1.00 Lecture 5

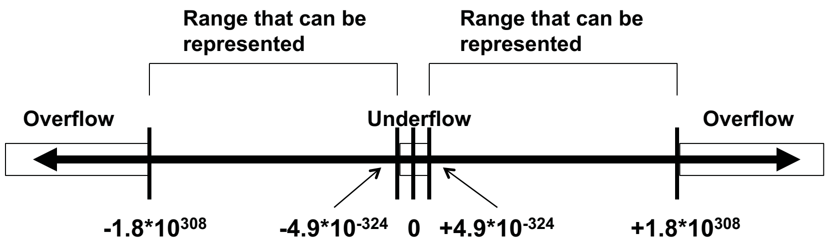
More Data Types,
Control Structures
Introduction to Methods

Reading for next time: Big Java: 2.1-2.5, 8.8

Floating Point Anomalies

- Anomalous floating point values:
  - Undefined, such as 0.0/0.0:
    - `0.0/0.0` produces result `NaN` (Not a Number)
    - Any operation involving `NaN` produces `NaN` as result
    - Two `NaN` values cannot be equal
    - Check if number is `NaN` by using methods:
      - `Double.isNaN(double d)` or `Float.isNAN(float f)`
      - Methods return boolean which is true if argument is `NaN`
  - Overflow, such as 1.0/0.0:
    - `1.0/0.0` produces result `Infinity`
    - Same rules, results as for `NaN`:
      `Double.isInfinite(double d)`
  - Underflow, when result is smaller than smallest possible number we can represent (absolute value)
    - Complex condition to detect, usually get zero result

Range of double precision numbers



Example

```
public class NaNTest {
    public static void main(String[] args) {
        double a=0.0, b=0.0, c, d;
        c= a/b;
        System.out.println("c: " + c);
        if (Double.isNaN(c))
            System.out.println("  c is NaN");
        d= c + 1.0;
        System.out.println("d: " + d);
        if (Double.isNaN(d))
            System.out.println("  d is NaN");
        if (c == d)
            System.out.println("Oops");
        else
            System.out.println("NaN != NaN");
        double e= 1.0, f;
        f= e/a;
        System.out.println("f: " + f);
        if (Double.isInfinite(f))
            System.out.println("  f is infinite");
    }
}
```

Example

```
public class NaNTest {
    public static void main(String[] args) {
        double a=0.0, b=0.0, c, d;
        c= a/b;
        System.out.println("c: " + c);        // c: NaN
        if (Double.isNaN(c))
            System.out.println("  c is NaN"); // c is NaN
        d= c + 1.0;
        System.out.println("d: " + d);        // d: NaN
        if (Double.isNaN(d))
            System.out.println("  d is NaN"); // d is NaN
        if (c == d)
            System.out.println("Oops");
        else
            System.out.println("NaN != NaN"); // NaN != NaN
        double e= 1.0, f;
        f= e/a;
        System.out.println("f: " + f);        // f: Infinity
        if (Double.isInfinite(f))
            System.out.println("  f is infinite"); // f is infinite
    }
}
```

Doubles Are Bad Loop Counters

```
// Suppose we have a stepper motor we want to move from
// x= 0 to x= 10 in increments of 0.2

public class Counter {
    public static void main(String[] args) {
        int i= 0;
        double x= 0.0;
        while (x < 10.0) {
            x += 0.2;
            i++;
            if ( i % 10 == 0 || i >= 48)
              System.out.println(“x: " + x + " i: " + i);
       }
    }
}
```

Doubles Are Bad Loop Counters

```
i : 10 x : 1.9999999999999998
i : 20 x : 4.000000000000001
i : 30 x : 6.000000000000003
i : 40 x : 8.000000000000004
i : 48 x : 9.599999999999998
i : 49 x : 9.799999999999997
i : 50 x : 9.999999999999996
i : 51 x : 10.199999999999996
```

Notice accumulating, increasing error.
Don't use floats or doubles as loop counters

We went one iteration too many

Exercise

- **Create a class InverseTest. In main():**
  - **Set xStart= 0.0, xEnd= 2.0, deltax= 0.1**
  - **Write a 'for' loop on x from xStart to xEnd, incrementing x by deltax each time**
    - **Use double TOLERANCE = 1E-14 to terminate the loop at the correct point. Without TOLERANCE, it won't.**
  - **Output x**
  - **Compute and output 1/(xEnd - x)**
  - **See next slide for some of the code**
- **What should happen at the end of the loop?**
  - **Does Java catch the zero divide?**
- **If you have time:**
  - **Implement this with an int loop counter**
  - **Does this necessarily fix all the problems?**

Exercise

```
public class InverseTest {
   public static void main(String[] args) {
        double xStart= 0.0, xEnd= 2.0, deltax= 0.1;
        final double TOLERANCE= 1E-14;
        for (…)  {      // Your code here
        // Loop on x, which goes from xStart to xEnd
        //   in steps of deltax
        // Output x
        // Compute and output 1/(xEnd-x)

        }
   }
}
```

Numerical Problems

Problem	Integer	Float, double
Zero divide	Program terminates (throws an exception)	Infinity
0/0	Program terminates (throws an exception)	NaN (not a number)
Overflow	No warning. Program gives wrong results.	Infinity
Underflow	Not possible	No warning, set to 0 usually
Rounding, accumulation errors	Not possible	No warning. Program gives wrong results.

