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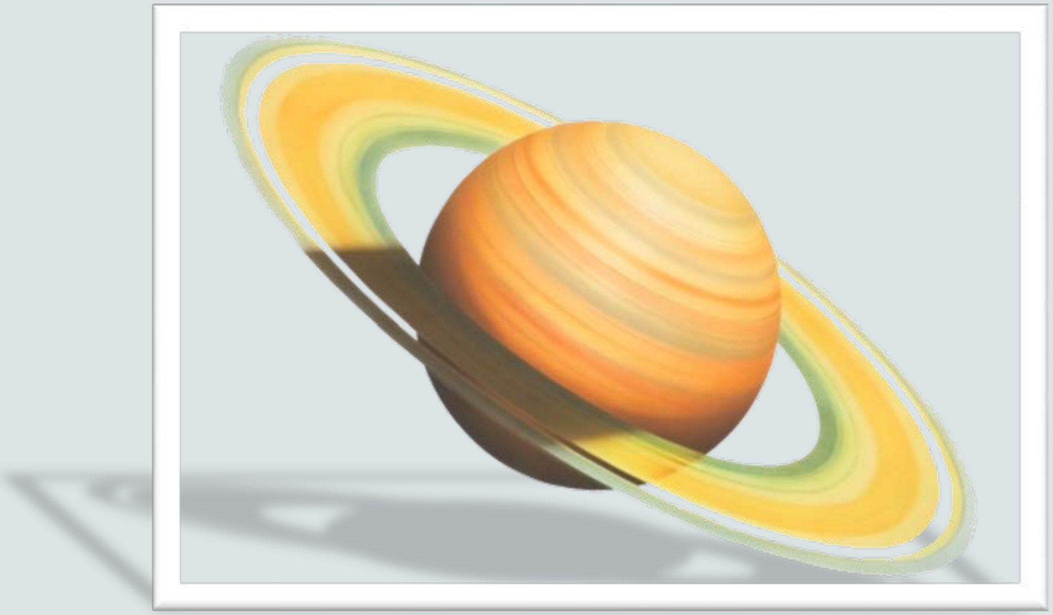
ACADEMY

Java Foundations

6-1
for Loops



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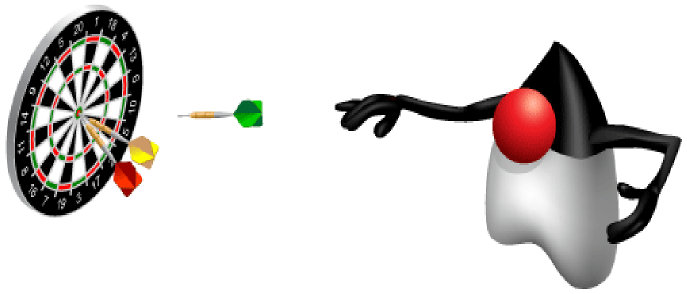
Objectives:

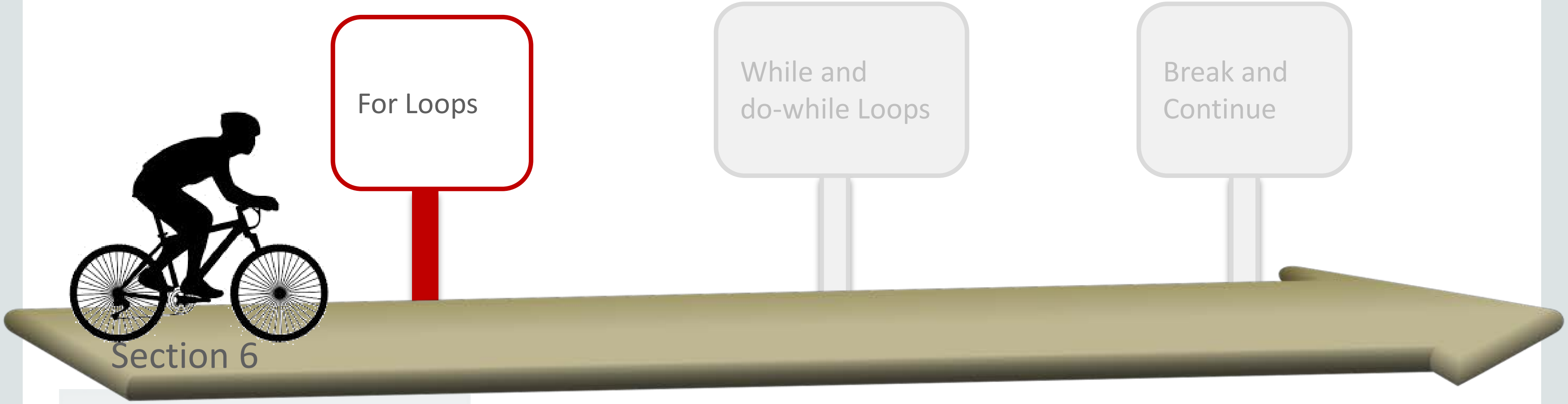
This lesson covers the following objectives:

