# Correctness and the Loop Invariant

by HackerRank



In the previous challenge, you wrote code to perform an *Insertion Sort* on an unsorted array. But how would you prove that the code is correct? I.e. how do you show that for any input your code will provide the right output?

**Loop Invariant**

In computer science, you could prove it formally with a *loop invariant*, where you state that a desired property is maintained in your loop. Such a proof is broken down into the following parts:

- *Initialization*: It is true (in a limited sense) before the loop runs.
- *Maintenance*: If it's true before an iteration of a loop, it remains true before the next iteration.
- *Termination*: It will terminate in a useful way once it is finished.

**Insertion Sort's Invariant**

Say, you have some InsertionSort code, where the outer loop goes through the whole array $A$:

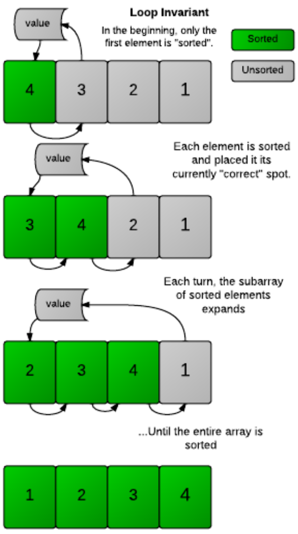
```
for(int i = 1; i < A.length; i++){
//insertion sort code
```

You could then state the following loop invariant:

> At the start of every iteration of the outer loop (indexed with $i$), the subarray until $ar[i]$ consists of the original elements that were there, but in sorted order.

To prove Insertion Sort is correct, you will then demonstrate it for the three stages:

- *Initialization* - The subarray starts with the first element of the array, and it is (obviously) sorted to begin with.
- *Maintenance* - Each iteration of the loop expands the subarray, but keeps the sorted property. An element $V$ gets inserted into the array only when it is greater than the element to its left. Since the elements to its left have already been sorted, it means $V$ is greater than all the elements to its left, so the array remains sorted. (In *Insertion Sort 2* we saw this by printing the array each time an element was properly inserted.)
- *Termination* - The code will terminate after $i$ has reached the last element in the array, which means the sorted subarray has expanded to encompass the entire array. The array is now fully sorted.




You can often use a similar process to demonstrate the correctness of many algorithms. You can see these notes for more information.

**Challenge**

Loading...

In the InsertionSort code below, there is an error. Can you fix it? Print the array only once, when it is fully sorted.

**Details**
The Input format and the constraints are the same as in the previous challenges and are presented below.

**Input Format**
There will be two lines of input:

- $s$ - the size of the array
- $ar$ - the list of numbers that makes up the array

**Output Format**
Output the numbers in order, space-separated.

**Constraints**
$1 \leq s \leq 1000$
$-1500 \leq V \leq 1500, V \in ar$

**Sample Input**

```
6
1 4 3 5 6 2
```

**Sample Output**

```
1 2 3 4 5 6
```

**Submissions:** 43999
**Max Score:** 30
**Difficulty:** Easy

**Rate This Challenge:**

More