Insertion Sort

Insertion sort is a simple sorting algorithm that works the way we sort playing cards in our hands.

Algorithm

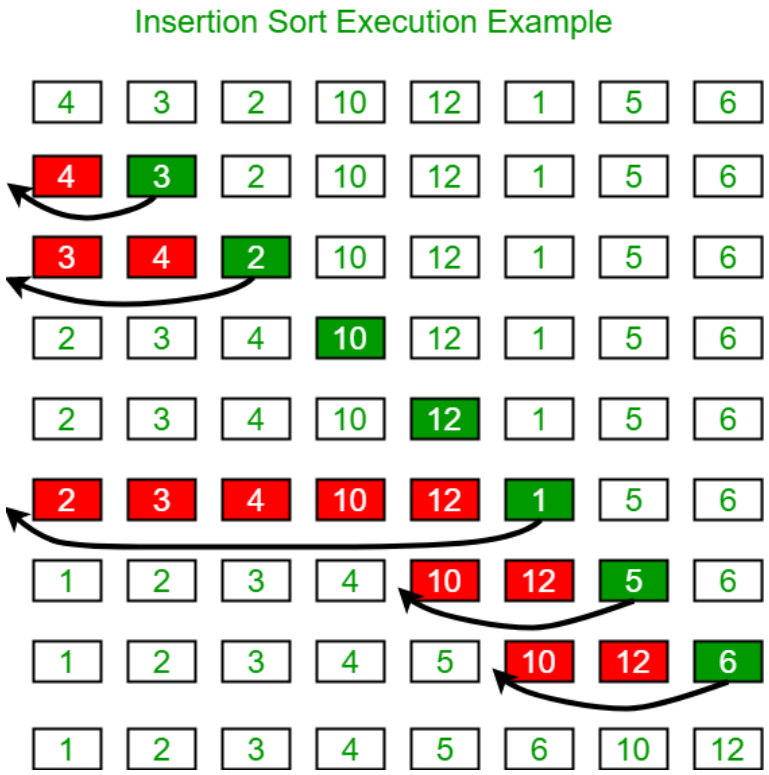
// Sort an arr[] of size n

insertionSort(arr, n)

Loop from i = 1 to n-1.

……a) Pick element arr[i] and insert it into sorted sequence arr[0…i-1]

Example:



Another Example:

12, 11, 13, 5, 6

Let us loop for i = 1 (second element of the array) to 4 (last element of the array)

i = 1. Since 11 is smaller than 12, move 12 and insert 11 before 12

11, 12, 13, 5, 6

i = 2. 13 will remain at its position as all elements in A[0..I-1] are smaller than 13

11, 12, 13, 5, 6

i = 3. 5 will move to the beginning and all other elements from 11 to 13 will move one position ahead of their current position.

5, 11, 12, 13, 6

i = 4. 6 will move to position after 5, and elements from 11 to 13 will move one position ahead of their current position.

5, 6, 11, 12, 13

Recommended: Please solve it on "*PRACTICE*" first, before moving on to the solution.

C++

```
// C++ program for insertion sort
#include <bits/stdc++.h>
using namespace std;

/* Function to sort an array using insertion sort*/
void insertionSort(int arr[], int n)
{
    int i, key, j;
    for (i = 1; i < n; i++)
    {
        key = arr[i];
        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;
    }
}

// A utility function to print an array of size n
void printArray(int arr[], int n)
{
    int i;
    for (i = 0; i < n; i++)
        cout << arr[i] << " ";
    cout << endl;
}

/* Driver code */
int main()
{
    int arr[] = { 12, 11, 13, 5, 6 };
    int n = sizeof(arr) / sizeof(arr[0]);

    insertionSort(arr, n);
    printArray(arr, n);

    return 0;
}

// This is code is contributed by rathbhupendra
```

C

```
// C program for insertion sort
#include <math.h>
#include <stdio.h>

/* Function to sort an array using insertion sort*/
void insertionSort(int arr[], int n)
{
    int i, key, j;
    for (i = 1; i < n; i++) {
        key = arr[i];
        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;
    }
}

// A utility function to print an array of size n
void printArray(int arr[], int n)
{
    int i;
    for (i = 0; i < n; i++)
        printf("%d ", arr[i]);
    printf("\n");
}

/* Driver program to test insertion sort */
int main()
{
    int arr[] = { 12, 11, 13, 5, 6 };
    int n = sizeof(arr) / sizeof(arr[0]);

    insertionSort(arr, n);
    printArray(arr, n);

    return 0;
}
```

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;
        }
    }

    /* 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. */
```

Python

```
# Python program for implementation of Insertion Sort

# Function to do insertion sort
def insertionSort(arr):

    # Traverse through 1 to len(arr)
    for i in range(1, len(arr)):

        key = arr[i]

        # Move elements of arr[0..i-1], that are
        # greater than key, to one position ahead
        # of their current position
        j = i-1
        while j >= 0 and key < arr[j] :
                arr[j + 1] = arr[j]
                j -= 1
        arr[j + 1] = key


