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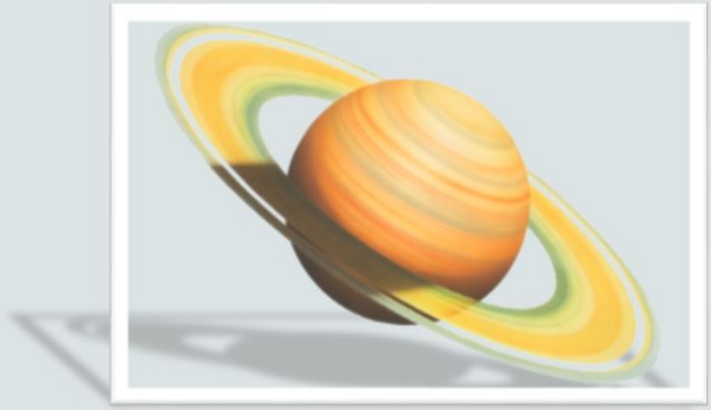
ACADEMY

Java Foundations

6-1
`for` Loops



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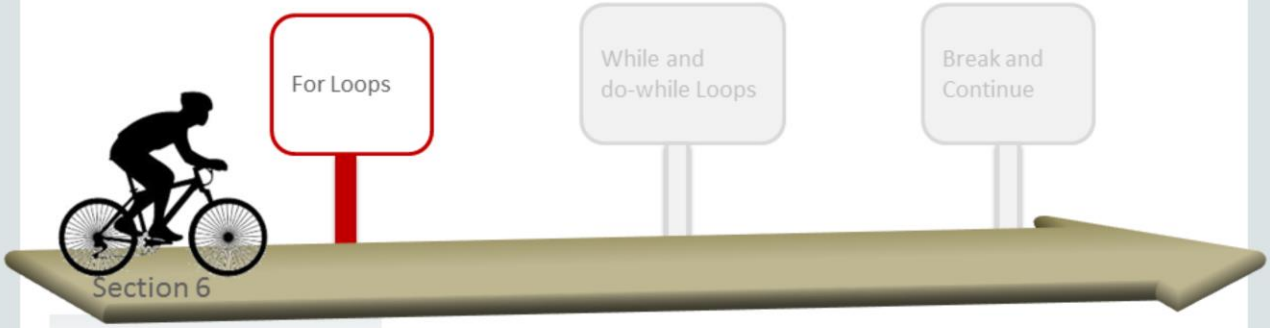
Objectives:

This lesson covers the following objectives:

- Understand the components of the standard `for` loop
- Understand how to create and use a `for` loop
- Understand variable scope
- Understand debugging techniques
- Explain how infinite loops occur in Java

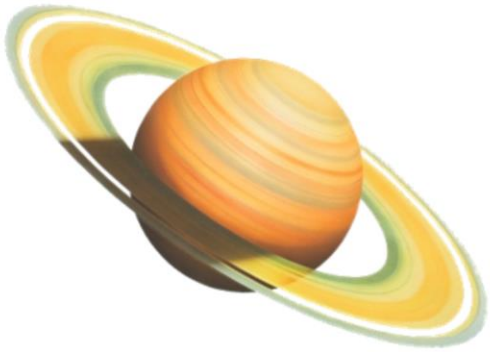
Topics

- What Is a Loop?
- The `for` Loop
- Variable Scope



Mission to Saturn's Rings

- We're going to launch a rocket ship.
- Its mission is to study Saturn's rings.
- Do you have any thoughts on how to program a countdown timer?



The Countdown

Counting down from 10 requires 10 lines of code.

```
System.out.println("Countdown to Launch: ");
System.out.println(10);
System.out.println(9);
System.out.println(8);
System.out.println(7);
System.out.println(6);
System.out.println(5);
System.out.println(4);
System.out.println(3);
System.out.println(2);
System.out.println(1);
System.out.println("Blast Off!");
```

The Countdown

Counting down from 100 would require 100 lines of code.

