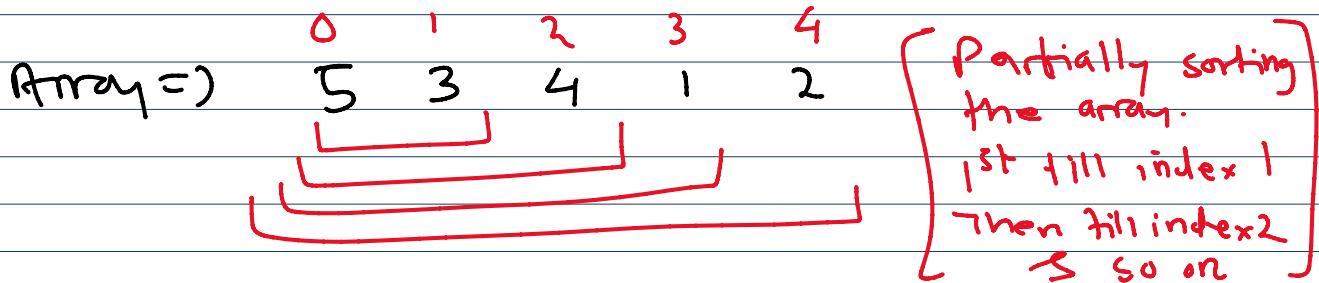


## Insertion Sort

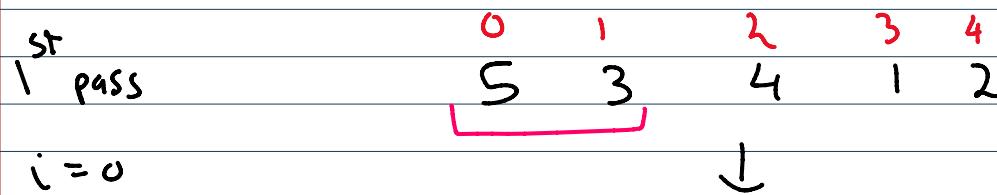
→ In Insertion sort, we partially sort the array till a particular index → then repeat the process till entire array is sorted



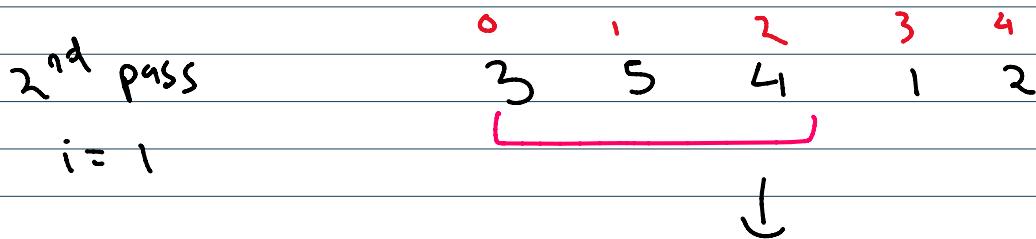
For every index, put that index element at the correct index of LHS

for eg. when index [0,1] is sorted, array will be [3 5 4 1 2]

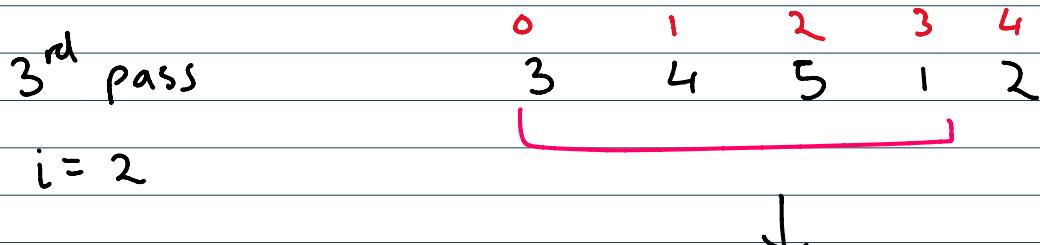
Now when we come to index 2; i.e '4' we will insert it in its correct index, which becomes [3 4 5 1 2]



3 5 4 1 2



3 4 5 1 2



~ ~



1 3 4 5 2

4<sup>th</sup> pass

i = 3

0 1 2 3 4  
1 3 4 5 2



1 2 3 4 5

=> Sorted Array!!

To understand what every 'i' is doing

Outer loop:

0 1 2 3 4      i      j  
5 3 4 1 2      0      1

Sort array till index 1 Pass no. 1

Sort array till index 2 Pass no. 2

Sort array till index 3 Pass no. 3

Sort array till index 4 Pass no. 4

i.e 'i' will run from

0, N-2

length of array

Working

0 1 2 3 4      i (< n-2)      j (> 0)  
5 3 4 1 2      0      1

3 < 5? Yes  
Swap  
j

Swap

3 5 4 1 2

3 5 4  $j$  1 2  
 $4 < 5?$  Yes  
 Swap

3 4 5 1 2

Now, since  $4 > 3$ ; we break  
the loop here. It is because  
the elements in the LHS are  
already sorted

Thus, if ( $j > j-1$ ), break the loop

3 4 5  $j$  1 2  
 $1 < 5?$  Yes  
 Swap

3 4 1 5 2

1  $< 4?$  Yes  
 Swap

3 1 4 5 2

1  $< 3?$  Yes  
 Swap

1 3 4 5 2

1 3 4 5 2  $j$

2  $< 5?$  Yes  
 Swap

3 4

$2 < 5$ ? Yes  
Swap ↴

1 3 4  $\overset{j}{2}$  5

$2 < 4$ ? Yes  
Swap ↴

1 3  $\overset{j}{2}$  4 5

$2 < 3$ ? Yes  
Swap ↴

1  $\overset{j}{2}$  3 4 5

$2 < 1$ ? No  
Break ↴

1 2 3 4 5

Sorted Array

Now, if we take  $i=4$ ,  $j$  will become ' $5$ ' which is index out of bound error. Thus, we take  $i$  till  $(n-2)$ .

### Complexity Analysis

Worst Case:  $O(n^2) \Rightarrow$  Descending array

Best Case:  $O(N) \Rightarrow$  Array is sorted

### Why use Insertion Sort

① Adaptive: Steps get reduced if the array is sorted

[Thus, no of swaps are reduced  $\Rightarrow$  also it's better than bubble sort]

than bubble sort]

② Stable Sorting Algorithm

③ Used for smaller values of 'n': Works good when array is  
partially sorted

Takes part in hybrid  
Sorting Algo

In the further  
videos, there will be  
sort algos which use  
Insertion Sort internally