

Laboratory: *Reasoning about Programs II (The Java Modeling Language)*

Objectives

1. Proving program correctness using JML and ESC/Java2.

Preliminaries

Usage of the tool can be done in three ways:

1. Access directly the tool in the browser: [`https://www.rise4fun.com/OpenJMLES/`](https://www.rise4fun.com/OpenJMLES/).
2. As a a command-line Java application or as an Eclipse plugin: [`http://www.openjml.org/downloads/`](http://www.openjml.org/downloads/).

Examples

Example 1. *Analyze the corectness of the following code:*

```
int i = n;
int s = 0;
/*@ loop invariant i+s == n;
   *@ decreases i+1;
   while (i >= 0)
   {
       i = i-1;
       s = s+1;
   }
```

Example 2. *Analyze the correctness of the following code:*

```
/*@ requires y >= 0;
   *@ ensures \result >= 0 && \result * \result <= y
   @ && y < (\result+1)*(\result+1);
   @*/
static int isqrt(int y)
{
    return (int) Math.sqrt(y);
}
```

Example 3. *Fill out the method `swap`. Prove its correctness.*

```

// swap a[i] and a[j], leave rest of array unchanged
/*@ requires a!=null && 0<=i && i<a.length && 0<=j && j<a.length;
@ ensures a[i] = \old(a[j]) && a[j] == \old(a[i]) && @ (\forall int k; 0 <= k && k < a.length;
@ (k != i && k != j) ==> a[k] == \old(a[k]));
@*/
static void swap(int[] a, int i, int j) { ... }

```

Example 4. Fill out the informal property expression and the method `sort`. Prove its correctness.

```

//sort array a in ascending order
/*@ requires a!=null;
@ ensures (* a contains the same elements as before the call *)
@ && (\forall int i; 0 <= i && i < a.length-1; a[i] <= a[i+1]);
@*/
static void sort(int[] a) { ... }

```

Example 5. Fill out the method `findFirst`. Prove its correctness.

```

//return index of first occurrence of x in a, -1 if x is not in a
/*@ requires a!=null;
@ ensures (\result == -1 && (\forall int i; 0 <= i && i < a.length; @ a[i] != x) ) ||
@ (0 <= \result && \result < a.length && a[\result] == x
@ && (\forall int i; 0 <= i && i < \result; a[i] != x));
@*/
static int findFirst(int[] a, int x) { ... }

```