Building Java Programs
Chapter 3

Parameters and Objects

Redundant recipes

- Recipe for baking **20** cookies:
  - Mix the following ingredients in a bowl:
    - **4** cups flour
    - **1** cup butter
    - **1** cup sugar
    - **2** eggs
    - **40** pounds chocolate chips ...
  - Place on sheet and Bake for about 10 minutes.

- Recipe for baking **40** cookies:
  - Mix the following ingredients in a bowl:
    - **8** cups flour
    - **2** cups butter
    - **2** cups sugar
    - **4** eggs
    - **80** pounds chocolate chips ...
  - Place on sheet and Bake for about 10 minutes.

Parameterized recipe

- Recipe for baking **20** cookies:
  - Mix the following ingredients in a bowl:
    - **4** cups flour
    - **1** cup sugar
    - **2** eggs
    - **...**

- Recipe for baking **N** cookies:
  - Mix the following ingredients in a bowl:
    - **N/5** cups flour
    - **N/20** cups butter
    - **N/20** cups sugar
    - **N/10** eggs
    - **2N** bags chocolate chips ...
  - Place on sheet and Bake for about 10 minutes.

- **parameter**: A value that distinguishes similar tasks.

Redundant figures

- Consider the task of printing the following lines/boxes:

```
************

*******

************************************

**********
*        *
**********

*****
*   *
*   *
*****
```

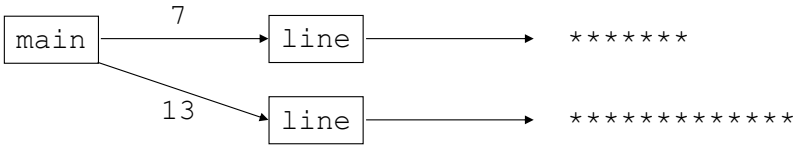
A redundant solution

```
public class Stars1 {
    public static void main(String[] args) {
        lineOf13();
        lineOf7();
        lineOf35();
        box10x3();
        box5x4();
    }

    public static void lineOf13() {
        for (int i = 1; i <= 13; i++) {
            System.out.print("*");
        }
        System.out.println();
    }

    public static void lineOf7() {
        for (int i = 1; i <= 7; i++) {
            System.out.print("*");
        }
        System.out.println();
    }

    public static void lineOf35() {
        for (int i = 1; i <= 35; i++) {
            System.out.print("*");
        }
        System.out.println();
    }
    ...
```

- This code is redundant.
- Would variables help? Would constants help?
- What is a better solution?
  - `line` - A method to draw a line of any number of stars.
  - `box` - A method to draw a box of any size.

Parameterization

- **parameter**: A value passed to a method by its caller.
  - Instead of `lineOf7`, `lineOf13`, write `line` to draw any length.
    - When *declaring* the method, we will state that it requires a parameter for the number of stars.
    - When *calling* the method, we will specify how many stars to draw.



Declaring a parameter

Stating that a method requires a parameter in order to run

```
public static void name ( type name ) {
    statement(s);
}
```

- Example:

```
public static void sayPassword(int code) {
    System.out.println("The password is: " +
  code);
}
```

  - When `sayPassword` is called, the caller must specify the integer code to print.

Passing a parameter

Calling a method and specifying values for its parameters

```
name (expression);
```

- Example:

```
public static void main(String[] args) {
    sayPassword(42);
    sayPassword(12345);
}
```

Output:

```
The password is 42
The password is 12345
```

Parameters and loops

- A parameter can guide the number of repetitions of a loop.

```
public static void main(String[] args) {
    chant(3);
}

public static void chant(int times) {
    for (int i = 1; i <= times; i++) {
        System.out.println("Just a salad...");
    }
}
```

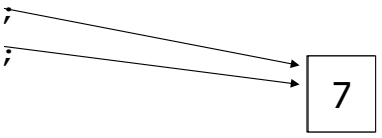
Output:

```
Just a salad...
Just a salad...
Just a salad...
```


How parameters are passed

- When the method is called:
  - The value is stored into the parameter variable.
  - The method's code executes using that value.

```
public static void main(String[] args) {
    chant(3);
    chant(7);
}

public static void chant(int times) {
    for (int i = 1; i <= times; i++) {
        System.out.println("Just a salad...");
    }
}
```



Common errors

- If a method accepts a parameter, it is illegal to call it without passing any value for that parameter.

```
chant();      // ERROR: parameter value required
```

- The value passed to a method must be of the correct type.

```
chant(3.7);   // ERROR: must be of type int
```

- Exercise: Change the `Stars` program to use a parameterized method for drawing lines of stars.

Stars solution

```
// Prints several lines of stars.
// Uses a parameterized method to remove redundancy.
public class Stars2 {
    public static void main(String[] args) {
        line(13);
        line(7);
        line(35);
    }

    // Prints the given number of stars plus a line break.
    public static void line(int count) {
        for (int i = 1; i <= count; i++) {
            System.out.print("*");
        }
        System.out.println();
    }
}
```

Multiple parameters

- A method can accept multiple parameters. (separate by ,)
  - When calling it, you must pass values for each parameter.

