

The Identical twin !

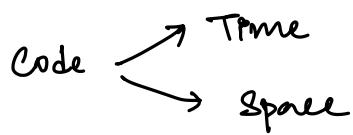


Agenda

- ① Space Complexity
- ② Introduction to Arrays
- ③ Pair with given sum
- ④ Reverse an array
- ⑤ Reverse an array for given range
- ⑥ Google + Amazon Question
- ⑦ Dynamic Arrays
- ⑧ What to expect in coming classes.

Space complexity

Major claim



If you know T.C
you already know
S.C

Ques 1

What is time Complexity based on?

- a) Operating system
- b) programming language
- c) Input size
- d) That how do I know sir?

a) Input size (Iteration count depend on it)

Question 1

[primitive data types]

Integer - 4 B

↳ int

↳ long

long - 8 B

↳ double

↳ float

↳ char

function (int N) {

Space Complexity

int x = N + 4 B

16 B

int y = x+x + 4 B

O(1)

long z = x+y + 8 B

Question 2

func (int N) {

int x = N; 4B

int y = x * x; 4B

long z = x + y; 8B

int [] arr = new int [N]; 4N

Space complexity

O(4N + 16)

O(n)

input size

}

Ques 2

func (int N) {

int x = N; 4B

int y = x * x; 4B

long z = x + y; 8B

int [] arr = new int [N]; 4NB

long [][] l = new long [N][N]; 8N²

Space complexity

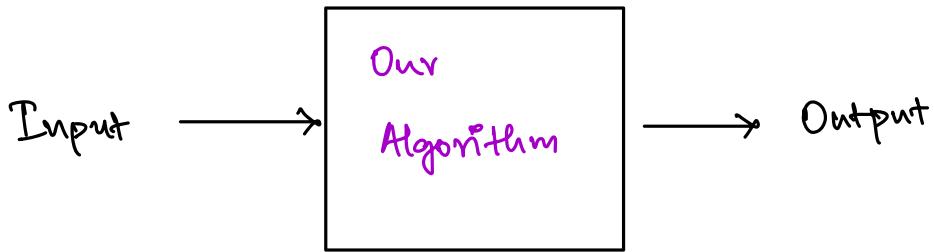
O(8N² + 4N + 16)

O(N²)

}

If you know T.C you know S.C as well!!

Algo we develop



Observation

Your input is a necessity. Without input your algo will not work.

Claim

If your algorithm creates additional space, that is considered for S.C. Input & Output is not in your control.

Example

int maxArr (int arr[], N) {

Space complexity ?

int mx = arr[0]; 4B

$O(8B)$

for (int i=1; i< N; i++) { 4B

$O(1)$

mx = max (mx, arr[i]);

y

}

DSA → 6.5 months

600 questions

T.C

S.C

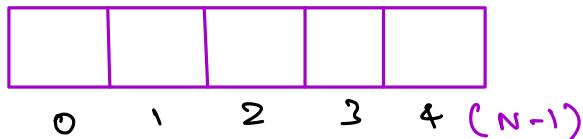
Introduction to Arrays

Collection of same type of data!

```
int arr = new int[5];  
↑  
Data type  
↑ size
```

Quiz 3

What will be the index of first and last element in array of size N ?



first $\rightarrow 0$
last $\rightarrow N-1$

Print all elements of array

```
void printArray (int arr, int N) {
```

```
    for (int i = 0; i < N; i++) {
```

```
        print (arr[i]);
```

}

y

Iterating through all elements \rightarrow printing to console

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

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

Quiz 4

What is the time complexity for accessing i^{th} index in an array?

5	-3	2	1	9
0	1	2	3	4

$$i = 2$$

$$\text{arr}[2] = 2$$



constant time

T.C ($O(1)$)

Quiz 5

int arr[5] = {5, -4, 8, 9, 10}

print sum of 1st and 5th element?

5	-4	8	9	10
0	1	2	3	4

1st element — 0th index

5th element —

4th ind.

