Math Return values & Scanner

Subset of the Supplement Lesson slides from: Building Java Programs, Chapter 3 Graphics
by Stuart Reges and Marty Stepp (http://www.buildingjavaprograms.com/)
& Thanks to Ms Martin for her suggestions too.

Distance between points

- Write a method that given x and y coordinates for two points prints the distance between them
  - If you can't do all of it, pseudocode?
  - What?! You don't remember the distance formula?!

$$\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$$

Java Libraries

- Java comes with lots of goodies
  - Graphics
  - Color
  - And Math, too! **-> java.lang.Math**

- Learn more from the Application Programming Interface linked from class page as "Java 6 API":

  http://download.oracle.com/javase/6/docs/api/index.html

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

Calling `Math` methods

`Math.`**methodName**`(`**parameters**`)`

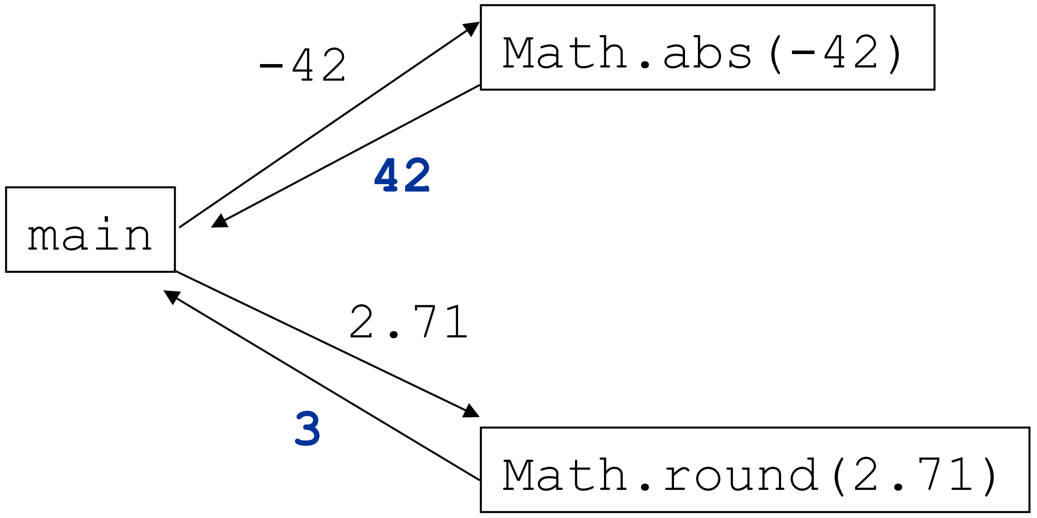
- Examples:

```
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);
```

`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);     // 0.3333333333333
```

- 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`
  - `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;`

Interactive Programs with `Scanner`

Input and `System.in`

- **interactive program**: Reads input from the console.
  - While the program runs, it asks the user to type input.
  - The input typed by the user is stored in variables in the code.

  - Can be tricky; users are unpredictable and misbehave.
  - But interactive programs have more interesting behavior.

- **`Scanner`**: An object that can read input from many sources.
  - Communicates with `System.in` (the opposite of `System.out`)
  - Can also read from files (Ch. 6), web sites, databases, ...

`Scanner` syntax

- The `Scanner` class is found in the `java.util` package.

```
import java.util.*;    // so you can use Scanner
```

- Constructing a `Scanner` object to read console input:

```
Scanner name = new Scanner(System.in);
```

  - Example:

```
Scanner console = new Scanner(System.in);
```

`Scanner` methods

Method	Description
`nextInt()`	reads an `int` from the user and returns it
`nextDouble()`	reads a `double` from the user
`next()`	reads a one-word `String` from the user
`nextLine()`	reads a one-*line* `String` from the user

- Each method waits until the user presses Enter.
- The value typed by the user is returned.

```
System.out.print("How old are you? ");  // prompt
int age = console.nextInt();
System.out.println("You typed " + age);
```

- **prompt**: A message telling the user what input to type.

Scanner example

```
import java.util.*;    // so that I can use Scanner

public class UserInputExample {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);

        System.out.print("How old are you? ");
        int age = console.nextInt();

        int years = 65 - age;
        System.out.println(years + " years to retirement!");
    }
}
```

age $\boxed{29}$

years $\boxed{36}$

- Console (user input underlined):

```
How old are you? 29
36 years until retirement!
```

Scanner example 2

```
import java.util.*;    // so that I can use Scanner

public class ScannerMultiply {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);

        System.out.print("Please type two numbers: ");
        int num1 = console.nextInt();
        int num2 = console.nextInt();

        int product = num1 * num2;
        System.out.println("The product is " + product);
    }
}
```

- Output (user input underlined):

```
Please type two numbers: 8 6
The product is 48
```

  - The `Scanner` can read multiple values from one line.

Input tokens

- **token**: A unit of user input, as read by the `Scanner`.
  - Tokens are separated by *whitespace* (spaces, tabs, new lines).
  - How many tokens appear on the following line of input?

```
23   John Smith    42.0   "Hello world"   $2.50   "   19"
```

- When a token is not the type you ask for, it crashes.

```
System.out.print("What is your age? ");
int age = console.nextInt();
```

Output:

```
What is your age? Timmy
java.util.InputMismatchException
        at java.util.Scanner.next(Unknown Source)
        at java.util.Scanner.nextInt(Unknown Source)
        ...
```

Scanners as parameter

- If many methods need to read input, declare a Scanner in main and pass it to the other methods as a parameter (like Graphics)

```
public static void main(String[] args) {
    Scanner console = new Scanner(System.in);
    readSum3(console);
}
// Prompts for 3 numbers and returns their sum.
public static int readSum3(Scanner console) {
    System.out.print("Type 3 numbers: ");
    int num1 = console.nextInt();
    int num2 = console.nextInt();
    int num3 = console.nextInt();
    System.out.println("The sum is " + sum);
}
```