- That would be painful and tedious to program.
- Is there a more practical way to write this program?
- Can the code easily accommodate any starting value?

```
System.out.println("Countdown to Launch: ");
System.out.println(100);
System.out.println(99);
System.out.println(98);
System.out.println(97);
System.out.println(96);
System.out.println(95);
…
System.out.println("Blast Off!");
```

Can Variables Help?

- Variables are somewhat helpful.
- But we still have to copy and paste the same lines of code until 0 prints.

```
System.out.println("Countdown to Launch: ");

int i = 10;
System.out.println(i);
i--;
System.out.println(i);
i--;
System.out.println(i);
i--;
…
System.out.println("Blast Off!");
```

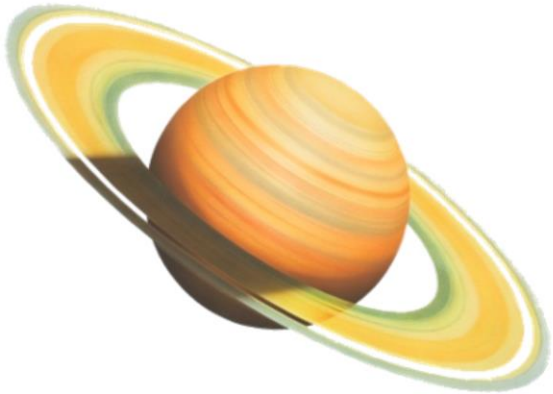
Repeating Code

- Can we make the same lines of code repeat a variable number of times?
- Lines 7–10 show the block of code we want to repeat.
- Remember the line-by-line nature of programs:
  - When the program reaches line 10 …
  - We want to loop back to line 7.

```
5   int i = 10;
6
7    {
8        System.out.println(i);
9        i--;
10   }
11
```

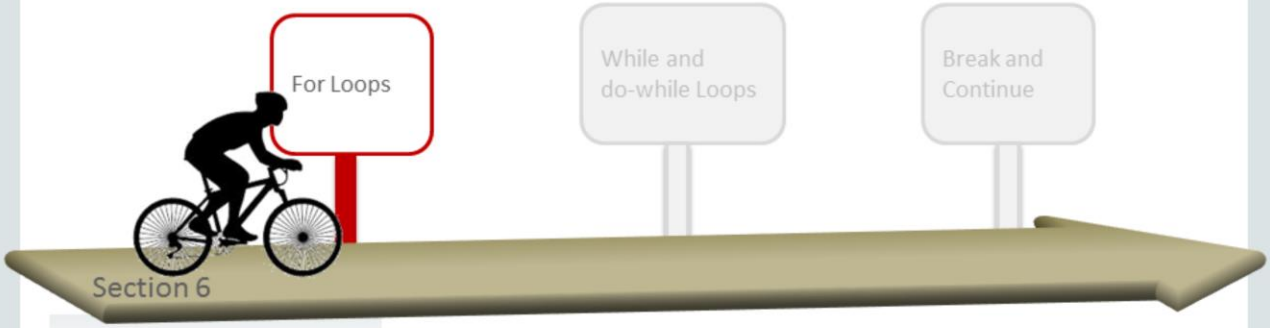
Loop Statements

- Loop statements are used to repeat lines of code.
- Java provides three types of loops:
  - `for`
  - `while`
  - `do-while`