If you want to access

ith element

we use $\text{arr}[i-1]$

$\text{arr}[0], \text{arr}[4]$

Question 1

Given an array of size 'N'. Find the maximum element.

$$N = 5$$

arr = {9, 1, 3, 5, 7} \rightarrow 9 max element

Quiz 6

Find the maximum element of

arr = {2, 5, 1, 4, 8, 0, 8, 1, 3, 8} \rightarrow 8

Solution

Approach : Iterate all elements, keep max stored in variable

pseudo code :

```
Put find max (Put C) arr, int N) &  
Put max = arr[0];  
for (int i=1; i<n; i++) {  
    if (arr[i] > max) &  
        max = arr[i];  
}  
return max;
```

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

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

Question 2

Given an array arr of size N. Check pf there exist a pair (i, j) such that $\text{arr}[i] + \text{arr}[j] = k$ and $i \neq j$

Example

$\text{arr} = \{9, 1, 3, 5, 9\}$

$k = 12$

True

Quiz 6

Given $\text{arr}[5] = \{3, 5, 2, 7, 3\}$ and $k = 6$

$i=0, j=4 \quad \text{arr}[i] + \text{arr}[j] = 6 \quad \text{True}$

Quiz 7

Given $\text{arr}[3] = \{4, 2, 7\}$ and $k = 8$

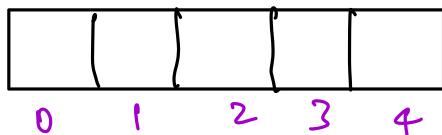
Do we have any pair such that $\text{arr}[i] + \text{arr}[j] = 8$

$4 + 4 = 8 \leftarrow \times \quad \text{False}$

Brute force approach

Idea 1

— Consider all pairs and check
if condition is true



$i == j$

bool check_pairs (arr, N, k) {

 for ($i = 0 \rightarrow N$) {

 for ($j = 0 \rightarrow N$) {

 if ($i \neq j$) {

 if ($arr[i] + arr[j] == k$) {

 return True

 }

 }

 }

 return False

possible pairs

(0,0)

(0,1) (0,2) (0,3) (0,4)

(1,0)

(1,1) (1,2) (1,3) (1,4)

(2,0)

(2,1) (2,2) (2,3) (2,4)

(3,0)

(3,1) (3,2) (3,3) (3,4)

(4,0)

(4,1) (4,2) (4,3) (4,4)

T.C = $O(n^2)$

S.C = $O(1)$

Observation

We see a lot of duplicate pairs

$$(0, 0) \rightarrow (1, 0)$$

$$(0, 2) \rightarrow (2, 0)$$

Duplicates exist on either side of diagonal
so consider 1 side

Optimized Approach

Initially

i = 0	j = [1, 4]
i = 1	j = [2, 4]
i = 2	j = [3, 4]
i = 3	j = [4, 4]

j starts from
i+1 and
goes till (N-1)

Pseudo code

```

bool checkpairs (arr, n, k) {
    for (i=0; i<n; i++) {
        for (j=i+1; j<n; j++) {
            if (arr[i] + arr[j] == k)
                return true
        }
    }
    return False;
}

```

iteration :

