Building Java Programs

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

reading: 3.2, 2.1 - 2.2

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.

```
public class TestMath {
    public static void main(String[] args) {
        Math.pow(3, 4);  // no output!
    }
}
```

No output!

- Math method calls use a feature called *return values* that cause them to be treated as expressions.

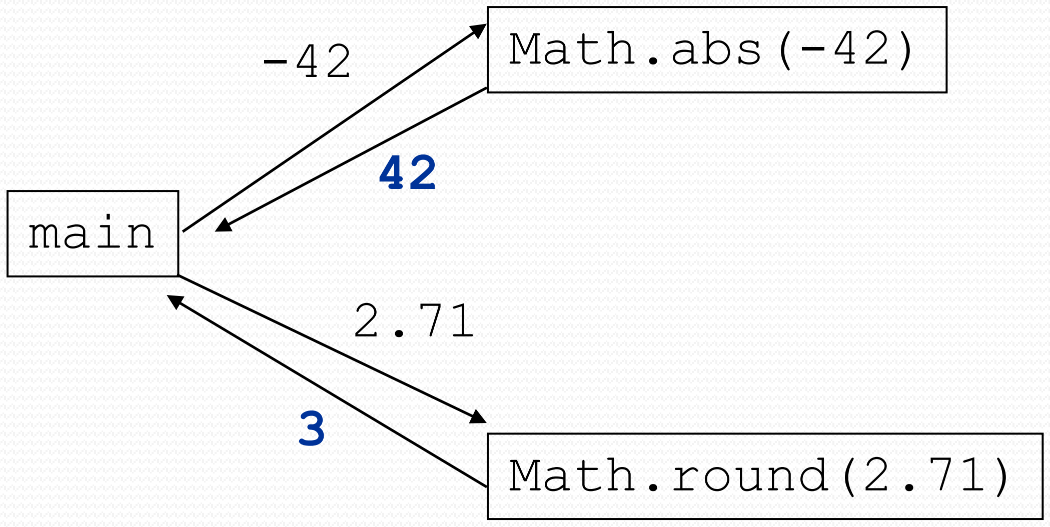
- The program runs the method, computes the answer, and then "replaces" the call with its computed result value.

  -
    ```
    Math.pow(3, 4);        // no output
    81.0;                  // no output
    ```
    (first line struck through: ~~Math.pow(3, 4)~~;)

- 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.
  - The opposite of a parameter
    - Parameters send information *in* from the caller to the 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.



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);
```

`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?

Incompatible types

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

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

- What if you wanted to store a `double` in an `int` variable? (maybe you don’t care about the decimal part)

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;`

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

```
// 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 the 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 y1, int x2, int y2) {
    double dy = y2 - y1;
    double dx = x2 - x1;
    double result = dy / dx;
    return result;
}
```

Fixing the common error

- Instead, returning sends the variable's *value* back.
  - The returned value must be stored into a variable or used in an expression to be useful to the caller.

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

Common error variation

- Particularly confusing is conflating the return variable with a variable in the calling method.
  - Your program will compile, but you won't get the right result!

```
public class ReturnExample {
  public static void main(String[] args) {
    int x = 1;
    addOne(x);
    System.out.println("x = " + x);
  }

  public static int addOne(int x) {
    x = x + 1;
    return x;
  }
}
```

Don’t ignore the return value!

- Just because the return variable in the called method has the same name as the variable in the calling method, they are **NOT** the same. Think scope!

```java
public class ReturnExample {
    public static void main(String[] args) {
        int x = 1;
        addOne(x);
        System.out.println("x = " + x);
    }

    public static int addOne(int x) {
        x = x + 1;
        return x;
    }
}
```

```java
public class ReturnExample {
    public static void main(String[] args) {
        int x = 1;
        x = addOne(x);
        System.out.println("x = " + x);
    }

    public static int addOne(int x) {
        x = x + 1;
        return x;
    }
}
```

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 = $v_0 t + ½ a t^2$
- 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 ≅ 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 final static int PANEL_HEIGHT = 600;
   public final static int PANEL_WIDTH = 600;

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

      int ball1x = 100,  initialBall1y = 600,  v01 = 25;
      int ball2x = 200,  initialBall2y = 500,  v02 = 15;

      // draw the balls at each time increment
      for (double t = 0; t <= 10.0; t = t + 0.1) {
         double height1 = initialBall1y - displacement(v01, 9.81, t);
         g.fillOval(ball1x, PANEL_HEIGHT - (int)height1, 10, 10);
         double height2 = initialBall2y - displacement(v02, 9.81, t);
         g.fillOval(ball2x, PANEL_HEIGHT - (int)height2, 10, 10);

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

   ...
```