Building Java Programs

Chapter 2

Lecture 2-3: Loop Figures and Constants

reading: 2.4 - 2.5

self-checks: 27

exercises: 16-17

videos: Ch. 2 #5

Drawing complex figures

- Use nested `for` loops to produce the following output.

- Why draw ASCII art?
  - Real graphics require a lot of finesse
  - ASCII art has complex patterns
  - Can focus on the algorithms

```
#================#
|      <><>      |
|    <>....<>    |
|  <>........<>  |
|<>............<>|
|<>............<>|
|  <>........<>  |
|    <>....<>    |
|      <><>      |
#================#
```

Development strategy

- Recommendations for managing complexity:
  1. Write an English description of steps required (*pseudo-code*)
     - use pseudo-code to decide methods
  2. Create a table of patterns of characters
     - use table to write loops in each method

```
#================#
|      <><>      |
|    <>....<>    |
|  <>........<>  |
|<>............<>|
|<>............<>|
|  <>........<>  |
|    <>....<>    |
|      <><>      |
#================#
```

1. Pseudo-code

- **pseudo-code**: An English description of an algorithm.

- Example: Drawing a 12 wide by 7 tall box of stars

```
print 12 stars.
for (each of 5 lines) {
    print a star.
    print 10 spaces.
    print a star.
}
print 12 stars.
```

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

Pseudo-code algorithm

1. Line
   - # , 16 =, #

2. Top half
   - |
   - spaces (decreasing)
   - <>
   - dots (increasing)
   - <>
   - spaces (same as above)
   - |

3. Bottom half (top half upside-down)

4. Line
   - # , 16 =, #

```
#================#
|      <><>      |
|    <>....<>    |
|  <>........<>  |
|<>............<>|
|<>............<>|
|  <>........<>  |
|    <>....<>    |
|      <><>      |
#================#
```

Methods from pseudocode

```
public class Mirror {
    public static void main(String[] args) {
        line();
        topHalf();
        bottomHalf();
        line();
    }

    public static void topHalf() {
        for (int line = 1; line <= 4; line++) {
            // contents of each line
        }
    }

    public static void bottomHalf() {
        for (int line = 1; line <= 4; line++) {
            // contents of each line
        }
    }

    public static void line() {
        // ...
    }
}
```

2. Tables

- A table for the top half:
  - Compute spaces and dots expressions from line number

line	spaces	line * -2 + 8	dots	4 * line - 4
1	6	6	0	0
2	4	4	4	4
3	2	2	8	8
4	0	0	12	12

```
#================#
|      <><>      |
|    <>....<>    |
|  <>........<>  |
|<>............<>|
|<>............<>|
|  <>........<>  |
|    <>....<>    |
|      <><>      |
#================#
```

3. Writing the code

- Useful questions about the top half:
  - What methods? (think structure and redundancy)
  - Number of (nested) loops per line?

```
#================#
|      <><>      |
|    <>....<>    |
|  <>........<>  |
|<>............<>|
|<>............<>|
|  <>........<>  |
|    <>....<>    |
|      <><>      |
#================#
```

Partial solution

```
// Prints the expanding pattern of <> for the top half of the figure.
public static void topHalf() {
    for (int line = 1; line <= 4; line++) {
        System.out.print("|");

        for (int space = 1; space <= (line * -2 + 8); space++) {
            System.out.print(" ");
        }

        System.out.print("<>");

        for (int dot = 1; dot <= (line * 4 - 4); dot++) {
            System.out.print(".");
        }

        System.out.print("<>");

        for (int space = 1; space <= (line * -2 + 8); space++) {
            System.out.print(" ");
        }

        System.out.println("|");
    }
}
```

Class constants and scope

reading: 2.4

self-check: 28

exercises: 11

videos: Ch. 2 #5

Scaling the mirror

- Let's modify our Mirror program so that it can scale.
  - The current mirror (left) is at size 4; the right is at size 3.
- We'd like to structure the code so we can scale the figure by changing the code in just one place.

```
#================#          #============#
|      <><>      |          |    <><>    |
|    <>....<>    |          |  <>....<>  |
|  <>........<>  |          |<>........<>|
|<>............<>|          |<>........<>|
|<>............<>|          |  <>....<>  |
|  <>........<>  |          |    <><>    |
|    <>....<>    |          #============#
|      <><>      |
#================#
```

Limitations of variables

- Idea: Make a variable to represent the size.
  - Use the variable's value in the methods.