- 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



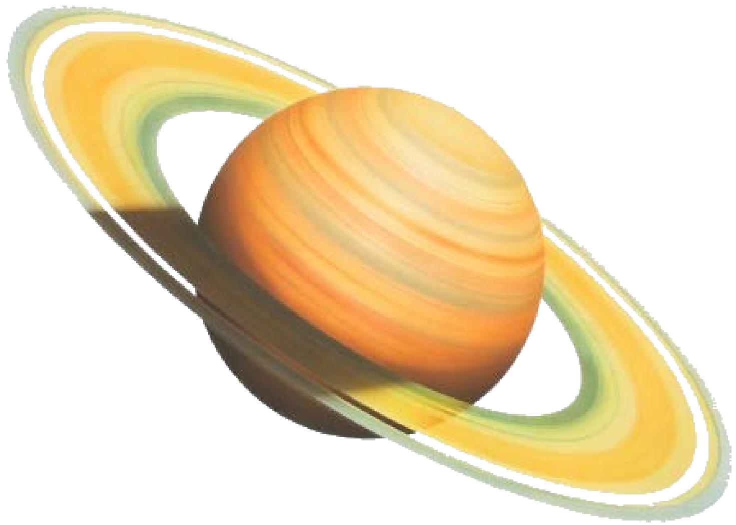
Topics

- 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!");
```

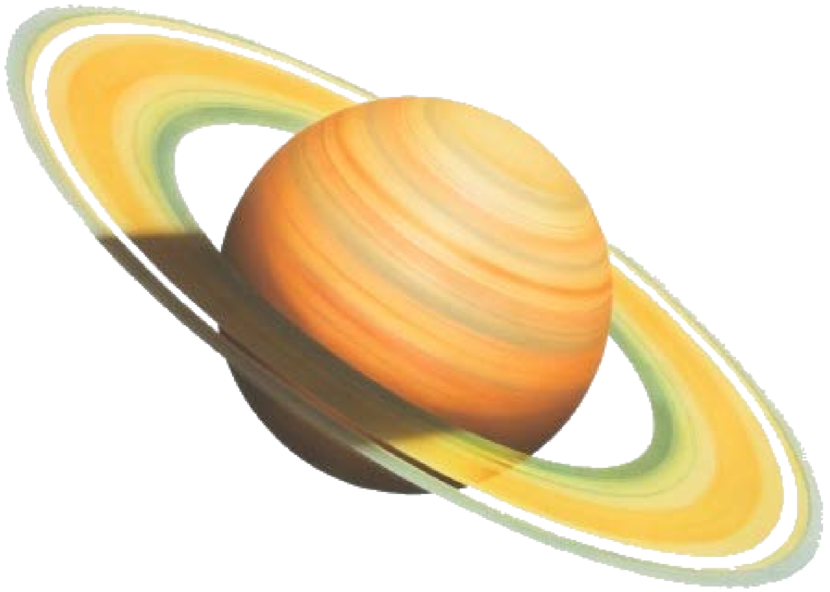
Repeating Code

- 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
```