Topics

- What Is a Loop?
- The `for` Loop
- Variable Scope

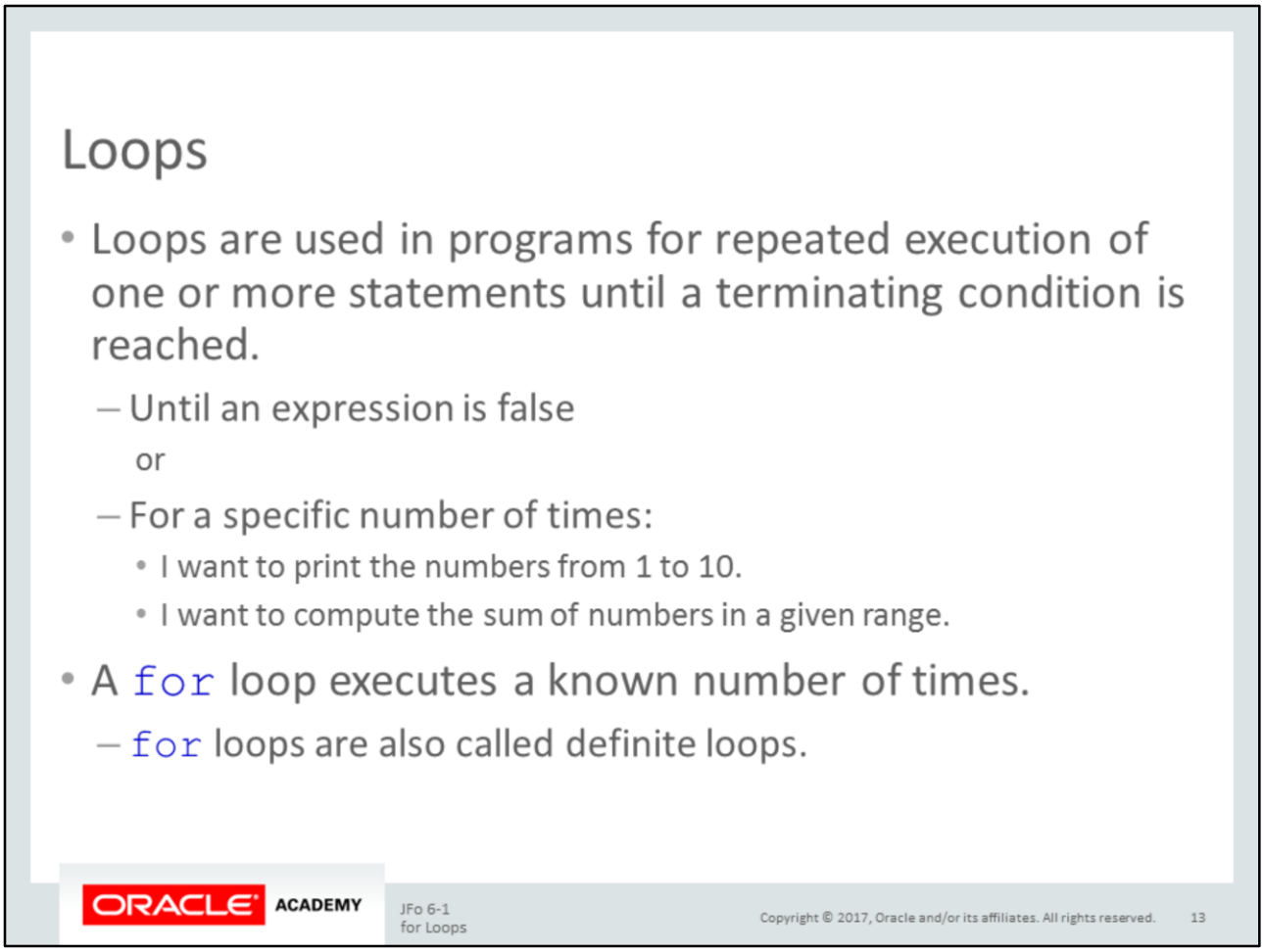


Repeating Behavior


```
while (!areWeThereYet) {

   read book;
   argue with sibling;
   ask, "Are we there yet?";

}

Woohoo!;
Get out of car;
```


A common requirement in a program is to repeat a number of statements. Typically, the code continues to repeat the statements until something changes. Then the code breaks out of the loop and continues with the next statement.

The pseudocode example shows a while loop that loops until the `areWeThereYet` boolean is `true`.



In programming, there are times when you want to work with multiple inputs, but you want to execute the same logic for each input item.

Loops start at the beginning of a piece of code, execute the logic, and then return to the beginning of the loop with new input, ready to execute the code again.

