just increment the count

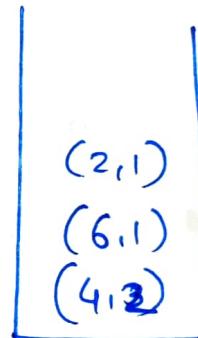
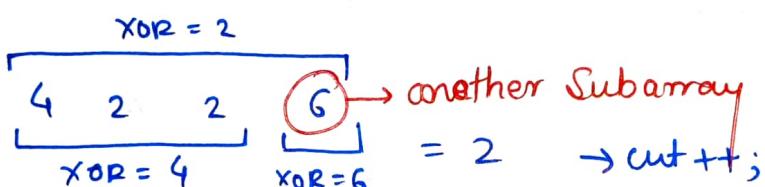
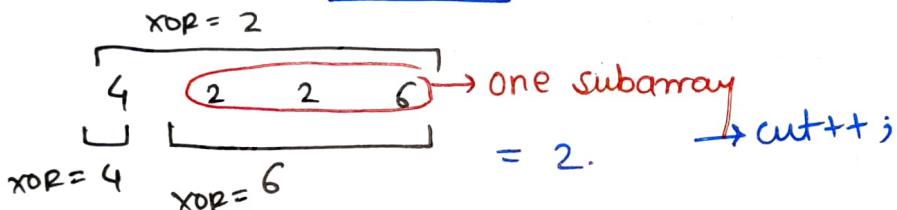


At i=3

$$\text{XOR} = 4 \wedge 6$$

$$= 2 \rightarrow y = \text{XOR} \wedge k$$
$$= 2 \wedge 6$$

$y = 4$ (present!)



Count = 3

At i=4

$$\text{XOR} = 2 \wedge 4$$

$$= 0$$

cut++;

cut = 4

$$y = \text{XOR} \wedge 6$$

$$= 6 \wedge 6$$

$$y = 0$$

Count = 4

T.C = O(nlogn)
S.C = O(n)



```
cnt=0
XOR=0
for (auto i: A) {
    XOR = XOR ^ i;
    if(XOR == B) {
        cnt++;
    }
    if (freq.find(XOR ^ B) != freq.end()) {
        cnt += freq[XOR ^ B];
    }
    freq[XOR] += 1;
}
return cnt;
```

24 Length of Longest Substring without any Repeating character

Given a string, find the length of the longest substring without any repeating character.

Ex :- $s = \underline{abc}abcbb$

O/p = 3

Solutions

① Brute force :-

Take two loops \Rightarrow

① One for traversing the string

② Another nested loop for finding different substrings

we will check for all substrings one by one & check for each and every element.

if the element is not found then we will store the element in hashset otherwise break from the loop

& count it.

```
int ans = 0;
int count = INT_MIN;
for (int i=0 ; i<n ; i++) {
    unordered_set<int> st;
    for (int j=i ; j<n ; j++) {
        if (st.find(s[j]) != st.end()) {
            count = max(count , j-i);
            break;
        }
        st.insert(s[j]);
    }
}
return count;
```

Time Complexity = $O(n^2)$
Space Complexity = $O(n)$



② Optimized Approach :-

$s = "a b c a a b c d b a"$

left →
Right ↓

0 1 2 3 4 5 6 7 8 9

c
b
a

At $i=0$:-

Check if $s[i]$ is present in the set (Not present) set

so Range $(L-R) \Rightarrow$ This substring has no repeating characters

$$len = (r-l+1) = 0-0+1 = 1$$

update len = 1

insert the character into set

move the right pointer

At $i=1$:-

'b' is not present

$$(L-R) \Rightarrow (r-l+1)$$

$$= 1-0+1 = 2$$

update $\Rightarrow len = 2$ (Insert b)

At $i=2$

'c' is not present in set

$$(L-R) \Rightarrow (r-l+1)$$

$$= (2-0+1)$$

$$= 3$$

update $\Rightarrow len = 3$ (Insert c)

At $i=3$

'a' is present so we can say that

$(L-R)$ range has some repeating characters, so we've to remove that

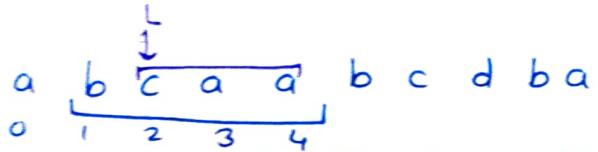
remove 'a' from set & do $left++$

$$(L-R) \cancel{\Rightarrow} (r-l+1)$$

$$= [(3-1)+1] = 2+1 = 3$$

push 'a' to set
 $len = 3$

At i=4



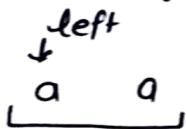
This has repeating characters

remove $\Rightarrow s[\text{left}] \Rightarrow$ remove 'b'

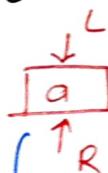
then $\text{left}++;$

Now c a a \rightarrow It still has repeating characters

remove 'c' $\Rightarrow \text{left}++;$



remove 'a'



(It does not have repeating characters)

$\text{len} = 1$

But we'll not update the length

push this "a" to set

move the "R++;"