Common, “bad news” cases

More on Control Structures

- Three control structures in Java, or any language:
  - Sequence: execute next statement
    - This is default behavior
  - Branching: if, else statements
    - If, else are the primary construct used
    - Switch statement used if many choices
  - Iteration: while, do, for loops
    - Additional constructs exist to terminate loops 'prematurely'

Terminating Iteration: Break

- Break statement in for, while or do-while loops transfers control to statement immediately after end of loop

```
public class BreakTest {
  public static void main(String[] args) {
     for (int i = 0; i < 6; i++) {
            if (i >= 3)
                   break;       // End loop
            System.out.println("i: "+i);
     }
     System.out.println("Done");
  }
}
// What will this print?
// If "break" in inner, nested loop, control is
// transferred to the outer loop
```

Terminating Iteration: Continue

- **Continue statement jumps to end of loop but continues looping**

```
public class ContinueTest {
  public static void main(String[] args) {
       for (int i = 0; i < 6; i++) {
              if (i < 4)
                     continue;    // Skip rest of loop
              System.out.println("i: "+i);
       }
       System.out.println("Done");
   }
}
// What will this print?
// If "continue" in inner, nested loop, control stays
// in inner loop
```

Control exercise

- **Write a class LoopExercise:**
  - **main() method has:**
    - **Loop over int i going from 0 through 8**
      - **Make j = i^2-5**
      - **If j negative, skip the rest of the loop**
      - **Find s= square root of j (use Math.sqrt(j);)**
      - **If s > 4, end the loop**
      - **Output i, j and s to see what's happening**
    - **Print "Done" at the end of the program**
    - **This is characteristic of, e.g., gearbox design problem:**
      - **Integer number of teeth**
      - **Double diameter**
      - **Minima and maxima for gear ratios, rpms, etc.**
      - **Loop to find feasible ones (skip rest of loop if infeasible)**
      - **If feasible, search for best (end the loop when found)**

Java Methods

- Methods are discrete units of behavior
  - You've already used some:
    - JOptionPane.showInputDialog()
    - Math.sqrt()
    - System.out.println()
  - You'll write your own for the rest of the term, as part of classes
  - Right now, you are writing classes but they only have a main() method and they create no objects
  - We'll write additional methods in our classes
  - (And then create objects that have methods)
  - For now, our methods will have the keywords `public static` in them
    - Treat them as an incantation for this and the next lecture

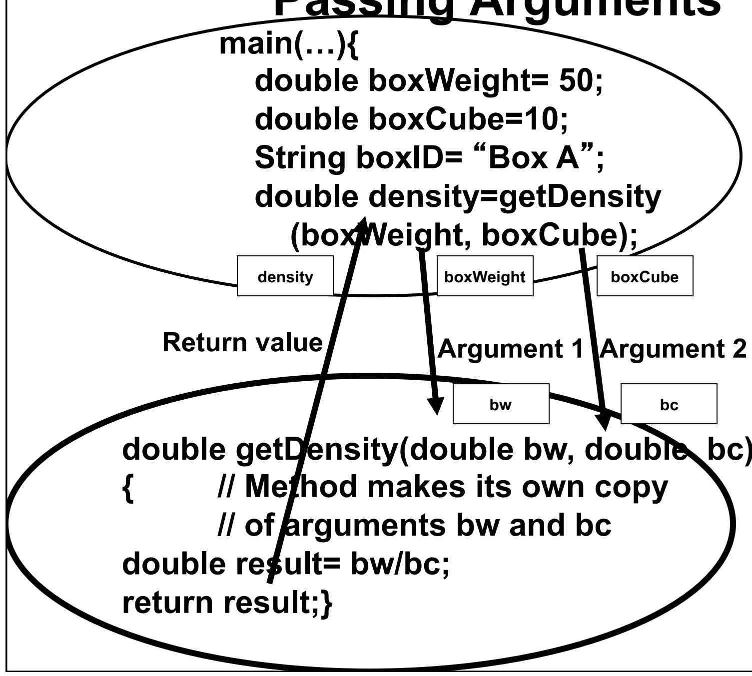
Java Methods

- Methods are the interface or communications between program components
  - They provide a way to invoke the same operation from many places in your program, avoiding code repetition
  - They hide implementation details from the component using the method
  - Variables defined within a method are not visible to users of the method; they have <u>local scope</u> within the method
  - The method cannot see variables in the component that calls it either. There is logical separation between the two, which avoids conflicts in variable names

Method example

```
public class MethodExample {
   public static void main(String[] args) {
        double boxWeight= 50;
        double boxCube= 10;
        String boxID= "Box A";
        double density= getDensity(boxWeight, boxCube);
        System.out.println("Density: "+ density);
        printBox(boxWeight, boxCube); // Prints density 2nd time
   }
   public static double getDensity(double bw, double bc) {
         double result= bw/bc;  // 'result' could be 'density'
         return result;
   }
   public static void printBox(double w, double c) {
         System.out.println("Box weight: "+w+" cube: "+c);
         System.out.println(" Density: "+getDensity(w,c));
//       System.out.println(" ID: "+boxID);  // No access to ID
   }                                         // Won't compile!
}
```

Passing Arguments



- Communi-cation only via arg list, return value
- Arguments matched by position
- Data type, meaning must match
- Explore with debugger

1.00 / 1.001 / 1.002 Introduction to Computers and Engineering Problem Solving
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