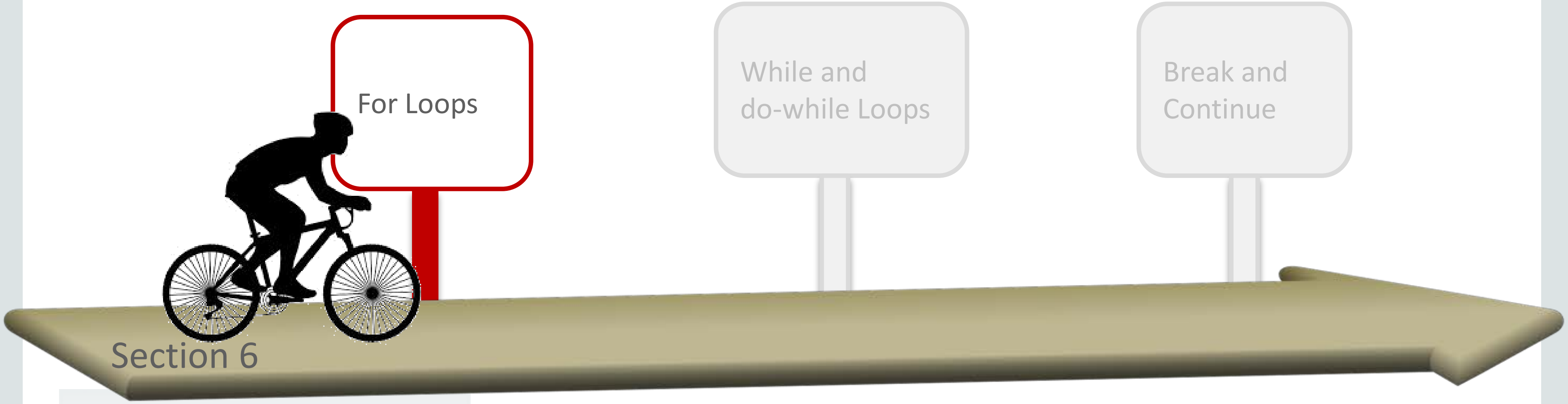
Loop Statements

- 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;
```

Loops

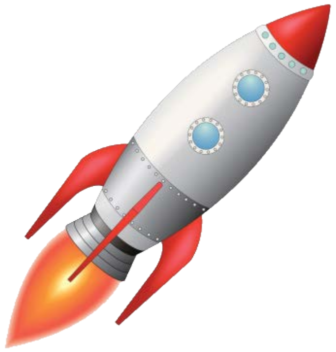
- Loops are used in programs for repeated execution of one or more statements until a terminating condition is reached.
  - Until an expression is false

    or
  - For a specific number of times:
    - I want to print the numbers from 1 to 10.
    - I want to compute the sum of numbers in a given range.
- A `for` loop executes a known number of times.
  - `for` loops are also called definite loops.

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:

Header

```
for(initialization; condition; update){
        Code statement(s)
        Code statement(s)
}
```

Body

- 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!");
```