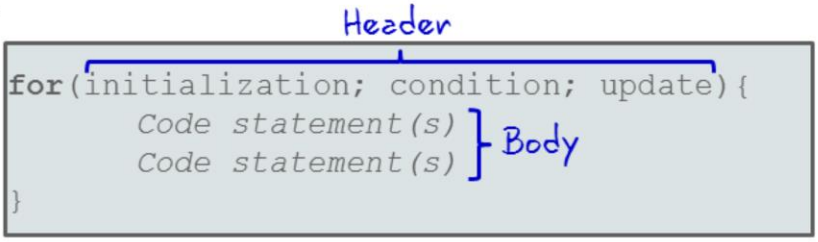
What We Know

In the Countdown scenario, here's what we know:

What We Know	Technical Name	Code
When the loop starts …	Initialization Expression	`int i = 10;`
Continue looping if …	Condition Expression	`i >= 0;`
After each loop …	Update Expression	`i--;`
Code to repeat	Code Statements	`System.out.println(i);`

`for` Loop Overview

Syntax:



- The **initialization** expression initializes the loop. It's executed only once, as the loop begins.
- When the **condition** expression evaluates to false, the loop terminates.
- The **update** expression is invoked after each iteration through the loop. This expression can increment or decrement a value.
- Each expression should be separated with a semicolon (`;`).

Initialization Expression

- Performed once as the loop begins .
- Tells the compiler what variable (called a **loop counter**) is used in the loop.
- Can start at any value, not just 10.

```
System.out.println("Countdown to Launch: ");

for(int i = 10; i >= 0; i--) {
       System.out.println(i);
}

System.out.println("Blast Off!");
```

Condition Expression

- Looping continues as long as this boolean expression is true.
- It uses comparison operators:
  - (==, !=, <, >, <=, >=)

```
System.out.println("Countdown to Launch: ");

for(int i = 10; i >= 0; i--) {
       System.out.println(i);
}

System.out.println("Blast Off!");
```

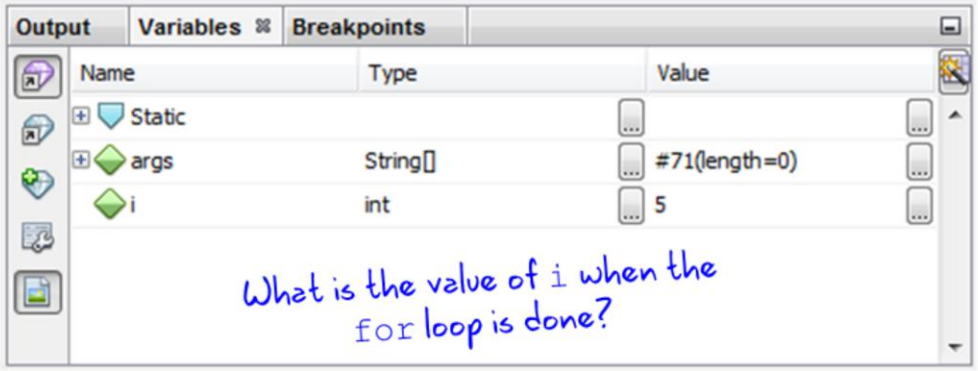
Update Expression

- This statement is executed after each iteration of the `for` loop.
- It's used to update the loop counter.

```
System.out.println("Countdown to Launch: ");

for(int i = 10; i >= 0; i--) {
       System.out.println(i);
}

System.out.println("Blast Off!");
```

Exercise 1, Part 1

- Import and open the ForLoopsEx project.
- Set a breakpoint in `Countdown.java` and observe …
  - How the `for` loop affects code execution
  - How the value of `i` changes



Exercise 1, Part 2

- Can you modify the code to count up from 0 to 5?
- Can you modify the code to count all even numbers from 0 to 20?

Do I Need the Update Expression?

- What if I wrote my loop like this?

```
for(int i = 10; i >= 0;  ) {
       System.out.println(i);
       i--;
}
```

- This works, too!
- But you may not want to code this way, as your loops may become more complicated.

Omitting Expressions in the `for` Loop

- Each expression in the header is optional.
- But there are risks when you omit an expression:
  - No initialization:
    - No initialization is performed.
    - There may be no loop counter.
  - No condition:
    - The loop condition is always considered to be true.
    - The loop is an infinite loop.
  - No update:
    - No increment operation is performed.
    - The loop counter keeps the same value.

