



ALBERT-LUDWIGS-  
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Hand in solutions via email to  
[christj@informatik.uni-freiburg.de](mailto:christj@informatik.uni-freiburg.de)  
until 23.11.2011 (only Java sources and  
PDFs accepted)

## Tutorials for “Formal methods for Java” Exercise sheet 4

### Exercise 1: ESC/Java 2 installation

Download and install ESC/Java 2 from <http://kind.ucd.ie/products/opensource/ESCJava2/releases/ESCJava2.0.5.html>.

### Exercise 2: Insertion Sort

Consider the following (buggy) implementation of an insertion sort algorithm.

```
class InsertionSort {
    class Node
    {
        public int key;
        public Object value;
    }

    public static void sort(Node[] arr) {
        for(int i = 1; i <= arr.length; i++) {
            for(int j = i; j >= 0; j--) {
                if (arr[j].key >= arr[j-1].key) {
                    Node tmp = arr[j];
                    arr[j] = arr[j-1];
                    arr[j] = tmp;
                }
            }
        }
    }
}
```

Use ESC/Java 2 to eliminate all runtime errors in the implementation. You may need to add a pre-condition to the specification, and increase the loop unrolling factor (command line parameter `-Loop`).

### Exercise 3: Insertion Sort (cont.)

Add the following post-condition for the method `sort`:

```
/*@ ensures (\forall int i; i >= 1 && i < arr.length;  
  @      arr[i].key >= arr[i-1].key); @*/
```

Modify the code such that this post-condition is established.