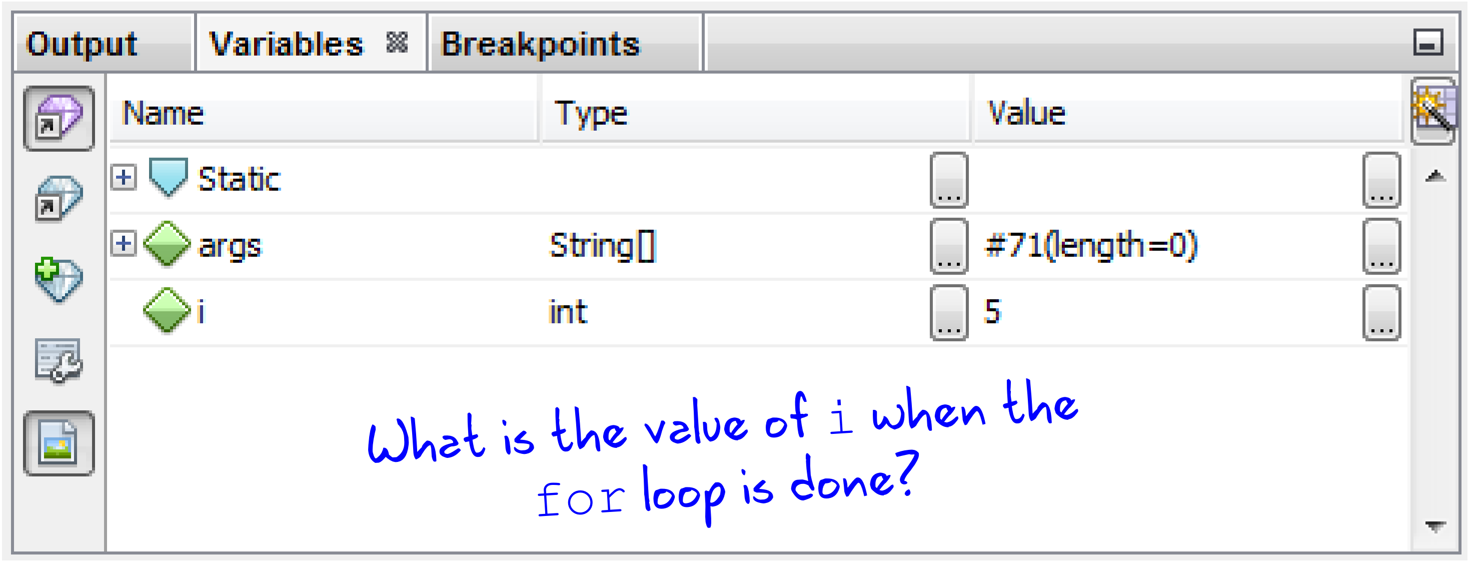
Update Expression

- 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



Name	Type	Value
Static		
args	String[]	#71(length=0)
i	int	5

What is the value of `i` when the `for` loop is done?

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

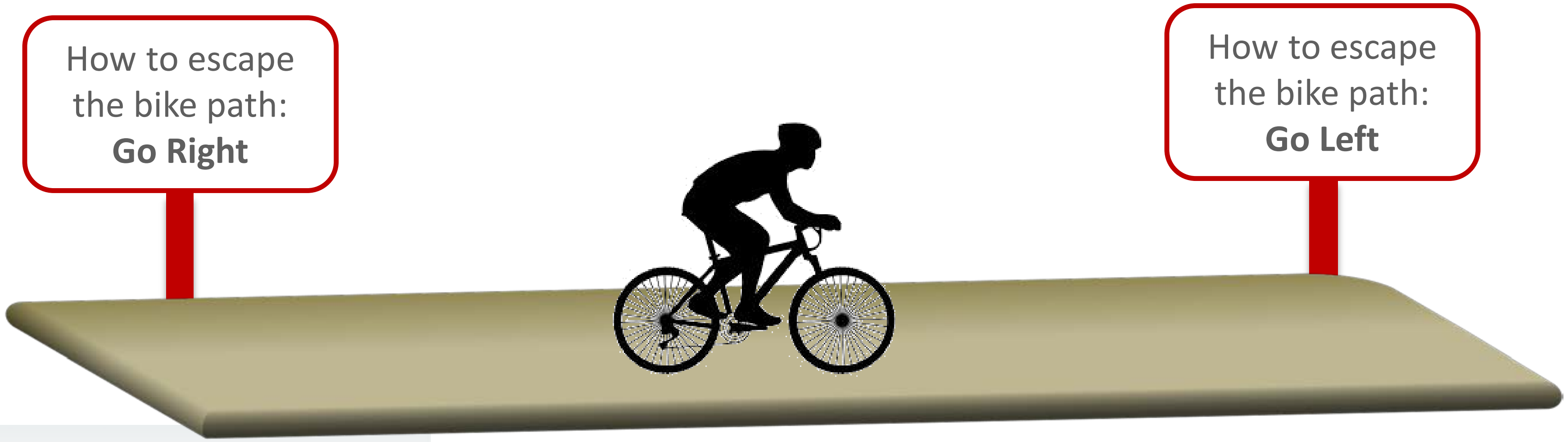
Examine the following code:

- 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`.


How to escape the bike path: **Go Right**
How to escape the bike path: **Go Left**

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.