Omitting All Expressions in the `for` Loop

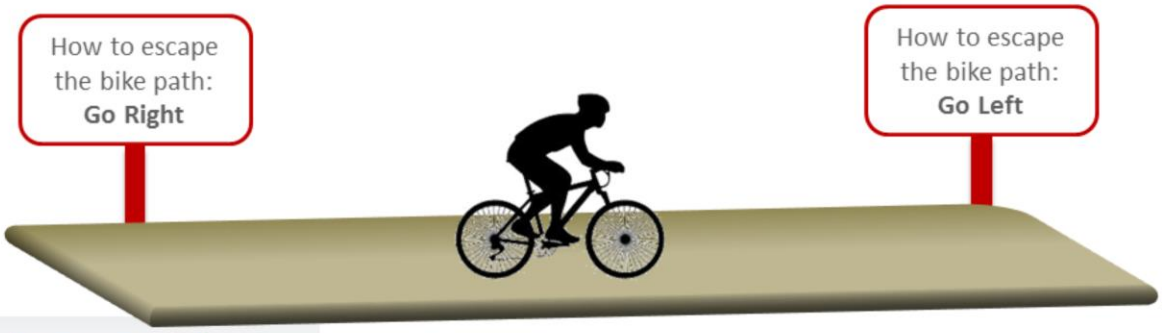
Examine the following code:

- All three expressions in the `for` loop can be omitted.
- The loop repeats infinitely.

```
for(;;){
   System.out.println("Welcome to Java");
}
```

Getting Stuck in an Infinite Loop

- One of the most common errors you can encounter with loops is the **infinite loop**.
- An infinite loop may occur when …
  - The loop's condition expression always evaluates as `true`.
  - The statements within the loop body never set the boolean condition as `false`.



Exercise 2

Import and open the ForLoopsEx project.

- Execute `InfiniteLoop.java` and observe the output.
- Modify the `for` loop in `InfiniteLoop.java` to print "Hello" five times.

Multiple statements within a loop body

To execute multiple statements within a body …

- Enclose the statements within a pair of curly braces.
- Otherwise, only the first statement in the body is executed.

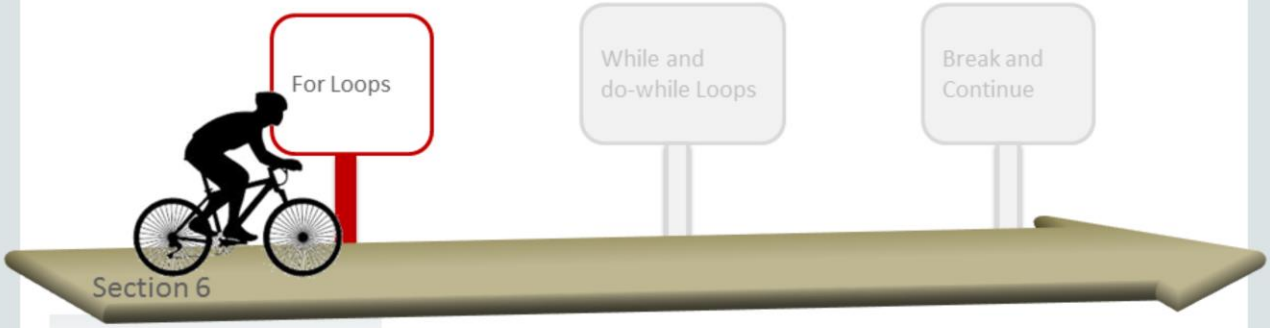
```
for(int i = 1; i <= 5; i++)
System.out.println(i);
System.out.println("second line");
```

Output:

```
1
2
3
4
5
second line
```

Topics

- What Is a Loop?
- The `for` Loop
- Variable Scope



One Use of the `for` Loop

- The `for` loop provides a compact way to iterate over a range of values.
- Repetition without the `for` loop:

```
//Prints the square of 1 through 5
System.out.println("1 squared = " + 1 * 1);
System.out.println("2 squared = " + 2 * 2);
System.out.println("3 squared = " + 3 * 3);
System.out.println("4 squared = " + 4 * 4);
System.out.println("5 squared = " + 5 * 5);
```

