

Space Complexity : auxiliary space required.  
↙  
extra space apart from given.

SC  $\rightarrow O(1)$

new array n size  $\rightarrow O(n)$

In-place  $\rightarrow$  no extra space  $O(1)$

SC of bubble sort  $\rightarrow O(1)$

Selection Sort :- pick the smallest element & place it in the start.  $i$  will start from 0

arr = 

0	1	2	3	4
8	6	-2	3	7

$i=0$   $i \downarrow$   
~~8~~<sub>2</sub> 6 - ~~2~~<sub>8</sub> 3 7

-2 6 8 3 7

$i=2$   $i \downarrow$   $m \downarrow$   
 -2 3 ~~8~~<sub>6</sub> ~~6~~<sub>8</sub> 7

-2 3 6 8 7

$i=1$   $i \downarrow$   $m \downarrow$   
-2 ~~6~~<sub>3</sub> 8 ~~3~~<sub>6</sub> 7  
 -2 3 8 6 7

$i=3$   $i \downarrow$   $m \downarrow$   
 -2 3 6 ~~8~~<sub>7</sub> 7<sub>8</sub>

0	1	2	3	4
-2	3	6	7	8

[n-1 sounds sorted]

Pseudo code.

- 1) Traverse from 0 to  $n-1$   
     $\text{int min} = i$
- 2) -traverse from  $i+1$  to  $n$
- 3) "if ( $\text{arr}[j] < \text{arr}[\text{min}]$ )  
     $\text{min} = j$
- 4)  $\text{swap}(i, \text{min})$

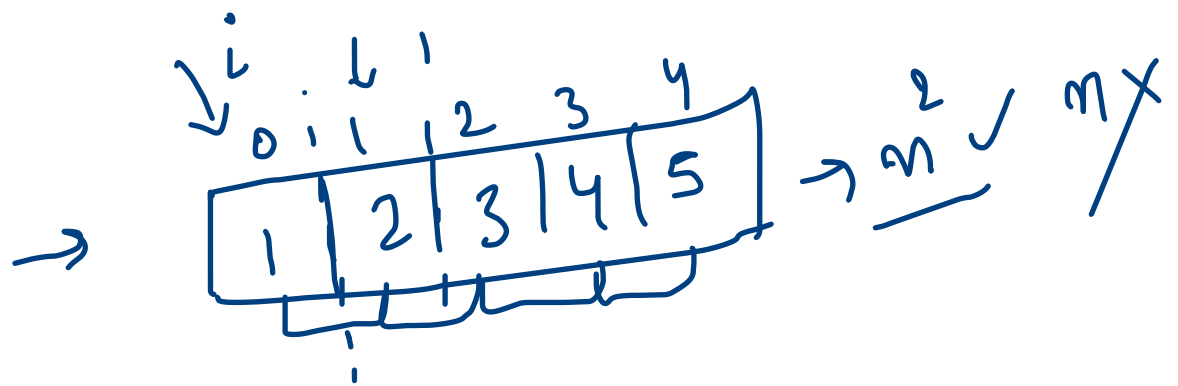
TC.

Best  $\rightarrow O(n^2)$

Avg.  $\rightarrow O(n^2)$

Worst  $\rightarrow O(n^2)$

SC.  $\rightarrow O(1)$



Insertion Sort - Assume that first element is already sorted and others are not. (shifting)

arr = 

0	1	2	3	4
5	9	8	2	1

i = 0  

0	1	2	3	4
5	9	8	2	1

  
sorted:  $i-1$       unsorted:  $i$

5	9
---	---

8	2	1
---	---	---

5	8	9
---	---	---

2	1
---	---

5 8 9 2 1  
5 8 2 9 1  
5 2 8 9 1  
2 5 8 9 1  
2 5 8 1 9  
2 5 1 8 9  
2 1 5 8 9  
1 1 2 5 8 9 → sorted

pseudo-code.

```
for (int i = 1; i < n; i++) {  
    for (int j = i; j > 0; j--) {  
        if (arr[j-1] > arr[j]) {  
            swap(j, j-1)  
        }  
        else {  
            break;  
        }  
    }  
}
```

```

public static void sort(int arr[], int n){
    for(int i = 1; i < n; i++){
        for(int j = i; j > 0; j--){
            if(arr[j-1] > arr[j]){
                swap(j, j-1);
            }
            else{
                break;
            }
        }
    }
    // print
}

```

arr = 

9	8	5	6	2	1
---	---	---	---	---	---

  
0 1 2 3 4 5  
Sorted unsorted

8 9 | 5 6 2 1  
 8 5 9 | 6 2 1  
 5 8 9 | 6 2 1

5 8 6 9 2 1  
 5 6 8 9 | 2 1

$i = 1 < 6$ $j = 1 > 0$ $arr[j-1] = 9 > 8 \uparrow$	$i = 3 < 6$ $j = 3 > 0$ $arr[j-1]$ $9 > 6 \uparrow$
<hr style="border: 0.5px solid red;"/> $i = 2 < 6$ $j = 2 > 0$ $arr[j-1] = 9 > 5 \uparrow$ $j = 1 > 0$ $arr[j-1] = 8 > 5 \uparrow$	$j = 2 > 0$ $arr[j-1] = 8 > 6 \uparrow$ $j = 1 > 0$ $arr[j-1]$ $5 > 1 \uparrow$

$n-1$  iterations

sc.  $\rightarrow \Theta(1)$

TC.

Best -  $O(n)$

Avg -  $O(n^2)$

Worst -  $O(n^2)$

	<u>TC</u>			sp
	B	A	W	
Bubble	$O(n)$	$O(n^2) \cdot O(n^2)$		$O(1)$
Selection	$O(n^2)$	$O(n^2)$	$O(n^2)$	$O(1)$
Insertion	$O(n)$	$O(n^2)$	$O(n^2)$	$O(1)$