

# Topic 10

## return values, Math methods

"Thinking like a computer scientist means more than being able to program a computer. It requires thinking at multiple levels of abstraction."

— Jeannette M. Wing



# static methods in other Classes

- ▶ Java includes 8 primitive data types
  - byte, short, **int**, long, float, **double**, char, boolean
- ▶ The Java Standard Library includes thousands of other data types, classes
  - System, String, Graphics, Color, ...
- ▶ The Math class contains static methods for common mathematical operations (for which an operator does not exist in Java)
- ▶ Call those methods: `Math.<MethodName>`  
`Math.pow(2, 5);`

# Java's Math class

Method name	Description
<code>Math.abs(<i>value</i>)</code>	absolute value
<code>Math.ceil(<i>value</i>)</code>	moves up to ceiling
<code>Math.floor(<i>value</i>)</code>	moves down to floor
<code>Math.log10(<i>value</i>)</code>	logarithm, base 10
<code>Math.max(<i>value1</i>, <i>value2</i>)</code>	larger of two values
<code>Math.min(<i>value1</i>, <i>value2</i>)</code>	smaller of two values
<code>Math.pow(<i>base</i>, <i>exp</i>)</code>	<i>base</i> to the <i>exp</i> power
<code>Math.random()</code>	random double between 0 and 1
<code>Math rint(<i>value</i>)</code>	Round int, nearest whole number
<code>Math.sqrt(<i>value</i>)</code>	square root
<code>Math.sin(<i>value</i>)</code> <code>Math.cos(<i>value</i>)</code> <code>Math.tan(<i>value</i>)</code>	sine/cosine/tangent of an angle in radians
<code>Math.toDegrees(<i>value</i>)</code> <code>Math.toRadians(<i>value</i>)</code>	convert degrees to radians and back

Constant	Description
<code>Math.E</code>	2.7182818...
<code>Math.PI</code>	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 4
```

# Calling Math methods

`Math.methodName (parameters)`

## ▶ Examples:

```
double squareRoot = Math.sqrt(121.0);  
System.out.println(squareRoot);           // 11.0
```

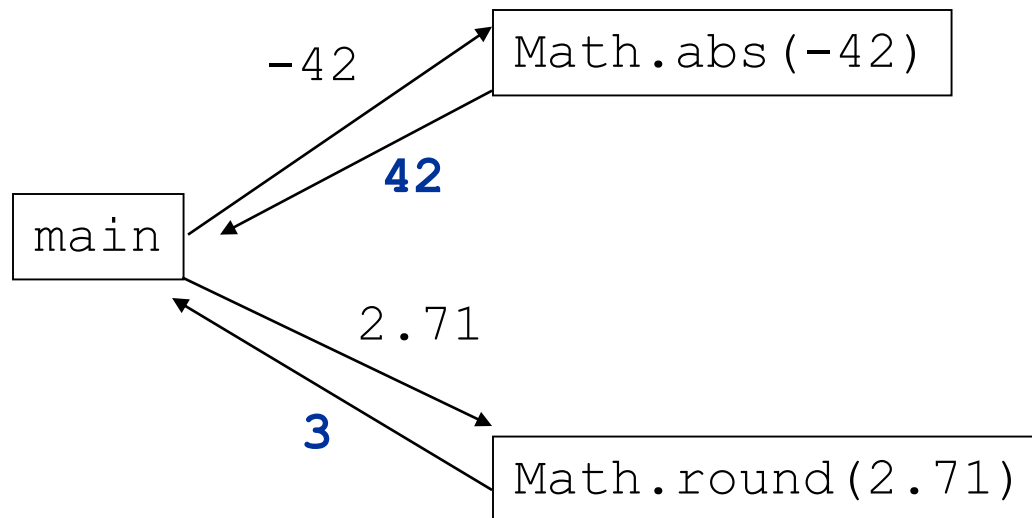
```
int absoluteValue = Math.abs(-50);  
System.out.println(absoluteValue);       // 50
```

```
System.out.println(Math.min(3, 7) + 2);  // 5
```

- ▶ The `Math` methods do not print to the console.
  - Each method produces ("returns") a numeric result.
  - The results are used as expressions (printed, stored, etc.).

# 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);
```

# Clicker 1

▶ What is output by the following code?

```
double a = -1.9;  
double b = 2.25;  
System.out.print( Math.floor(a) +  
    " " + Math.ceil(b) + " " + a );
```

- A. 3.0
- B. -2.0 3.0 -2.0
- C. -1.0 3.0 -1.0
- D. -1 3 -1.9
- E. -2.0 3.0 -1.9

# 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?

# 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); // 0.3333333333333333
```

- ▶ The computer represents `doubles` in an imprecise way.

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

– Instead of 0.3, the output is 0.30000000000000004 **10**

# Type casting

- ▶ **type cast:** A conversion from one type to another.
  - To promote an `int` into a `double` for floating point division
  - 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; 12
```

# Returning a value from a method

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

## ► Example:

```
// Returns the slope of the line between the given points.  
public static double slope(int x1, int y1, int x2, int y2) {  
    double dy = y2 - y1;  
    double dx = x2 - x1;  
    return dy / dx;  
}
```

slope(5, 11, 1, 3) returns 2.0

# Clicker 2

▶ Have we (in CS312, before today) used a method that returns a value in lecture?

A. No

B. Yes, a few times

C. Yes, hundreds of times

D. Lecture?? What lecture?

E. Maybe?

# 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

- ▶ a `return` statement DOES NOT send 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: result not defined
}

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

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

# Clicker 3

► What is the output of the following code?

```
int x = 5;
int y = 7;
System.out.print(m(x, y) + " " + x + " " + m(y, x));

public static int m(int x, int y) {
    x += 2;
    System.out.print(x + " ");
    y -= 2;
    return x * y;
}
```

- A. 7 9 35 5 27
- B. 7 7 35 7 27
- C. 7 5 9 27 35
- D. 35 7 5 9 27
- E. None of A - D are correct

# 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  $\text{m/s}^2$ , 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;  
}
```

# Exercises

- ▶ write a method to
  - return the int average of 3 ints
  - return the double average of 3 ints
  - return the average of a given number of rolls of 2 six sided dice
  - calculate and return N factorial (N!).
  - return the number of seconds in a given number of years.
  - return the Nth digit of a given integer.
  - return the distance between two points.



# 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  $\cong 9.81 \text{ m/s}^2$ , 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) {
            g.setColor(Color.GRAY);
            panel.fillRect(0, 0, 600, 600);
            g.setColor(Color.RED);
            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
        }
    }
    ...
}
```