- Declaration:

```
public static void name (type name, ..., type name) {
    statement(s);
}
```

- Call:

```
methodName (value, value, ..., value);
```


Multiple params example

```
public static void main(String[] args) {
    printNumber(4, 9);
    printNumber(17, 6);
    printNumber(8, 0);
    printNumber(0, 8);
}

public static void printNumber(int number, int count) {
    for (int i = 1; i <= count; i++) {
        System.out.print(number);
    }
    System.out.println();
}
```

Output:

```
444444444
171717171717

00000000
```

- Modify the `Stars` program to draw boxes with parameters.

Stars solution

```
// Prints several lines and boxes made of stars.
// Third version with multiple parameterized methods.

public class Stars3 {
    public static void main(String[] args) {
        line(13);
        line(7);
        line(35);
        System.out.println();
        box(10, 3);
        box(5, 4);
        box(20, 7);
    }

    // Prints the given number of stars plus a line break.
    public static void line(int count) {
        for (int i = 1; i <= count; i++) {
            System.out.print("*");
        }
        System.out.println();
    }
    ...
```


Stars solution, cont'd.

```
    ...

    // Prints a box of stars of the given size.
    public static void box(int width, int height) {
        line(width);

        for (int line = 1; line <= height - 2; line++) {
            System.out.print("*");
            for (int space = 1; space <= width - 2; space++) {
                System.out.print(" ");
            }
            System.out.println("*");
        }

        line(width);
    }
}
```

Value semantics

- **value semantics**: When primitive variables (`int`, `double`) are passed as parameters, their values are copied.
  - Modifying the parameter will not affect the variable passed in.

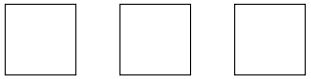
```
public static void strange(int x) {
    x = x + 1;
    System.out.println("1. x = " + x);
}

public static void main(String[] args) {
    int x = 23;
    strange(x);
    System.out.println("2. x = " + x);
    ...
}
```

Output:

```
1. x = 24
2. x = 23
```


"Parameter Mystery" problem

```
public class ParameterMystery {
    public static void main(String[] args) {
        int x = 9;
        int y = 2;
        int z = 5;

        mystery(z, y, x);

        mystery(y, x, z);
    }

    public static void mystery(int x, int z, int y) {
        System.out.println(z + " and " + (y - x));
    }
}
```



Strings

- **string**: A sequence of text characters.

```
String name = "text";
String name = expression;
```

  - Examples:

```
String name = "Marla Singer";

int x = 3;
int y = 5;
String point = "(" + x + ", " + y + ")";
```


Strings as parameters

```
public class StringParameters {
    public static void main(String[] args) {
        sayHello("Marty");
        String teacher = "Bictolia";
        sayHello(teacher);
    }

    public static void sayHello(String name) {
        System.out.println("Welcome, " + name);
    }
}
```

Output:

```
Welcome, Marty
Welcome, Bictolia
```

- Modify the `Stars` program to use string parameters. Use a method named `repeat` that prints a string many times.

Stars solution

```
// Prints several lines and boxes made of stars.
// Fourth version with String parameters.

public class Stars4 {
    public static void main(String[] args) {
        line(13);
        line(7);
        line(35);
        System.out.println();
        box(10, 3);
        box(5, 4);
        box(20, 7);
    }

    // Prints the given number of stars plus a line break.
    public static void line(int count) {
        repeat("*", count);
        System.out.println();
    }

    ...
```


Stars solution, cont'd.

```
    ...

    // Prints a box of stars of the given size.
    public static void box(int width, int height) {
        line(width);

        for (int line = 1; line <= height - 2; line++) {
            System.out.print("*");
            repeat(" ", width - 2);
            System.out.println("*");
        }

        line(width);
    }

    // Prints the given String the given number of times.
    public static void repeat(String s, int times) {
        for (int i = 1; i <= times; i++) {
            System.out.print(s);
        }
    }
}
```


Return values

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...

Calling `Math` methods

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

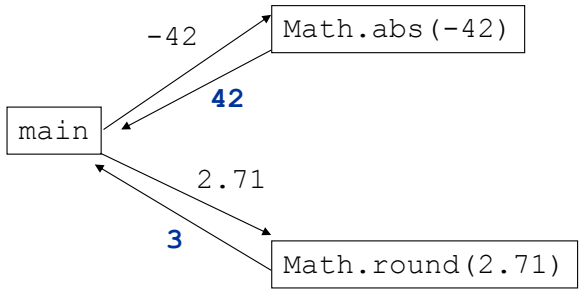
- Examples:

```
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.



`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;`

Returning a value

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

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:
}                                                  // 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;
}
```

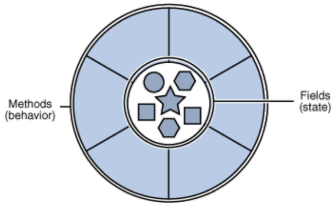

Objects and Classes; Strings

Classes and objects

- **class**: A program entity that represents either:
  1. A program / module, or
  2. A type of objects.
  - A class is a blueprint or template for constructing objects.
  - Example: The `DrawingPanel` class (type) is a template for creating many `DrawingPanel` objects (windows).
    - Java has 1000s of classes. Later (Ch.8) we will write our own.
- **object**: An entity that combines data and behavior.
  - **object-oriented programming (OOP)**: Programs that perform their behavior as interactions between objects.