- Problem: A variable in one method can't be seen in others.

```
public static void main(String[] args) {
    int size = 4;
    topHalf();
    printBottom();
}

public static void topHalf() {
    for (int i = 1; i <= size; i++) {    // ERROR: size not found
        ...
    }
}

public static void bottomHalf() {
    for (int i = max; i >= 1; i--) {     // ERROR: size not found
        ...
    }
}
```

Variable scope

- **scope**: The part of a program where a variable exists.
  - From its declaration to the end of the { } braces
    - A variable declared in a `for` loop exists only in that loop.
    - A variable declared in a method exists only in that method.

```
public static void example() {
    int x = 3;
    for (int i = 1; i <= 10; i++) {
        System.out.println(x);
    }
    // i no longer exists here
} // x ceases to exist here
```

i's scope

x's scope

Scope implications

- Variables without overlapping scope can have same name.

```
for (int i = 1; i <= 100; i++) {
    System.out.print("/");
}
for (int i = 1; i <= 100; i++) {   // OK
    System.out.print("\\");
}
int i = 5;                  // OK: outside of loop's scope
```

- A variable can't be declared twice or used out of its scope.

```
for (int i = 1; i <= 100 * line; i++) {
    int i = 2;              // ERROR: overlapping scope
    System.out.print("/");
}
i = 4;                      // ERROR: outside scope
```

Class constants

- **class constant**: A value visible to the whole program.
  - value can only be set at declaration
  - value can't be changed while the program is running

- Syntax:

  `public static final` **type** **name** `=` **value**`;`

  - name is usually in ALL_UPPER_CASE

  - Examples:

    ```
    public static final int DAYS_IN_WEEK = 7;
    public static final double INTEREST_RATE = 3.5;
    public static final int SSN = 658234569;
    ```

Constants and figures

- Consider the task of drawing the following scalable figure:

```
+/\/\/\/\/\/\/\/\/\/\+
|                    |
|                    |
|                    |
|                    |
|                    |
+/\/\/\/\/\/\/\/\/\/\+
```

Multiples of 5 occur many times

```
+/\/\/\/\+
|        |
|        |
+/\/\/\/\+
```

The same figure at size 2

Repetitive figure code

```
public class Sign {

    public static void main(String[] args) {
        drawLine();
        drawBody();
        drawLine();
    }

    public static void drawLine() {
        System.out.print("+");
        for (int i = 1; i <= 10; i++) {
            System.out.print("/\\");
        }
        System.out.println("+");
    }

    public static void drawBody() {
        for (int line = 1; line <= 5; line++) {
            System.out.print("|");
            for (int spaces = 1; spaces <= 20; spaces++) {
                System.out.print(" ");
            }
            System.out.println("|");
        }
    }
}
```

Adding a constant

```
public class Sign {
    public static final int HEIGHT = 5;

    public static void main(String[] args) {
        drawLine();
        drawBody();
        drawLine();
    }

    public static void drawLine() {
        System.out.print("+");
        for (int i = 1; i <= HEIGHT * 2; i++) {
            System.out.print("/\\");
        }
        System.out.println("+");
    }

    public static void drawBody() {
        for (int line = 1; line <= HEIGHT; line++) {
            System.out.print("|");
            for (int spaces = 1; spaces <= HEIGHT * 4; spaces++) {
                System.out.print(" ");
            }
            System.out.println("|");
        }
    }
}
```

Complex figure w/ constant

- Modify the Mirror code to be resizable using a constant.

A mirror of size 4:

```
#================#
|      <><>      |
|    <>....<>    |
|  <>........<>  |
|<>............<>|
|<>............<>|
|  <>........<>  |
|    <>....<>    |
|      <><>      |
#================#
```

A mirror of size 3:

```
#============#
|    <><>    |
|  <>....<>  |
|<>........<>|
|<>........<>|
|  <>....<>  |
|    <><>    |
#============#
```

Using a constant

- Constant allows many methods to refer to same value:

```
public static final int SIZE = 4;

public static void main(String[] args) {
    topHalf();
    printBottom();
}

public static void topHalf() {
    for (int i = 1; i <= SIZE; i++) {    // OK
        ...
    }
}

public static void bottomHalf() {
    for (int i = SIZE; i >= 1; i--) {    // OK
        ...
    }
}
```

Loop tables and constant

- Let's modify our loop table to use SIZE
  - This can change the *b* in *y* = *mx* + *b*

SIZE	line	spaces	`-2*line + (2*SIZE)`	dots	`4*line - 4`
4	1,2,3,4	6,4,2,0	-2*line + **8**	0,4,8,12	4*line - 4
3	1,2,3	4,2,0	-2*line + **6**	0,4,8	4*line - 4

```
#================#
|      <><>      |
|    <>....<>    |
|  <>........<>  |
|<>............<>|
|<>............<>|
|  <>........<>  |
|    <>....<>    |
|      <><>      |
#================#
```

```
#============#
|    <><>    |
|  <>....<>  |
|<>........<>|
|<>........<>|
|  <>....<>  |
|    <><>    |
#============#
```

Partial solution

```
public static final int SIZE = 4;

// Prints the expanding pattern of <> for the top half of the figure.
public static void topHalf() {
    for (int line = 1; line <= SIZE; line++) {
        System.out.print("|");

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

        System.out.print("<>");

        for (int dot = 1; dot <= (line * 4 - 4); dot++) {
            System.out.print(".");
        }

        System.out.print("<>");

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

        System.out.println("|");
    }
}
```

Observations about constant

- The constant can change the "intercept" in an expression.
  - Usually the "slope" is unchanged.

```
public static final int SIZE = 4;

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

- It doesn't replace *every* occurrence of the original value.

```
for (int dot = 1; dot <= (line * 4 - 4); dot++) {
    System.out.print(".");
}
```