- Repetition with the `for` loop:

```
for(int i = 1; i <= 5; i++){
        System.out.println("i squared = " + i * i);
}
```

i Is the Loop Counter

- Every example we've seen relies on the loop counter.

```
for(int i = 1; i <= 5; i++){
        System.out.println("i squared = " + i * i);
}
```

- i can:
  - Be printed
  - Have its value changed
  - Be used in calculations
- This is great for:
  - Counting
  - Calculating values quickly

Understanding Variable Scope

- But `i` exists only within the `for` loop.
  - This is known as the **scope** of `i`.
  - `i` no longer exists when the `for` loop terminates.
  - If `i` is used to calculate values, we'll never get those values out of the `for` loop.
- Did you observe `i` disappear when you debugged `Countdown.java`?

```
for(int i = 1; i <= 5; i++){
        System.out.println("i squared = " + i * i);
}
```

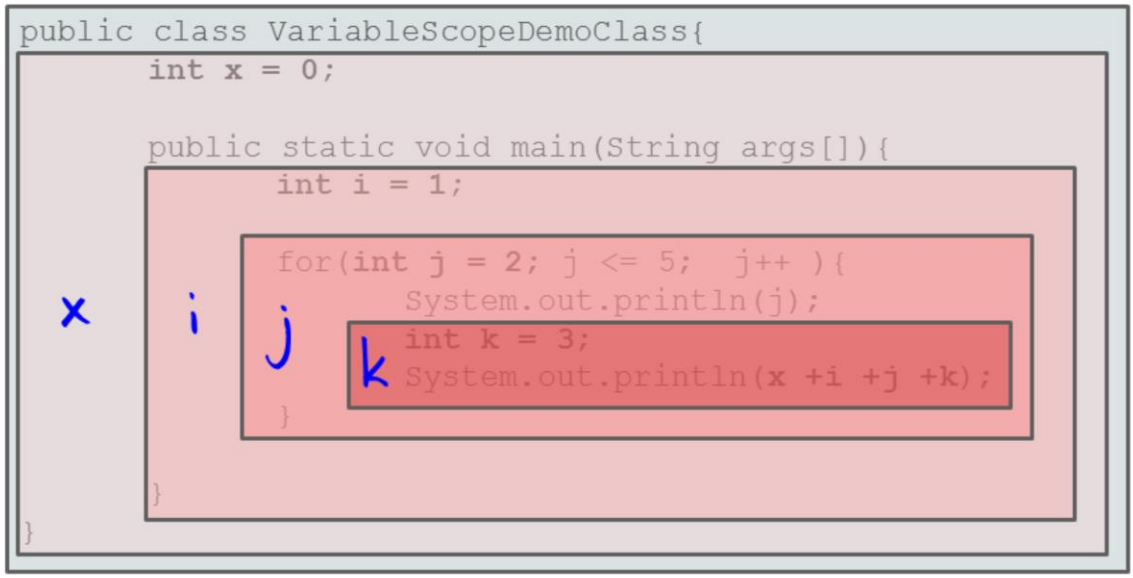
Variable Scope: Example

- Variable `i` declared in the `for` loop is a **local variable** and cannot be accessed outside the loop.
- Compiler error is generated at line 8.

```
1  public class VariableScopeDemo {
2
3      public static void main(String args[]){
4
5          for(int i = 0; i <= 5;  i++ ){
6              System.out.println("i: " +i);
7          }
8          System.out.println("i: " +i);
9      }
10 }
```

Variable Scope Animation

Variables cannot exist before or outside their block of code.



Another Use for Loops

Suppose you need to find the sum of many numbers. Assume `readInt()` is a method that accepts input via `Scanner`.

```
public class Add4Integers  {
    public static void main(String[] args){

         println("This program adds four numbers.");
         int n1 = readInt("Enter n1: ");
         int n2 = readInt("Enter n2: ");
         int n3 = readInt("Enter n3: ");
         int n4 = readInt("Enter n4: ");
         int total = n1 + n2 + n3 + n4;
         println("The total is " + total + ".");
    }
    …
}
```

Another Use for Loops

- This approach is cumbersome to program if you want to add 100 values.

```
int n1 = readInt("Enter n1: ");
int n2 = readInt("Enter n2: ");
int n3 = readInt("Enter n3: ");
int n4 = readInt("Enter n4: ");
…
int n100 = readInt("Enter n100: ");

int total = n1 + n2 + n3 + n4 +… +n100;
```

- Can a `for` loop make this program shorter?
- Can a `for` loop help find the sum of a variable number of integers?