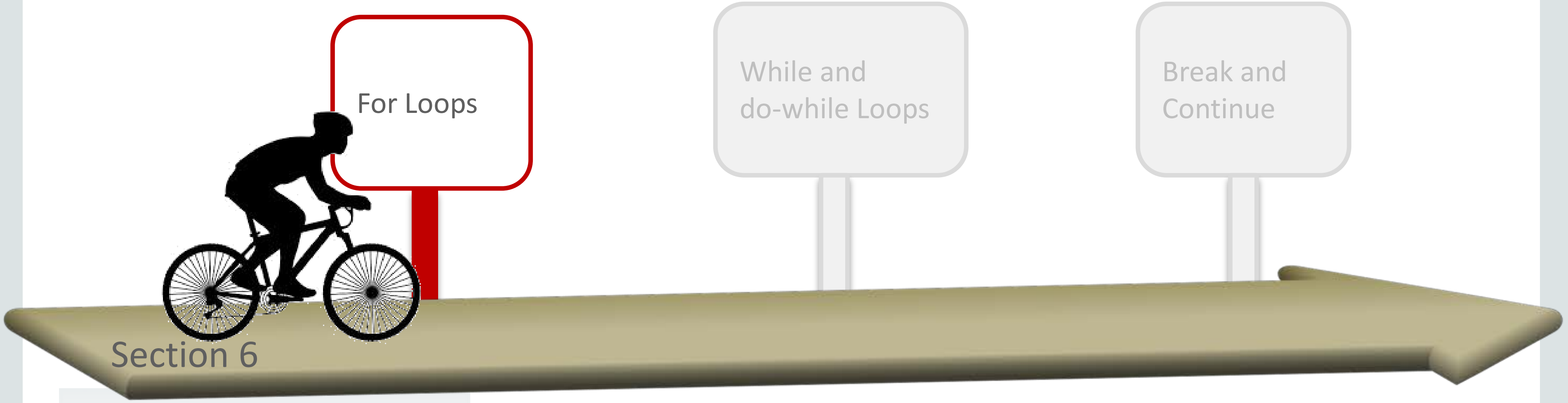
```
for(int i = 1; i <= 5; i++)
System.out.println(i);
System.out.println("second line");
```

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:

```java
//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:

```java
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);
}
```

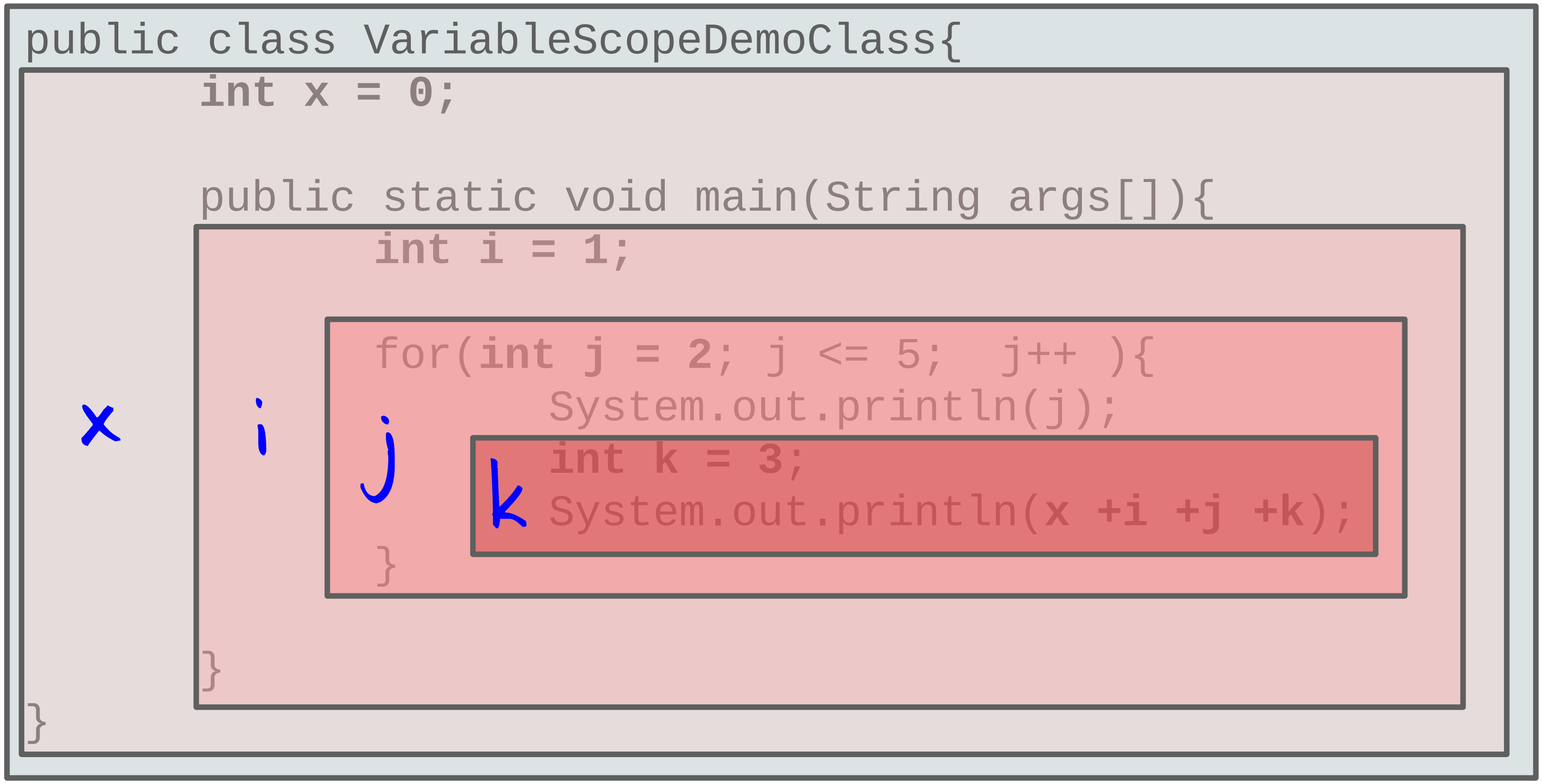
Variable Scope: Example

- 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.



