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Insertion Sort

Insertion sort is a simple sorting algorithm that works similar to the way you sort playing cards in your hands. The array is virtually split into a sorted and an unsorted part. Values from the unsorted part are picked and placed at the correct position in the sorted part.

Characteristics of Insertion Sort:

- This algorithm is one of the simplest algorithm with simple implementation
- Basically, Insertion sort is efficient for small data values
- Insertion sort is adaptive in nature, i.e. it is appropriate for data sets which are already partially sorted.

Working of Insertion Sort algorithm:

> *Consider an example: arr[]: {12, 11, 13, 5, 6}*
>
> ***12 11 13 5 6***
>
> ***First Pass:***
>
> - *Initially, the first two elements of the array are compared in insertion sort.*
>
> | | | | | |
> |---|---|---|---|---|
> | ***12*** | ***11*** | *13* | *5* | *6* |

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- *Here, 12 is greater than 11 hence they are not in the ascending order and 12 is not at its correct position. Thus, swap 11 and 12.*
- *So, for now 11 is stored in a sorted sub-array.*

11	***12***	*13*	*5*	*6*

Second Pass:

- *Now, move to the next two elements and compare them*

11	***12***	***13***	*5*	*6*

- *Here, 13 is greater than 12, thus both elements seems to be in ascending order, hence, no swapping will occur. 12 also stored in a sorted sub-array along with 11*

Third Pass:

- *Now, two elements are present in the sorted sub-array which are **11** and **12***
- *Moving forward to the next two elements which are 13 and 5*

11	*12*	***13***	***5***	*6*

- *Both 5 and 13 are not present at their correct place so swap them*

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11	12	**5**	**13**	6

- *After swapping, elements 12 and 5 are not sorted, thus swap again*

11	**5**	**12**	13	6

- *Here, again 11 and 5 are not sorted, hence swap again*

5	**11**	12	13	6

- *here, it is at its correct position*

Fourth Pass:

- *Now, the elements which are present in the sorted sub-array are **5, 11** and **12***
- *Moving to the next two elements 13 and 6*

5	11	12	**13**	**6**

- *Clearly, they are not sorted, thus perform swap between both*

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5	*11*	*12*	***6***	***13***