Using Scope with for Loops

This can be solved using …

- A `for` loop
- Variables of different scope

```
public static void main(String[] args){

   int final N = 100;
   int total = 0;
   println("This program adds " + N + " numbers.");

   for(int i = 0; i < N; i++){
         int value = readInt(" ? ");
         total += value;
   }
   println("The total is " + total + ".");
}
```

Scope Animation

- This can be solved using …
  - A `for` loop
  - Variables of different scope

```
public static void main(String[] args){

    int final N = 100;
    int total = 0;
    println("This program adds " + N + " numbers.");

    for(int i = 0; i < N; i++){
        int value = readInt(" ? ");
        total += value;
    }
    println("The total is " + total + ".");
}
```

N

total

i

value

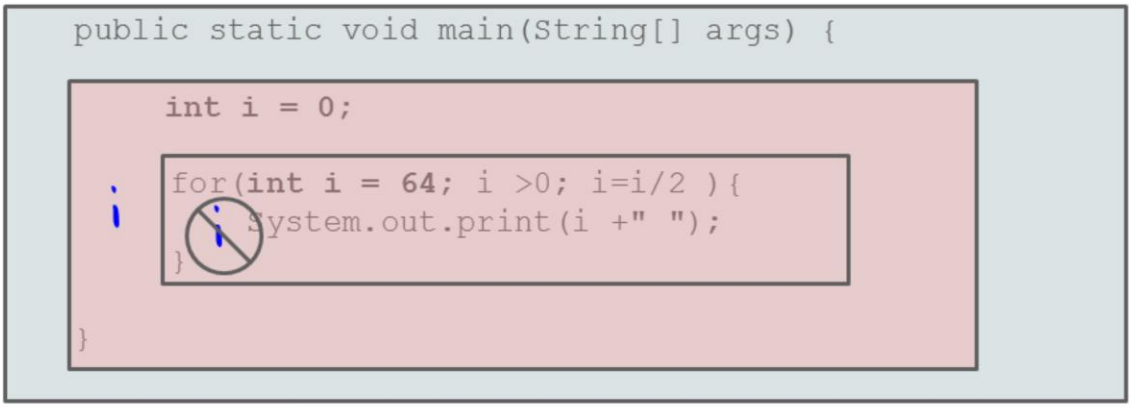
Exercise 3

- Import and open the ForLoopsEx project.
- `ScopeTest.java` is broken. Can you fix it?
- You should get the following output:

```
-64 32 16 8 4 2 1
-0 1 2 3 4 5
-5 4 3 2 1 0
-2 4 8 16 32 64
```

Variable Already Defined

- `i` is created before the `for` loop.
- Another `i` can't exist within the same scope.
- One of these variables needs a different name.



Out of Scope

- `j` can't exist outside the scope where it was created.
- A different `j` can be created if the scopes don't overlap.

```
public static void main(String[] args) {
    for(int j = 0; j<=5; j++){
        System.out.print(j +" ");
    }

    for(int j = 5; j>=0; j--){
        System.out.print(j +" ");
    }

    for(int k = 2; k<=64; k=k*2){
        System.out.print(j +" ");
    }
}
```

Do I Need the Initialization Expression?

- What if I wrote my loop like this?

```
int i = 10;
for(; i >= 0; i--){
        System.out.println(i);
}
```

- This works, too!
  - But `i` exists outside the scope of the `for` loop.
  - If `i` is only meant to be a loop counter, the variable is wasting memory.
  - Keep the scope narrow (as small as possible).
  - Stray variables complicate code and increase the potential for bugs.

Summary

In this lesson, you should have learned how to:

- Understand the components of the standard `for` loop
- Understand how to create and use a `for` loop
- Understand variable scope
- Understand debugging techniques
- Explain how infinite loops occur in Java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