i	j	# iteration
0	[1 to (n-1)]	n-1
1	[2 to (n-1)]	n-2
:	:	:
N-1	[N to (n-1)]	0

$$\frac{n(n-1)}{2} \text{ # iteration}$$

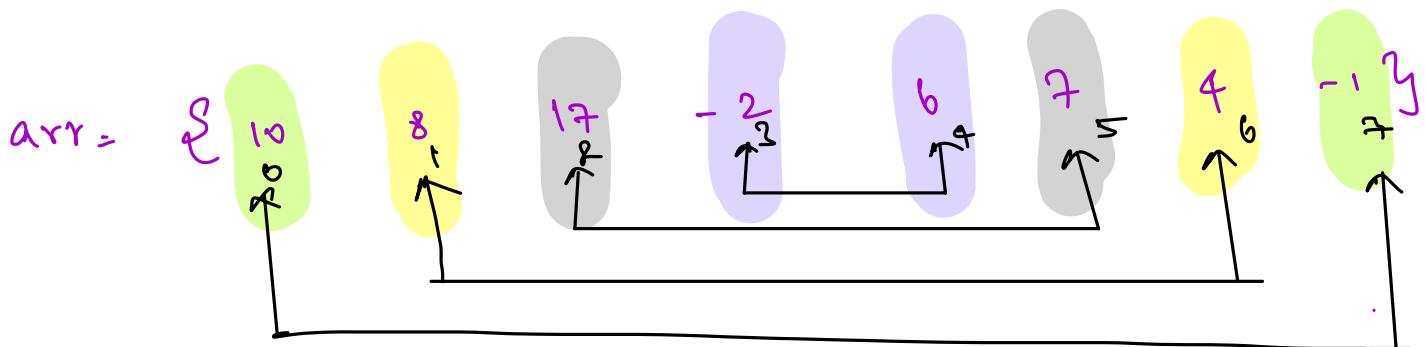
$$T.C = O(n^2)$$

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

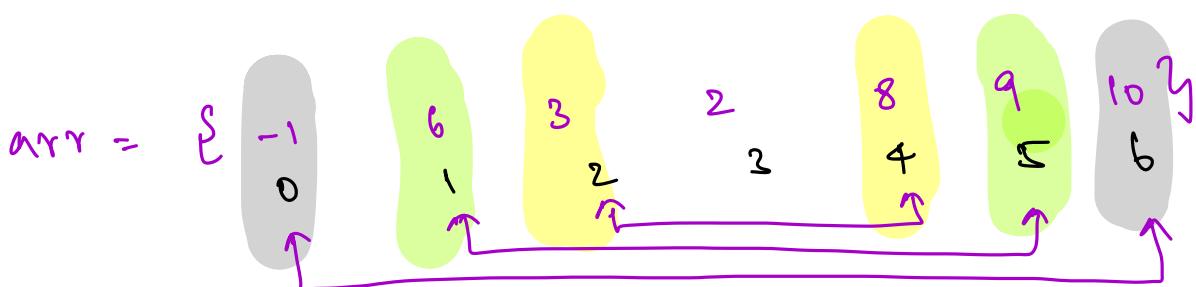
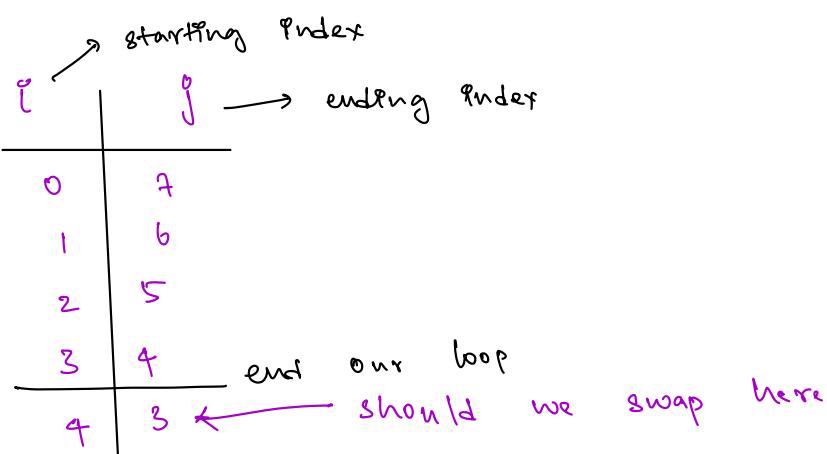
Question 3

Given an array of size 'N'. Reverse the entire array.

