

Code for bubble sort

```
def bubbleSortAscend(arr):  
    for i in range(len(arr)):  
        for j in range(0, len(arr)-i-1):  
            if arr[j] > arr[j+1] :  
                temp=arr[j]  
                arr[j]=arr[j+1]  
                arr[j+1]=temp
```

```
def bubbleSortDescend(arr):  
    for i in range(len(arr)):  
        for j in range(0, len(arr)-i-1):  
            if arr[j] < arr[j+1] :  
                temp=arr[j]  
                arr[j]=arr[j+1]  
                arr[j+1]=temp
```

```
arr = [64, 34, 25, 12, 22, 11, 90]
```

```
bubbleSortAscend(arr)  
print (arr)
```

```
arr = [64, 34, 25, 12, 22, 11, 90]
```

```
bubbleSortDescend(arr)  
print (arr)
```

```
[90, 64, 34, 25, 22, 12, 11]
```

loop invariant property

Loop invariant property: After every i th iteration the rightmost i elements are sorted

Initialisation: Since at the start of the program there is no iteration of any loop, the array is unsorted. After the first iteration the largest element is at the end

Consider the example: arr= arr = [64, 34, 25, 12, 22, 90, 11]

```
arr = [64, 34, 25, 12, 22, 90, 11]  
for j in range(len(arr)-1):  
    if arr[j] > arr[j+1] :  
        temp=arr[j]  
        arr[j]=arr[j+1]  
        arr[j+1]=temp
```

```
print(arr)
```

```
[34, 25, 12, 22, 64, 11, 90]
```

Maintenance: At the beginning of the iteration of a loop, the rightmost section of the array is sorted. And at the end of that iteration of the loop another element is added to that sorted part of the array i.e. after the (i+1)th iteration 1 element is added to the sorted part of array that contains i elements(implies now there are i+1 sorted elements)

Example

```
print("Before the 2nd iteration: arr= ",arr)
for j in range(len(arr)-1):
    if arr[j] > arr[j+1] :
        temp=arr[j]
        arr[j]=arr[j+1]
        arr[j+1]=temp

print("After the 2nd iteration: arr=",arr)
```

Before the 2nd iteration: arr= [34, 25, 12, 22, 64, 11, 90]
After the 2nd iteration: arr= [25, 12, 22, 34, 11, 64, 90]

Termination: Once the loop runs for len(arr) number of times, all the elements in the array are sorted and the program returns the sorted array.

Similarly we can prove for descending order bubble sort