

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

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 =, #

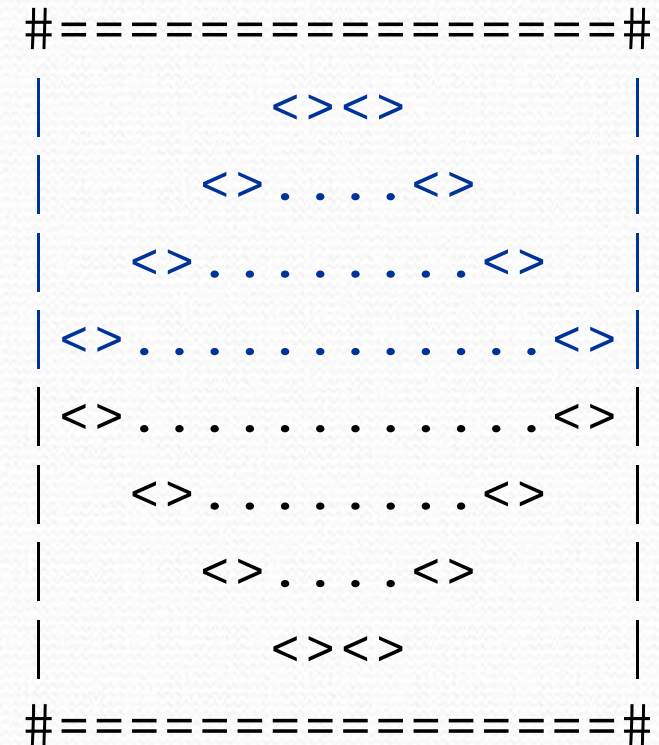
2. Top half

- |
- 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
        }
    }

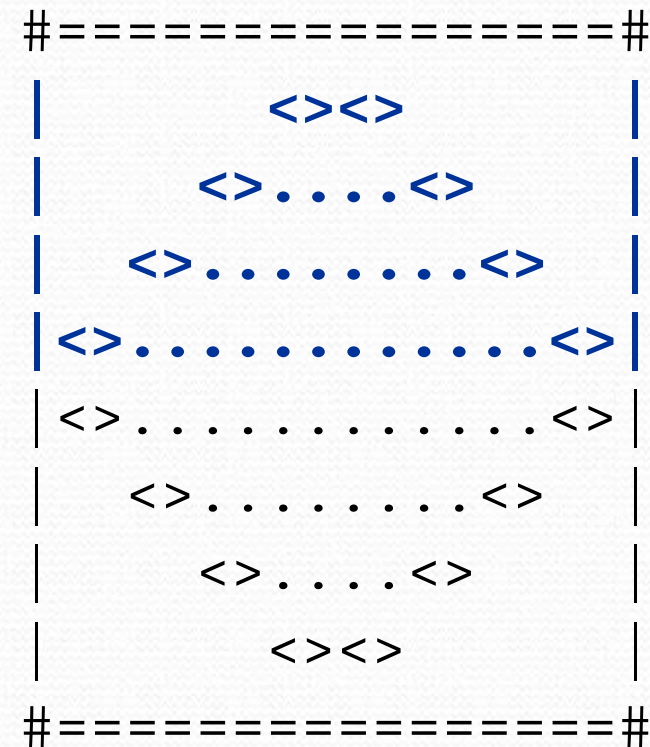
    public static void bottomHalf() {
        for (int line = 1; line <= 4; line++) {
            // contents of each line
        }
    }

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

2. Tables

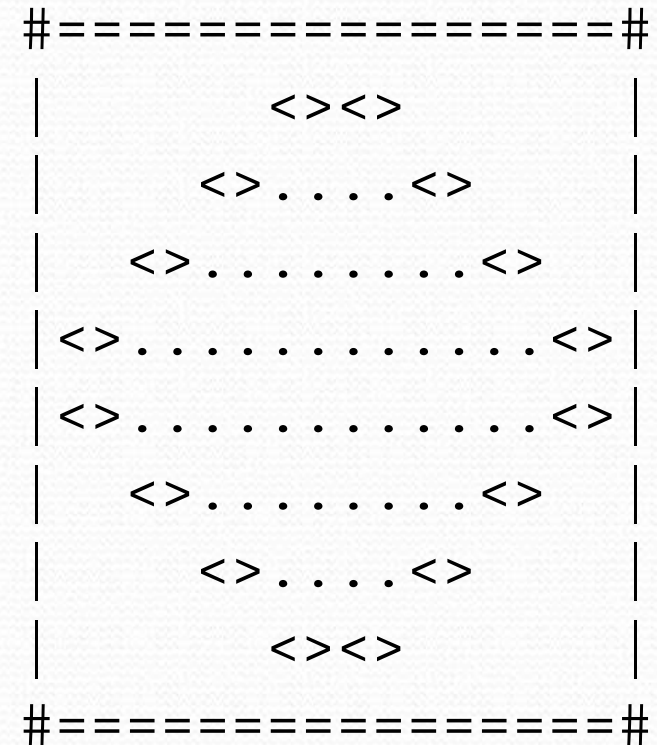
- A table for the top half:
 - Compute spaces and dots expressions from line number

