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

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

#===========#
```
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

```plaintext
#================# |
|      <><>      |
|    <>....<>    |
|  <>........<>  |
|<>............<>|
|<>............<>|
|  <>........<>  |
|    <>....<>    |
|      <><>      |
#================#
```
1. Pseudo-code

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

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

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

  ```plaintext
  ************
  *          *
  *          *
  *          *
  *          *
  ************
  ```
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 =, #
```java
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

<table>
<thead>
<tr>
<th>line</th>
<th>spaces</th>
<th>line * -2 + 8</th>
<th>dots</th>
<th>4 * line - 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

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3. Writing the code

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

```java
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.

```java
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
```
Scope implications

• Variables without overlapping scope can have same name.

```java
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.

```java
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:
  ```java
  public static final type name = value;
  ```
  - name is usually in ALL_UPPER_CASE

- Examples:
  ```java
  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
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("\\\n");
        }
        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("|");
        }
    }
}

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Adding a constant

```java
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:

```java
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
    }
}
```
Let's modify our loop table to use \( \text{SIZE} \)

This can change the \( b \) in \( y = mx + b \)

<table>
<thead>
<tr>
<th>SIZE</th>
<th>line</th>
<th>spaces</th>
<th>(-2\times\text{line} + (2\times\text{SIZE}))</th>
<th>dots</th>
<th>(4\times\text{line} - 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1,2,3,4</td>
<td>6,4,2,0</td>
<td>(-2\times\text{line} + 8)</td>
<td>0,4,8,12</td>
<td>(4\times\text{line} - 4)</td>
</tr>
<tr>
<td>3</td>
<td>1,2,3</td>
<td>4,2,0</td>
<td>(-2\times\text{line} + 6)</td>
<td>0,4,8</td>
<td>(4\times\text{line} - 4)</td>
</tr>
</tbody>
</table>
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.

```java
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.

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