Multiple Methods

Java programs are organized into ***classes***, each of which has one or more ***methods***, each of which has one or more ***statements***. Writing methods allows you to break down a complex program into smaller blocks of reusable code.

Manager: Recorder:

Presenter: Reflector:

Content Learning Objectives

After completing this activity, students should be able to:

- Apply methods from the Math class based on their documentation.
- Explain the syntax of a method declaration (parameters and return type).
- Draw a diagram that shows the call stack at a given point of execution.

Process Skill Goals

During the activity, students should make progress toward:

- Tracing the execution of methods to determine contents of memory. (Critical Thinking)

Model 1 Invoke and Return

Each statement in this program ***invokes*** (or calls) a method. At the end of a method, Java ***returns*** to where it was invoked. The list of events on the right illustrates how the program runs.

```
1  public class Print {
2
3      public static void main(String[] args) {
4          System.out.println("First line.");
5          threeLine();
6          System.out.println("Second line.");
7      }
8
9      public static void newLine() {
10         System.out.println();
11     }
12
13     public static void threeLine() {
14         newLine();
15         newLine();
16         newLine();
17     }
18
19 }
```

```
INVOKE println
RETURN to line 5
INVOKE threeLine
    INVOKE newLine
        INVOKE println
        RETURN to line 11
    RETURN to line 15
    INVOKE newLine
        INVOKE println
        RETURN to line 11
    RETURN to line 16
    INVOKE newLine
        INVOKE println
        RETURN to line 11
    RETURN to line 17
RETURN to line 6
INVOKE println
RETURN to line 7
```

Questions (10 min) Start time:

1. How many lines of source code invoke the `println` method?

2. How many times is `println` invoked when the program runs?

3. For each `INVOKE` on the right, draw an arrow to the corresponding line of code. (Plan ahead or use different colors so that crossing lines will be legible.)

4. What is the output of the program? Please write `\n` to show each newline character.

5. When the Java compiler sees a name like `x`, `count`, or `newLine`, how can it tell whether it's a variable or a method? (Hint: syntax)

6. What is the difference between a method and a variable?

7. In your own words, describe what methods are for. Why not just write everything in `main`?

Model 2 Math Methods

Consider the following methods defined in the `Math` class. (This list isn't exhaustive; the `Math` class has over 90 methods in total!)

Modifier and Type	Method and Description
`static int`	**`abs`**`(int a)` Returns the absolute value of an `int` value.
`static double`	**`log`**`(double a)` Returns the natural logarithm (base *e*) of a `double` value.
`static double`	**`pow`**`(double a, double b)` Returns the value of the first argument raised to the power of the second argument.
`static double`	**`random`**`()` Returns a `double` value with a positive sign, greater than or equal to `0.0` and less than `1.0`.
`static int`	**`subtractExact`**`(int x, int y)` Returns the difference of the arguments, throwing an exception if the result overflows an `int`.

The code for these methods is provided in a source file named *Math.java*. Here is what the definition of the `abs` method looks like:

```
public static int abs(int a) {
    // code omitted
}
```

To use a method from another source file (like *Math.java*), you must first specify the class name:

```
value = abs(-5);       // Error: cannot find symbol
value = Math.abs(-5);  // correct
```

Questions (20 min) Start time:

8. What type of value does `Math.random()` return? Give an example of what a random value might look like.

9. When *defining* a method (like `abs` or `log`), what do you need to specify before the method name and after the method name?

10. Define a method named `average` that takes two integers named `x` and `y` and returns a `double`. Don't write any semicolons or braces.

11. When *using* a method, what do you need to specify before the method name and after the method name?

12. For each method in Model 2, write a Java statement that uses the method and assigns the result to a variable.

*What you wrote for Question #10 is called the method's **signature**. The variables declared inside the parentheses are called **parameters**. When invoking a method, the values you provide are called **arguments**. Since arguments will be assigned to parameters, their types must be compatible.*

13. In the table below, how many parameters and arguments does each method have? What is the relationship between the last two columns?

Method	# Params	# Args
`abs`		
`log`		
`pow`		
`random`		
`subtractExact`		

14. Consider the statement `System.out.println("Price: " + price);` where the value of `price` is 9.99. What is the argument that `println` receives?

15. Consider the statement `System.out.printf("Price: %f", price);` where the value of `price` is 9.99. Why does `println` use *plus* and `printf` use *comma* to specify the arguments?

IMPORTANT: Never use + (string concatenation) with printf. You might accidentally add values to the format string itself, rather than substitute them.

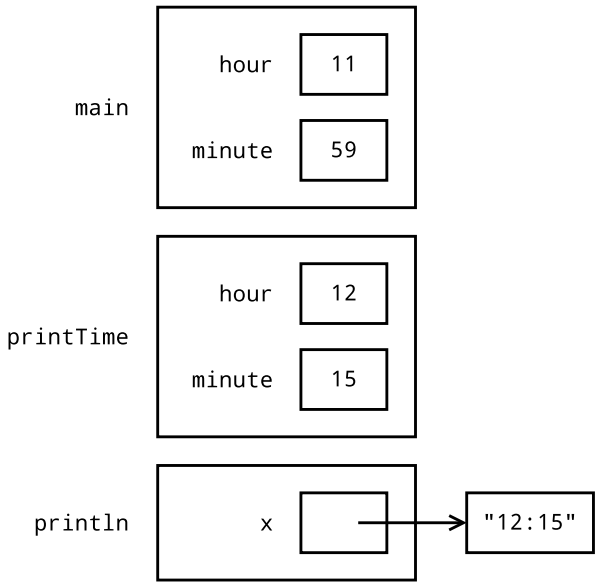
Model 3 Stack Diagrams

The following program displays the time `12:15` on the screen:

```
public static void printTime(int hour, int minute) {
    System.out.println(hour + ":" + minute);
}

public static void main(String[] args) {
    int hour = 11;
    int minute = 59;
    printTime(12, 15);
}
```

We can draw a ***stack diagram*** to visualize how the program works. Each method has its own area of memory to store parameters and other variables. For convenience, we stack method calls underneath each other (upside down).



Questions (15 min) Start time:

16. Based on the diagram, how many methods does the program use?

17. Based on the diagram, how many variables does the program have?

18. How are stack diagrams different from the memory diagrams we've seen previously?

19. How is it possible that two variables with the same name can have different values?

20. Draw a stack diagram to show the state of memory just before `println` is called. Assume the user inputs the value 10. (You should be able to do this kind of math without a calculator.)

```
public static void show(double c) {
    double f;
    String str;
    f = c * 1.8 + 32;
    str = String.format("%.1f C = %.1f F\n", c, f);
    System.out.println(str);
}

public static void main(String[] args) {
    double c;
    Scanner in = new Scanner(System.in);
    System.out.print("Enter temperature in Celsius: ");
    c = in.nextDouble();
    show(c);
}
```

21. What is the difference between the `String.format` method (used in the previous question) and `System.out.printf`?