Objects

- **object:** An entity that contains data and behavior.
  - *data*: variables inside the object
  - *behavior*: methods inside the object
    - You interact with the methods; the data is hidden in the object.



- Constructing (creating) an object:

  Type objectName = new **Type**(**parameters**);

- Calling an object's method:

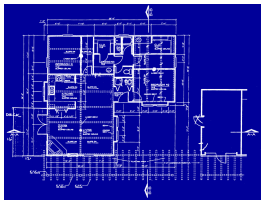
  objectName.**methodName**(**parameters**);

Blueprint analogy

iPod blueprint/factory

state:
current song
volume
battery life

behavior:
power on/off
change station/song
change volume
choose random song



creates

iPod #1

state:
song = "1,000,000 Miles"
volume = 17
battery life = 2.5 hrs

behavior:
power on/off
change station/song
change volume
choose random song

iPod #2

state:
song = "Letting You"
volume = 9
battery life = 3.41 hrs

behavior:
power on/off
change station/song
change volume
choose random song

iPod #3

state:
song = "Discipline"
volume = 24
battery life = 1.8 hrs

behavior:
power on/off
change station/song
change volume
choose random song

Strings

- **string**: An object storing a sequence of text characters.
  - Unlike most other objects, a `String` is not created with `new`.

```
String name = "text";
String name = expression;
```

  - Examples:

```
String name = "Marla Singer";

int x = 3;
int y = 5;
String point = "(" + x + ", " + y + ")";
```


Indexes

- Characters of a string are numbered with 0-based *indexes*:

```
String name = "woodpile";
```

index	0	1	2	3	4	5	6	7
character	w	o	o	d	p	i	l	e

  - First character's index : 0
  - Last character's index : 1 less than the string's length

  - The individual characters are values of type `char` (seen later)

`String` methods

Method name	Description
`indexOf(`**`str`**`)`	index where the start of the given string appears in this string (-1 if not found)
`length()`	number of characters in this string
`substring(`**`index1`**`, `**`index2`**`)` or `substring(`**`index1`**`)`	the characters in this string from *index1* (inclusive) to *index2* (exclusive); if *index2* is omitted, grabs till end of string
`toLowerCase()`	a new string with all lowercase letters
`toUpperCase()`	a new string with all uppercase letters

- These methods are called using the dot notation:

```
String gangsta = "Dr. Dre";
System.out.println(gangsta.length());    // 7
```


`String` method examples

```
// index      012345678901
String s1 = "Stuart Reges";
String s2 = "Marty Stepp";

System.out.println(s1.length());          // 12
System.out.println(s1.indexOf("e"));      // 8
System.out.println(s1.substring(7, 10)); // "Reg"

String s3 = s2.substring(1, 7);
System.out.println(s3.toLowerCase());     // "arty s"
```

- Given the following string:

```
// index       0123456789012345678901
String book = "Building Java Programs";
```

  - How would you extract the word `"Java"` ?

Modifying strings

- Methods like `substring` and `toLowerCase` build and return a new string, rather than modifying the current string.

```
String s = "lil bow wow";
s.toUpperCase();
System.out.println(s);    // lil bow wow
```

- To modify a variable's value, you must reassign it:

```
String s = "lil bow wow";
s = s.toUpperCase();
System.out.println(s);    // LIL BOW WOW
```

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	29
years	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)
        ...
```


Strings as user input

- `Scanner`'s `next` method reads a word of input as a `String`.

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
name = name.toUpperCase();
System.out.println(name + " has " + name.length() +
    " letters and starts with " + name.substring(0, 1));
```

Output:

```
What is your name? Chamillionaire
CHAMILLIONAIRE has 14 letters and starts with C
```

- The `nextLine` method reads a line of input as a `String`.

```
System.out.print("What is your address? ");
String address = console.nextLine();
```


Strings question

- Write a program that outputs a person's "gangsta name."
  - first initial
  - *Diddy*
  - last name (all caps)
  - first name
  - *-izzle*

Example Output:

```
Type your name, playa: Marge Simpson
Your gangsta name is "M. Diddy SIMPSON Marge-izzle"
```

Strings answer

```
// This program prints your "gangsta" name.
import java.util.*;

public class GangstaName {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        System.out.print("Type your name, playa: ");
        String name = console.nextLine();

        // split name into first/last name and initials
        String first = name.substring(0, name.indexOf(" "));
        String last = name.substring(name.indexOf(" ") + 1);
        last = last.toUpperCase();
        String fInitial = first.substring(0, 1);

        System.out.println("Your gangsta name is \"" + fInitial +
                ". Diddy " + last + " " + first + "-izzle\"");
    }
}
```