# Driver code to test above
arr = [12, 11, 13, 5, 6]
insertionSort(arr)
for i in range(len(arr)):
    print ("% d" % arr[i])

# This code is contributed by Mohit Kumra
```

C#

```
// C# program for implementation of Insertion Sort
using System;

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;
        }
    }

    // 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)
            Console.Write(arr[i] + " ");

        Console.Write("\n");
    }

    // Driver Code
    public static void Main()
    {
        int[] arr = { 12, 11, 13, 5, 6 };
        InsertionSort ob = new InsertionSort();
        ob.sort(arr);
        printArray(arr);
    }
```

```
}

// This code is contributed by ChitraNayal.
```

PHP

```
<?php
// PHP program for insertion sort

// Function to sort an array
// using insertion sort
function insertionSort(&$arr, $n)
{
    for ($i = 1; $i < $n; $i++)
    {
        $key = $arr[$i];
        $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;
    }
}

// A utility function to
// print an array of size n
function printArray(&$arr, $n)
{
    for ($i = 0; $i < $n; $i++)
        echo $arr[$i]." ";
    echo "\n";
}

// Driver Code
$arr = array(12, 11, 13, 5, 6);
$n = sizeof($arr);
insertionSort($arr, $n);
printArray($arr, $n);

// This code is contributed by ChitraNayal.
?>
```

Output:

```
 5 6 11 12 13
```

Time Complexity: O(n*2)

Auxiliary Space: O(1)

Boundary Cases: Insertion sort takes maximum time to sort if elements are sorted in reverse order. And it takes minimum time (Order of n) when elements are already sorted.

Algorithmic Paradigm: Incremental Approach

Sorting In Place: Yes

Stable: Yes

Online: Yes

Uses: Insertion sort is used when number of elements is small. It can also be useful when input array is almost sorted, only few elements are misplaced in complete big array.

What is Binary Insertion Sort?

We can use binary search to reduce the number of comparisons in normal insertion sort. Binary Insertion Sort uses binary search to find the

proper location to insert the selected item at each iteration. In normal insertion, sorting takes O(i) (at ith iteration) in worst case. We can reduce it to O(logi) by using binary search. The algorithm, as a whole, still has a running worst case running time of O(n2) because of the series of swaps required for each insertion. Refer this for implementation.

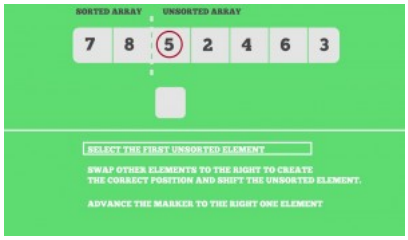
How to implement Insertion Sort for Linked List?

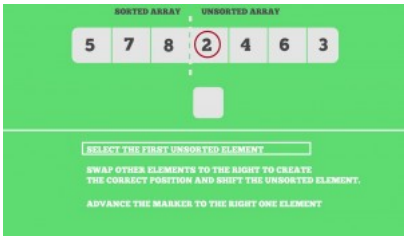
Below is simple insertion sort algorithm for linked list.

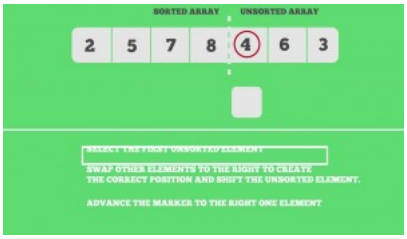
```
1) Create an empty sorted (or result) list
2) Traverse the given list, do following for every node.
.....a) Insert current node in sorted way in sorted or result list.
3) Change head of given linked list to head of sorted (or result) list.
```

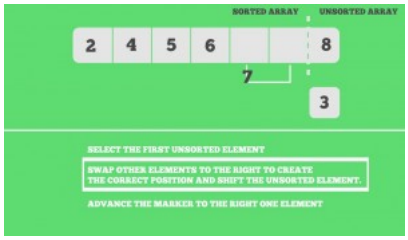
Refer this for implementation.

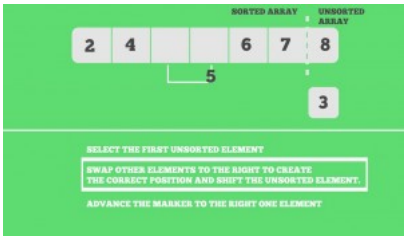
Snapshots:

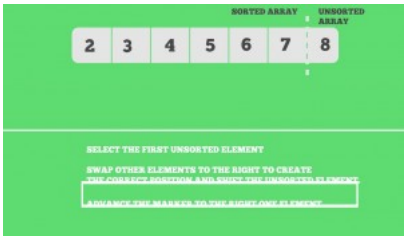












Quiz on Insertion Sort

Other Sorting Algorithms on GeeksforGeeks/GeeksQuiz

Selection Sort, Bubble Sort, Insertion Sort, Merge Sort, Heap Sort, QuickSort, Radix Sort, Counting Sort, Bucket Sort, ShellSort, Comb Sort,

Coding practice for sorting.

Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above.

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