```
public class VariableScopeDemoClass{
        int x = 0;

        public static void main(String args[]){
                int i = 1;

                for(int j = 2; j <= 5;  j++ ){
                        System.out.println(j);
                        int k = 3;
                        System.out.println(x +i +j +k);
                }

        }
}
```

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

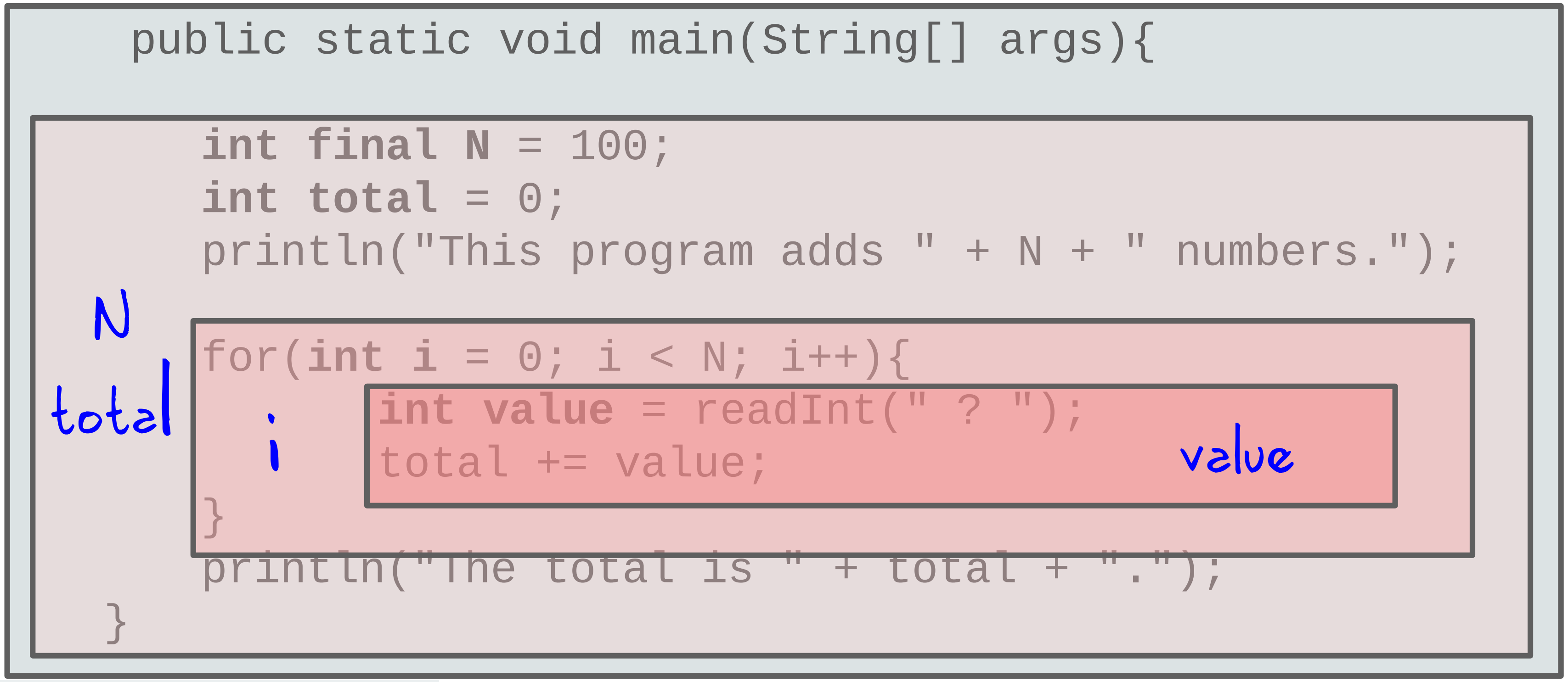
This can be solved using …

- 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



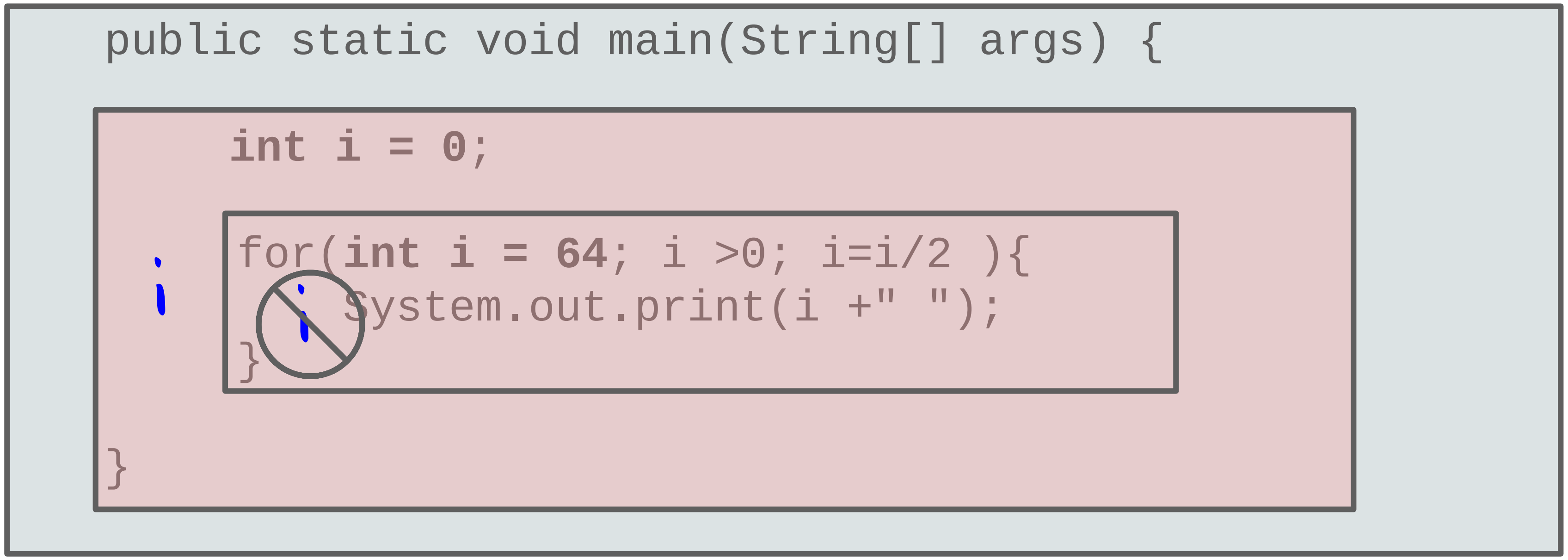
```
    public static void main(String[] args){

       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 + ".");
   }
```

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.



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

       int i = 0;

      for(int i = 64; i >0; i=i/2 ){
         System.out.print(i +" ");
      }

   }
```

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++){
 j              System.out.print(j +" ");
        }

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

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

Do I Need the Initialization Expression?

- What if I wrote my loop like this?

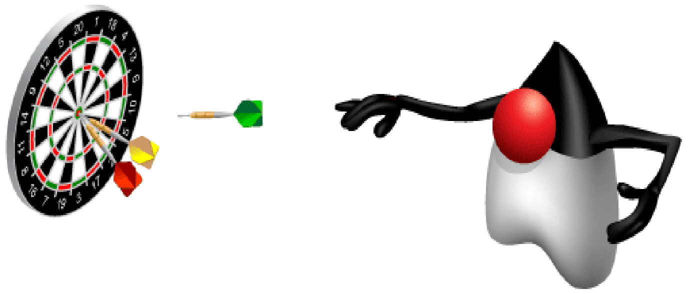
```
int i = 10;
for(; i >= 0; i--){
       System.out.println(i);
}
```

- 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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