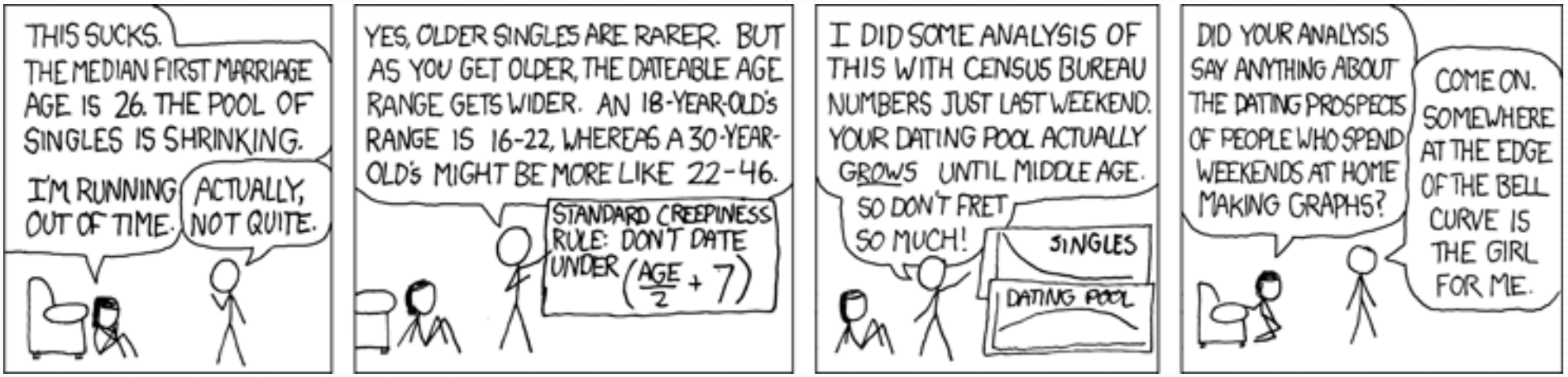
Building Java Programs

Chapter 3
Lecture 3-2: Return values, `Math`, and `double`

reading: 3.2, 2.1 - 2.2


THIS SUCKS. THE MEDIAN FIRST MARRIAGE AGE IS 26. THE POOL OF SINGLES IS SHRINKING.
I'M RUNNING OUT OF TIME.
ACTUALLY, NOT QUITE.
YES, OLDER SINGLES ARE RARER. BUT AS YOU GET OLDER, THE DATEABLE AGE RANGE GETS WIDER. AN 18-YEAR-OLD'S RANGE IS 16-22, WHEREAS A 30-YEAR-OLD'S MIGHT BE MORE LIKE 22-46.
STANDARD CREEPINESS RULE: DON'T DATE UNDER (AGE/2 + 7)
I DID SOME ANALYSIS OF THIS WITH CENSUS BUREAU NUMBERS JUST LAST WEEKEND. YOUR DATING POOL ACTUALLY GROWS UNTIL MIDDLE AGE. SO DON'T FRET SO MUCH!
SINGLES
DATING POOL
DID YOUR ANALYSIS SAY ANYTHING ABOUT THE DATING PROSPECTS OF PEOPLE WHO SPEND WEEKENDS AT HOME MAKING GRAPHS?
COME ON. SOMEWHERE AT THE EDGE OF THE BELL CURVE IS THE GIRL FOR ME.

Java's `Math` class

Method name	Description
`Math.abs(`*value*`)`	absolute value
`Math.ceil(`*value*`)`	rounds up
`Math.floor(`*value*`)`	rounds down
`Math.log10(`*value*`)`	logarithm, base 10
`Math.max(`*value1*`, `*value2*`)`	larger of two values
`Math.min(`*value1*`, `*value2*`)`	smaller of two values
`Math.pow(`*base*`, `*exp*`)`	*base* to the *exp* power
`Math.random()`	random `double` between 0 and 1
`Math.round(`*value*`)`	nearest whole number
`Math.sqrt(`*value*`)`	square root

`Math.sin(`*value*`)`
`Math.cos(`*value*`)`
`Math.tan(`*value*`)`
	sine/cosine/tangent of an angle in radians

`Math.toDegrees(`*value*`)` `Math.toRadians(`*value*`)`	convert degrees to radians and back