- *Now, 6 is smaller than 12, hence, swap again*

5	*11*	***6***	***12***	*13*

- *Here, also swapping makes 11 and 6 unsorted hence, swap again*

5	***6***	***11***	*12*	*13*

- *Finally, the array is completely sorted.*

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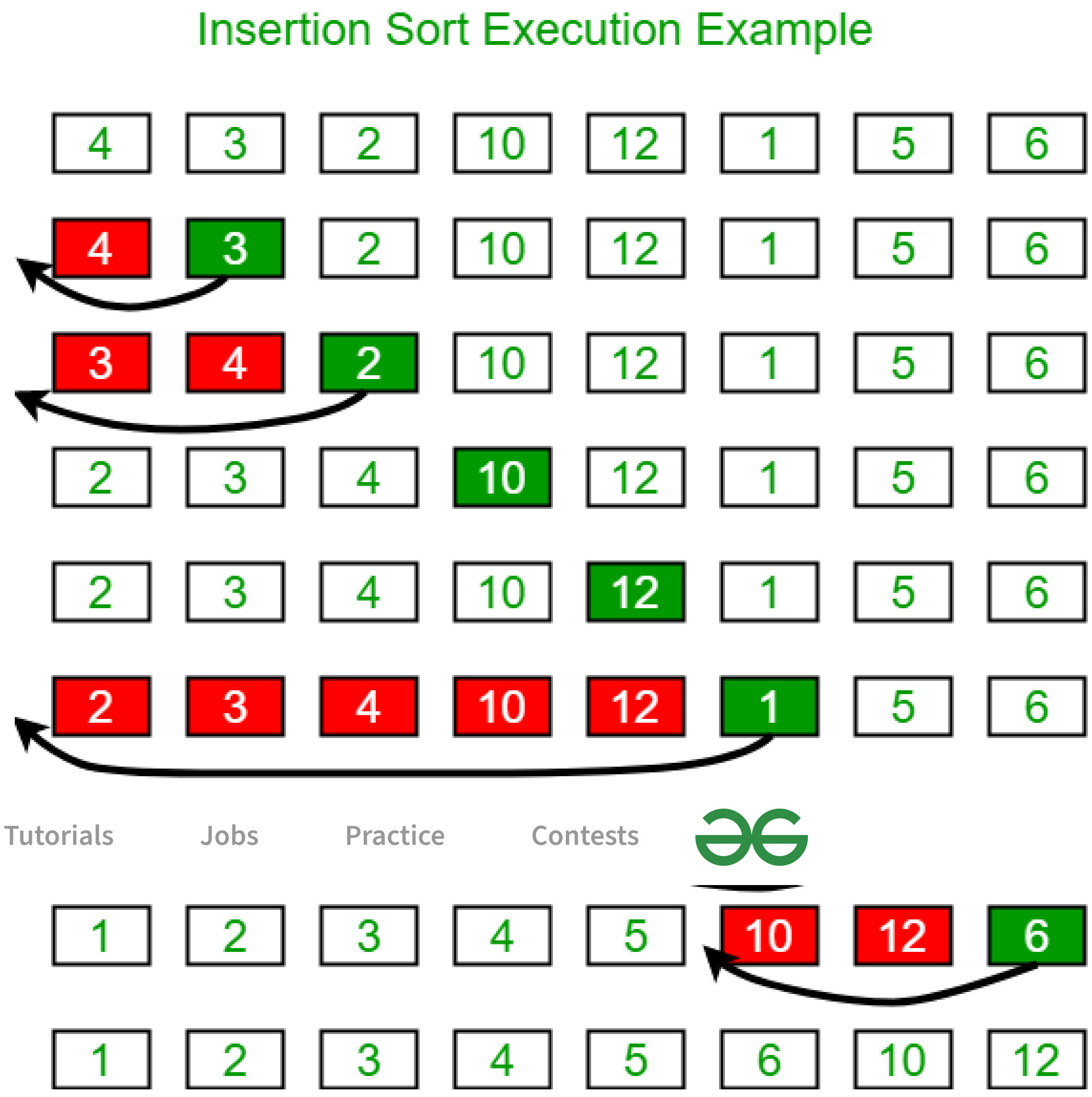

Insertion Sort Execution Example

4	3	2	10	12	1	5	6
4	3	2	10	12	1	5	6
3	4	2	10	12	1	5	6
2	3	4	10	12	1	5	6
2	3	4	10	12	1	5	6
2	3	4	10	12	1	5	6
1	2	3	4	5	10	12	6
1	2	3	4	5	6	10	12

Insertion Sort Algorithm

To sort an array of size N in ascending order:

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- Iterate from arr[1] to arr[N] over the array.
- Compare the current element (key) to its predecessor.
- If the key element is smaller than its predecessor, compare it to the elements before. Move the greater elements one position up to make space for the swapped element.

Implementation

C++ Java

```
// Java program for implementation of Insertion Sort
class InsertionSort {
    /*Function to sort array using insertion sort*/
    void sort(int arr[])
    {
        int n = arr.length;
        for (int i = 1; i < n; ++i) {
            int key = arr[i];
            int j = i - 1;

            /* Move elements of arr[0..i-1], that are
               greater than key, to one position ahead
               of their current position */
            while (j >= 0 && arr[j] > key) {
                arr[j + 1] = arr[j];
                j = j - 1;
            }
            arr[j + 1] = key;
        }
```

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```
    }

    /* A utility function to print array of size n*/
    static void printArray(int arr[])
    {
        int n = arr.length;
        for (int i = 0; i < n; ++i)
            System.out.print(arr[i] + " ");

        System.out.println();
    }

    // Driver method
    public static void main(String args[])
    {
        int arr[] = { 12, 11, 13, 5, 6 };

        InsertionSort ob = new InsertionSort();
        ob.sort(arr);

        printArray(arr);
    }
} /* This code is contributed by Rajat Mishra. */
```

Output

```
5 6 11 12 13
```

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Time Complexity: O(N^2)
Auxiliary Space: O(1)

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