At i=5

'b' is not present

$\text{len} = 2$ (No updation)

push 'b' into set

At i=6

'c' is not present

$\text{len} = 3$ (No updation)

push 'c' into set

At i=7

'd' is not present

$$\text{len} = 4 \quad (L - R) \Rightarrow (7 - 4) + 1 \\ = 4$$

update $\text{len} = 4$

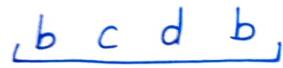
push 'd' into set

Now At i=8



~~left++~~ \Rightarrow remove [left] \Rightarrow remove 'a'

$\text{left}++;$



we still have 'b'

remove 'b'

$\text{left}++;$



~~len = 3~~ (No updation)

Now At i=9

'a' is not present

$$\text{len} = 4 \Rightarrow (L - R) \\ = (9 - 6) + 1 \\ = 3 + 1 = 4$$

push 'a'



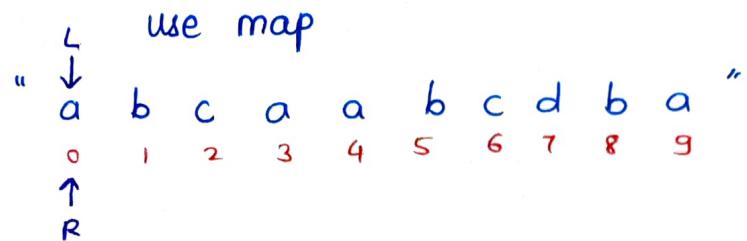


Time Complexity = $O(2*n)$

Space Complexity = $O(n)$

```
int maxlen = INT_MIN;
unordered_set<int> st;
int l=0
for( int t=0 ; t<n ; t++ )
{
    if (st.find(s[t]) != st.end())
    {
        while (l < t && st.find(s[t]) != st.end())
        {
            st.erase(st[l]);
            l++;
        }
        st.insert(s[t]);
        maxlen = max(maxlen, t-l+1);
    }
}
return maxlen;
```

③ Most Optimized Approach



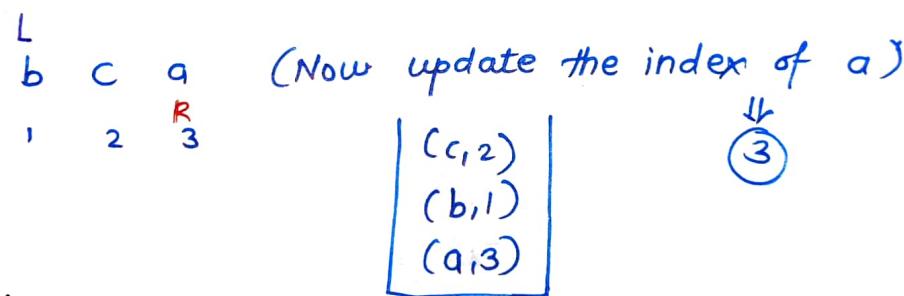
(c, 2)
(b, 1)
(a, 0)

① push 'a' $\Rightarrow (a, 0)$
 $\text{len} = 1 \quad \underline{R++}$

② push 'b' $\Rightarrow (b, 1)$
 $\text{len} = 2 \quad \underline{R++}$

③ push 'c' $\Rightarrow (c, 2)$
 $\text{len} = 3 \quad R++$

④ Now 'a' is present in the map if I know 'a' is present at '0' index
 so we will shift "L" to $\underline{(0+1)}$
~~(L-R)~~ ↓
1st index



③

⑤ L
 b c a R so we will
 ↓ ↓
 1 2 3 4

$$l = 3 + 1 = 4$$

$\frac{l}{\cancel{R}}$

↑
r

(c, 2)
(b, 1)
(a, 4)

⑥ L
 a b range [4-5]

(c, 2)
(b, 5)
(a, 4)



a, b, c

(c, 6)
(b, 5)
(a, 4)

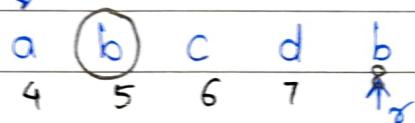
Now at i=7

'd' is there (4-7)

$$\begin{aligned} \text{length} &= 7 - 4 + 1 \\ &= 4 \end{aligned}$$

(d, 7)
(c, 6)
(b, 5)
(a, 4)

Now at i=8 ↓ jump



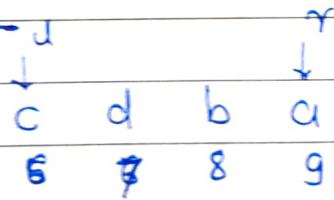
$$l = 5 + 1 = 6$$

↓

c d b

(d, 7)
(c, 6)
(b, 8)
(a, 4)

Now at i=9



$$(6 - 9) \Rightarrow \boxed{\text{length} = 4}$$

(d, 7)
(c, 6)
(b, 8)
(a, 9)

Time Complexity = $O(n)$
Space Complexity = $O(1)$

→ Avg. case (s.c.)

↙ a string can have '256' char

```
vector<int> mp(256, -1);
int left = 0, right = 0;
int len = 0;
while (right < n) {
    if (mp[s[right]] != -1) {
        left = max(mp[s[right]] + 1, left);
    }
    mp[s[right]] = right;
    len = max(len, right - left + 1);
    right++;
}
return len;
```