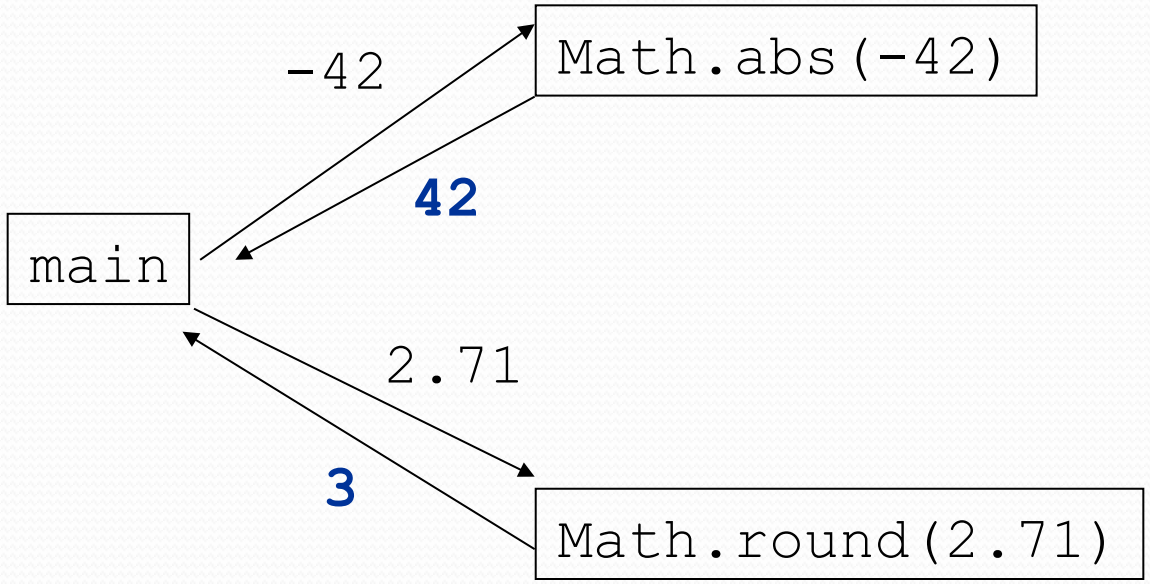
Constant	Description
`Math.E`	2.7182818...
`Math.PI`	3.1415926...

No output?

- Simply calling these methods produces no visible result.
  - `Math.pow(3, 4);  // no output`
- Math method calls use a Java feature called *return values* that cause them to be treated as expressions.
- The program runs the method, computes the answer, and then "replaces" the call with its computed result value.
  - ~~`Math.pow(3, 4);`~~ `// no output`
    `81.0;` `// no output`
- To see the result, we must print it or store it in a variable.
  - `double result = Math.pow(3, 4);`
  - `System.out.println(result);  // 81.0`

Return

- **return**: To send out a value as the result of a method.
  - Return values send information *out* from a method to its caller.
    - A call to the method can be used as part of an expression.
  - (Compare to parameters which send values *into* a method)



`Math` questions

- Evaluate the following expressions:
  - `Math.abs(-1.23)`
  - `Math.pow(3, 2)`
  - `Math.pow(10, -2)`
  - `Math.sqrt(121.0) - Math.sqrt(256.0)`
  - `Math.round(Math.PI) + Math.round(Math.E)`
  - `Math.ceil(6.022) + Math.floor(15.9994)`
  - `Math.abs(Math.min(-3, -5))`

- `Math.max` and `Math.min` can be used to bound numbers.

  Consider an `int` variable named `age`.
  - What statement would replace negative ages with 0?
  - What statement would cap the maximum age to 40?

Why return and not print?

- It might seem more useful for the `Math` methods to print their results rather than returning them. Why don't they?

- Answer: Returning is more flexible than printing.
  - We can compute several things before printing:

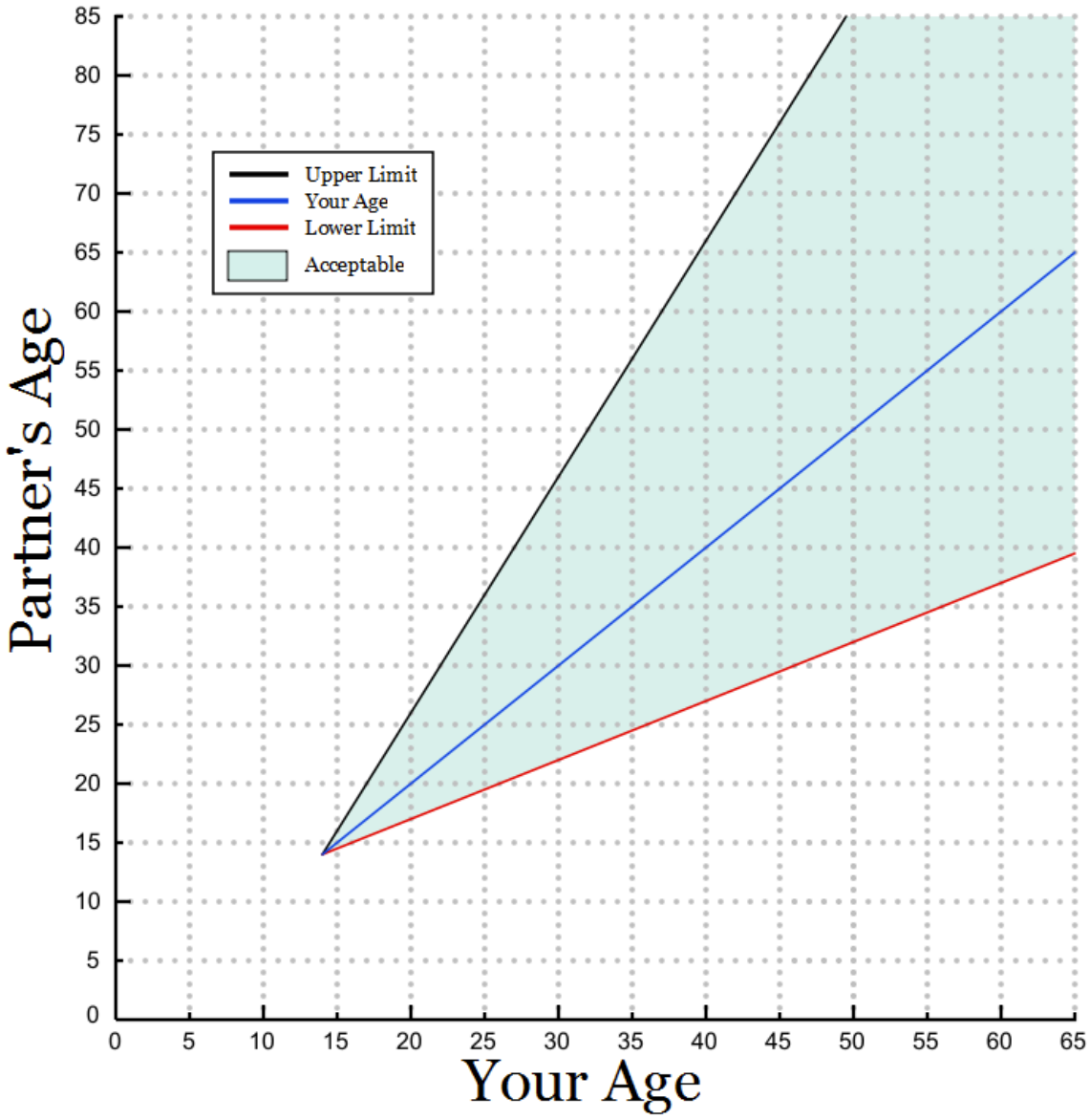
```
double pow1 = Math.pow(3, 4);
double pow2 = Math.pow(10, 6);
System.out.println("Powers are " + pow1 + " and " + pow2);
```

  - We can combine the results of many computations:

```
double k = 13 * Math.pow(3, 4) + 5 - Math.sqrt(17.8);
```

Write a method that, given an age, returns the minimum appropriate age to date

Minimum dating age =
age / 2 + 7



Returning a value

```
public static type name(parameters) {
    statements;
    ...
    return expression;
}
```

- When Java reaches a return statement:
  - it evaluates the expression
  - it substitutes the return value in place of the call
  - it goes back to the caller and continues after the method call

Return examples

```
// Calculates the minimum acceptable dating age.
public static int minimumDatingAge(int age) {
    int minimumAge = age / 2 + 7;
    return minimumAge;
}
```

- You can shorten the examples by returning an expression:

```
public static int minimumDatingAge(int age) {
    return age / 2 + 7;
}
```

More Return examples

```
// Converts degrees Fahrenheit to Celsius.
public static double fToC(double degreesF) {
    double degreesC = 5.0 / 9.0 * (degreesF - 32);
    return degreesC;
}

// Computes triangle hypotenuse length given its side lengths.
public static double hypotenuse(int a, int b) {
    double c = Math.sqrt(a * a + b * b);
    return c;
}
```