Note: Do it in O(1) space complexity

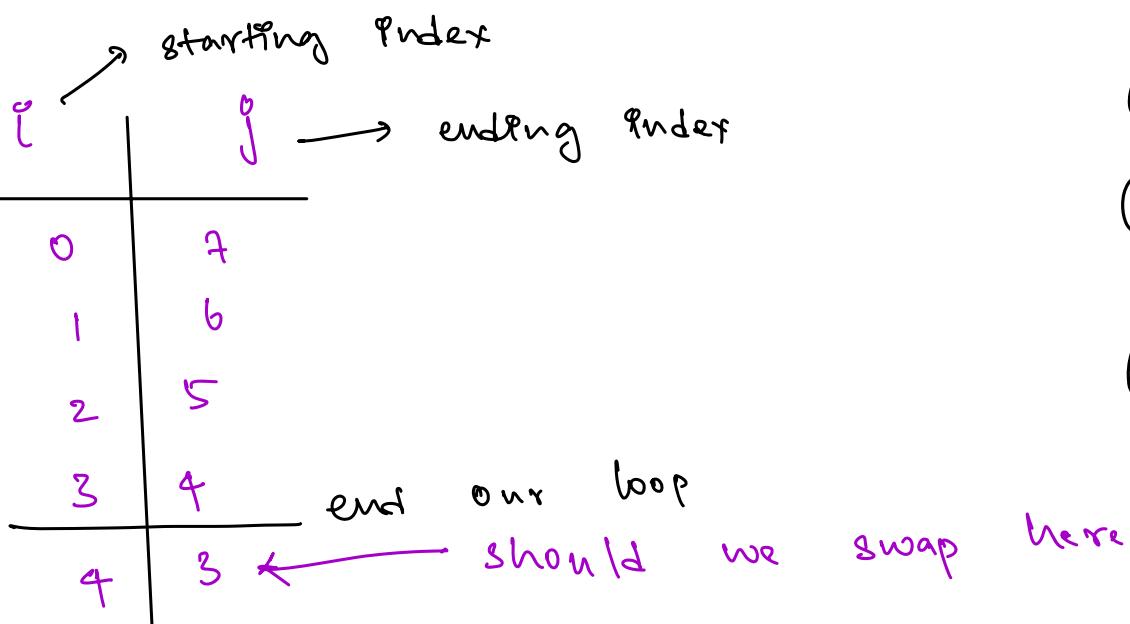


Ans = [-1 4 7 6 -2 17 8 10]



ans = { 10 8 7 6 -2 4 1 0 }

Pseudo Code



Steps

- ① Initialize i, j
- ② Check condition $i < j$
- ③ Increment i
- ④ reducing j

Pseudo code

```
void reverse ( arr , N ) {
```

```
    i = 0 ;   j = N - 1 ;
    while ( i < j ) {
        temp = arr [ i ]
        arr [ i ] = arr [ j ]
        arr [ j ] = temp
        i ++ ;   j -- ;
```

}

}

arr

5	4	3	11	
11	3	7	4	5

$i = 0 \neq 2$

$j = 4 \neq 2$

↓ reverse

5	4	7	3	11
---	---	---	---	----

T.C = $O(n)$

S.C = $O(1)$

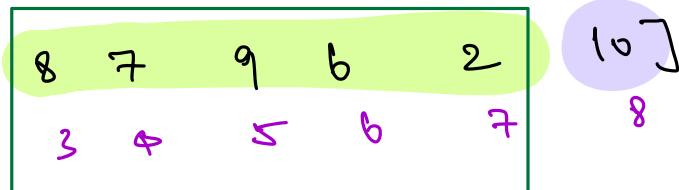
Question 4

Given an array arr of size N and integers l and r. Reverse the array from l to r

example

$$\text{arr} = [-3 \quad 4 \quad 2]$$

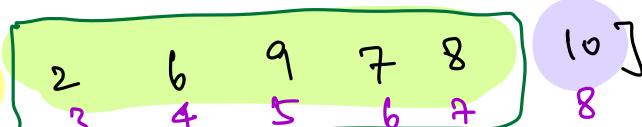
0 1 2



$$l = 3, R = 7$$

$$\text{ans} = [-3 \quad 4 \quad 2]$$

0 1 2



void reverse (arr , N , l , r) { . . . }

$$i = l; j = r;$$

while ($i < j$) {

$$\text{temp} = \text{arr}[i]$$

$$\text{arr}[i] = \text{arr}[j]$$

$$\text{arr}[j] = \text{temp}$$

$$i++; j--;$$

}

}

Direction 5

Given an array of size N , and integer k . Rotate array from last to first by k times.



