Announcements

- Lab tomorrow
  - Exceptions and unit testing
- Quiz Thursday
- P3 due Friday

Follow-ups

- Exceptions and Try-catch
  - Using try-catch with loops
  - Comparison to switch vs. if-else if
  - Realistic examples

Unit testing

- Testing is a critical part of real-world software development
- “Unit testing”: running a series of automated tests on each conceptual “unit” of code
  - Each class might be treated as a unit
  - Individual methods might be treated as units
- Unit tests are written by developers (i.e. you!)
  - Going forward you may be expected to write your own tests on labs and projects
- Ideally every possible scenario gets tested
  - Each possible branch of execution

Unit testing

Example of “exhaustive” testing:
myLine.toString() -> e.g. “3.0*x – 2.0”

Suppose our spec has the following requirements:

- If b is negative, no ‘+’ sign (not “3.0*x + –2.0”)
- If m or b is zero, don’t print

How many logical branches are there?

Unit testing

Example of “exhaustive” testing:

The pentium floating-point division bug

- http://en.wikipedia.org/wiki/Pentium_FDIV_bug
- Identified by a mathematician (Thomas R. Nicely) who was enumerating twin primes.

Unit testing

Corner cases

- Pathological cases that often get missed in a "first draft" implementation.
  - E.g. An implementation of list insertion may work correctly in the middle of the list, but not at the first or last position.

Error cases

- Testing cases where methods are "supposed" to fail (throw exceptions) on bad input.

The JUnit testing framework

- A popular framework for writing unit tests in Java.
  - http://junit.org/
  - Included with your Eclipse installation:

    File -> New -> Junit Test case
- Based around “assertions”
  - The typical unit test will initialize some objects, call some methods, and then make assertions about their various states
  - If the assertion is false the test will fail.

Testing Syntax (JUnit 4)

```
import static org.junit.Assert.*;
import org.junit.Test;

public class JUnit4Tests {

        @Test
        public void testMyObj() {
                MyObj obj1 = new MyObj(3);
                assertTrue(obj1.data == 3);
        }

        @Test
        public void testMyObjMethod1() {…}

        …
}
```

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Test sets are classes too

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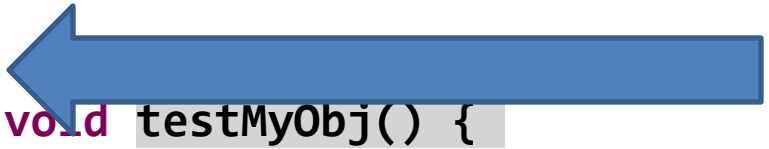
```



"@Test" before every unit test

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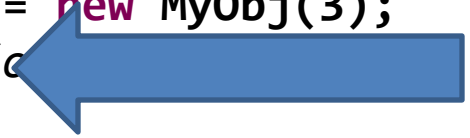

Assertion of expected outcome

Other JUnit 4 syntax

- Other “Annotations”
  - @Before, @After: Can be used to do some set-up/clean-up, like initializing objects that other tests will use
- Other assertions
  - assertFalse(*boolean expression*)
  - assertSame(*variable1, variable2*): Compares variable1 and variable2 (either primitive or reference) with ==.
  - assertEquals(*variable1, variable2*): Compares using variable1.equals(variable2). Requires a special version of equals we have not fully covered yet.
    - When used with primitives, behaves according to ==.

JUnit 3

- An older version of JUnit, you may still see it used in some labs/projects for legacy reasons.
- Both versions 3 & 4 can be used in one project (but separate classes).
- JUnit 4 seems to be generally preferable.

  http://sanjaal.com/java/981/java-unit-testing-and-junit/10-differences-between-junit-3-x-and-junit-4-x-and-why-you-should-move-to-junit-4-x-platform/

More on reference

“Reference” ↔ “Memory address”

- Terminology:
  - “Reference variable”: a variable that stores the memory address of an object (any variable that is not a primitive data type)

    e.g. `MyObj obj1 = new MyObj();`
  - “De-referencing”: Accessing data or calling methods via a reference variable

    e.g. `obj1.getData();`

More on reference

“Reference” ↔ “Memory address”

- Terminology:
  - “Call by value”: A method call where the parameters are assigned *copies* of the argument values
  - “Call by reference”: A method call where the parameters are assigned *references* to the arguments
- Java is often said to be “call by reference”, since an object is not copied in RAM every time its reference is passed to a method.
  - On the other hand, one might say that Java is call by value, but the “values” of reference variables are memory addresses.

Copy constructors

Sometimes we *do* want to copy objects: Allocating a new object in memory, but with identical fields to the original.

```
MyObj obj2 = new MyObj();
obj2.a = obj1.a;
obj2.b = obj1.b;
obj2.c = obj1.c;
//OR
MyObj obj2 = new MyObj(obj1.a, obj1.b, ...);
```

Copy constructors

“Copy constructors” allow a more convenient usage.

```
//Usage:
MyObj obj2 = new MyObj(obj1);

//Implementation:
public MyObj(MyObj orig) {
      this.a = orig.a;
      this.b = orig.b;
      ...
}
```

Prep for Lab05

- BigInt implementation
  - Using and testing linked lists, throwing out of bounds exceptions
  - Copying linked lists
  - Algorithm for adding two BigInts