- You can shorten the examples by returning an expression:

```
public static double fToC(double degreesF) {
    return 5.0 / 9.0 * (degreesF - 32);
}
```

Common error: Not storing

- Many students incorrectly think that a `return` statement sends a variable's name back to the calling method.

```
public static void main(String[] args) {
    slope(0, 0, 6, 3);
    System.out.println("The slope is " + result);  // ERROR:
}                                                  // cannot find symbol: result

public static double slope(int x1, int x2, int y1, int y2) {
    double dy = y2 - y1;
    double dx = x2 - x1;
    double result = dy / dx;
    return result;
}
```

Fixing the common error

- Returning sends the variable's *value* back. Store the returned value into a variable or use it in an expression.

```
public static void main(String[] args) {
    double s = slope(0, 0, 6, 3);
    System.out.println("The slope is " + s);
}

public static double slope(int x1, int x2, int y1, int y2) {
    double dy = y2 - y1;
    double dx = x2 - x1;
    double result = dy / dx;
    return result;
}
```

Quirks of real numbers

- Some `Math` methods return `double` or other non-`int` types.

```
int x = Math.pow(10, 3);   // ERROR: incompat. types
```

- Some `double` values print poorly (too many digits).

```
double result = 1.0 / 3.0;
System.out.println(result);    // 0.3333333333333
```

- The computer represents `double`s in an imprecise way.

```
System.out.println(0.1 + 0.2);
```

  - Instead of 0.3, the output is `0.30000000000000004`

Type casting

- **type cast**: A conversion from one type to another.
  - To promote an `int` into a `double` to get exact division from `/`
  - To truncate a `double` from a real number to an integer

- Syntax:

  `(`**type**`)` **expression**

  Examples:

```
double result = (double) 19 / 5;      // 3.8
int result2 = (int) result;           // 3
int x = (int) Math.pow(10, 3);        // 1000
```

More about type casting

- Type casting has high precedence and only casts the item immediately next to it.
  - `double x = (double) 1 + 1 / 2;  // 1.0`
  - `double y = 1 + (double) 1 / 2;  // 1.5`
- You can use parentheses to force evaluation order.
  - `double average = (double) (a + b + c) / 3;`
- A conversion to `double` can be achieved in other ways.
  - `double average = 1.0 * (a + b + c) / 3;`

Exercise

- In physics, the *displacement* of a moving body represents its change in position over time while accelerating.
  - Given initial velocity v_0 in m/s, acceleration a in m/s^2, and elapsed time t in s, the displacement of the body is:
  - Displacement = $v_0 t + \frac{1}{2} a t^2$

- Write a method `displacement` that accepts v_0, a, and t and computes and returns the change in position.
  - example: `displacement(3.0, 4.0, 5.0)` returns `65.0`

Exercise solution

```
public static double displacement(double v0, double a, double t)
   {
     double d = v0 * t + 0.5 * a * Math.pow(t, 2);
     return d;
}
```

Exercise

- If you drop two balls, which will hit the ground first?
  - Ball 1: height of 600m, initial velocity = 25 m/sec downward
  - Ball 2: height of 500m, initial velocity = 15 m/sec downward
- Write a program that determines how long each ball takes to hit the ground (and draws each ball falling).
- Total time is based on the force of gravity on each ball.
  - Acceleration due to gravity $\cong 9.81$ m/s^2, downward
  - Displacement = $v_0 t + \frac{1}{2} a t^2$

Ball solution

```
// Simulates the dropping of two balls from various heights.
import java.awt.*;

public class Balls {
    public static void main(String[] args) {
        DrawingPanel panel = new DrawingPanel(600, 600);
        Graphics g = panel.getGraphics();

        int ball1x = 100,  ball1y =   0,  v01 = 25;
        int ball2x = 200,  ball2y = 100,  v02 = 15;

        // draw the balls at each time increment
        for (double t = 0; t <= 10.0; t = t + 0.1) {
            double disp1 = displacement(v01, t, 9.81);
            g.fillOval(ball1x, ball1y + (int) disp1, 10, 10);
            double disp2 = displacement(v02, t, 9.81);
            g.fillOval(ball2x, ball2y + (int) disp2, 10, 10);

            panel.sleep(50);   // pause for 50 ms
            panel.clear();
        }
    }
    ...
```