arr = { 3 -2 1 4 } { 6 9 8 }

$k = 3$

$k = 1$ { 8 3 -2 1 4 } { 6 9 }

$k = 2$ { 9 8 3 -2 1 4 } { 6 }

$k = 3$ { 6 9 8 } { 3 -2 1 4 }

example 2

arr = { 4 1 6 9 2 } { 14 7 8 3 }

$k = 4$

ans = { 14 7 8 3 } { 4 1 6 9 2 }

Bring last elements to front and

front elements to last

Reversing an array brings last elements to

front and front elements to last

arr = { 4 1 6 9 2 14 7 8 3 }
k = 4

reverse arr = { 3 8 7 14 } 2 9 6 1 4
ans = { 14 7 8 3 } 4 1 6 9 2
reverse reversal

last example

arr = { 3 2 7 4 6 1 9 }

k = 5

arr - k = { 9 1 6 4 7 } 2 3

ans = { 7 4 6 1 9 } 3 2

Pseudo code

- ① Reverse the entire arr $\text{reverse}(\text{arr}, N, 0, N-1)$
- ② Reverse first K elements $\text{reverse}(\text{arr}, N, 0, K-1)$
- ③ Reverse second $N-K$ elements $\text{reverse}(\text{arr}, N, K, N-1)$

Amazon answer making

arr = { 3 2 7 5 4 } $K = 7$

array index out of bound

$k=1$ { 4 3 2 7 5 }

$k=2$ { 5 4 3 2 7 }

$k=3$ { 7 5 4 3 2 }

$k=4$ { 2 7 5 4 3 }

$k=5$ { 3 2 7 5 4 }

$k=6$ { 4 3 2 7 5 }

$k=7$ { 5 4 3 2 7 }

$k=8$ { 7 5 4 3 2 }

$k=9$ { 2 7 5 4 3 }

$k=10$ { 3 2 7 5 4 }

When are they repeating

$$k=0 \rightarrow 5 \rightarrow 10 \rightarrow 15$$

$$k=1 \rightarrow 6 \rightarrow 11 \rightarrow 16$$

$$k=2 \rightarrow 7 \rightarrow 12 \rightarrow 17$$

$$k=3 \rightarrow 8 \rightarrow 13 \rightarrow 18$$

$$k=4 \rightarrow 9 \rightarrow 14 \rightarrow 19$$

$n=5$

mod give

same ans

claim

- ① The rotated values repeat periodically
- ② This period is dependent on N ← size of array
- ③ To get base rotation value we should modulo with N

Steps

- ① $k = k \% n$
- ② Reverse entire array
- ③ Reverse array from 0 to $k-1$
- ④ Reverse array from k to $n-1$

Time complexity = $O(n)$

Space complexity = $O(1)$

Dynamic Array

Disadvantages

- ① fixed size
- ② You need to know size before writing the program

Dynamic Array

- Array list do not have fixed size
- Vectors
- List do not have fixed size

Advantages of Array

- $O(1)$ access to element in index

ArrayList

Array [10] → when you declare
array list / list

when you add 3rd element

ArrayList creates new array of
size $2 \times N$
and copies the value

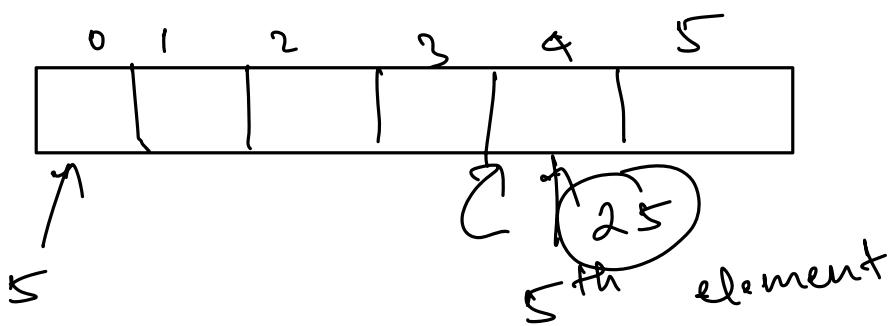
Ammortization T.C

90% we use Dynamic Arrays.

When to use static → size of array
before hand

Dynamic array → if we dont know max
size of array

```
int arr(6)
```



$$\text{base add} + 5 \times 4$$

$$5 + 5 \times 4$$

$$= \boxed{25}$$

Once we get address we can
access the value easily