| 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

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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 = size; i >= 1; i--) {           // ERROR: size not found  
        ...  
    }  
}
```

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 fixed value visible to the whole program.
 - value can be set only at declaration; cannot be reassigned

- Syntax:

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

- name is usually in ALL_UPPER_CASE

- Examples:

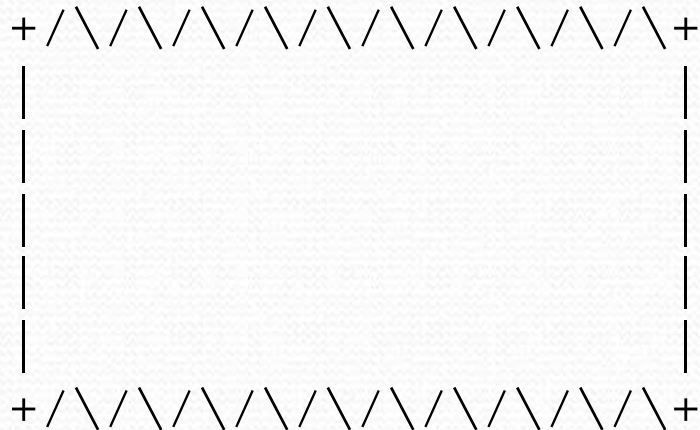
```
public static final int DAYS_IN_WEEK = 7;
```

```
public static final double INTEREST_RATE = 3.5;
```

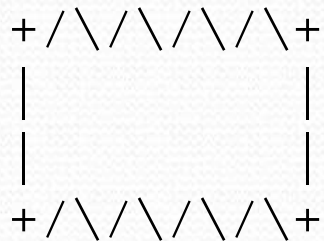
```
public static final int SSN = 658234569;
```

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();  
}
```

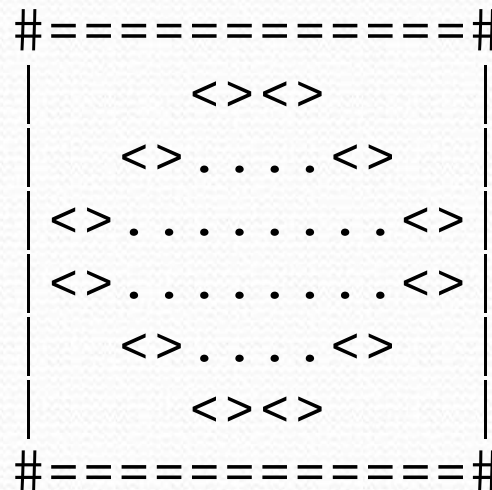
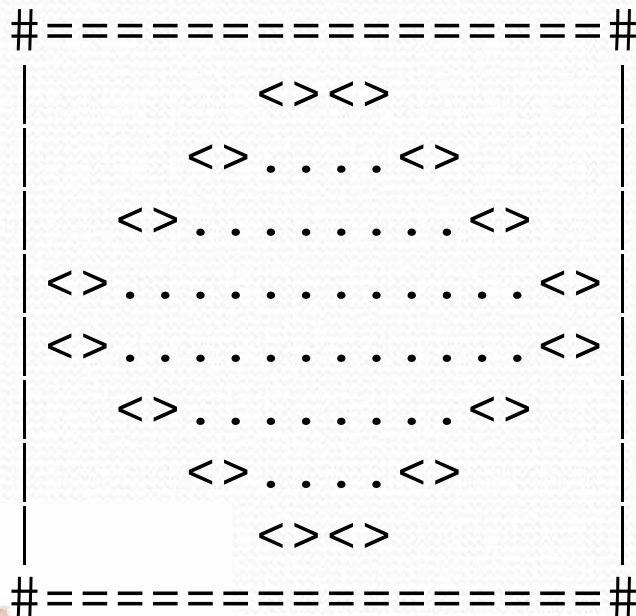
```
public static void topHalf() {  
    for (int i = 1; i <= SIZE; i++) { // OK  
        ...  
    }  
}
```

```
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 amount added in the loop expression

| SIZE | line | spaces | $-2*\text{line} + (2*\text{SIZE})$ | dots | $4*\text{line} - 4$ |
|------|---------|---------|------------------------------------|----------|---------------------|
| 4 | 1,2,3,4 | 6,4,2,0 | $-2*\text{line} + \mathbf{8}$ | 0,4,8,12 | $4*\text{line} - 4$ |
| 3 | 1,2,3 | 4,2,0 | $-2*\text{line} + \mathbf{6}$ | 0,4,8 | $4*\text{line} - 4$ |



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(".");
}
```