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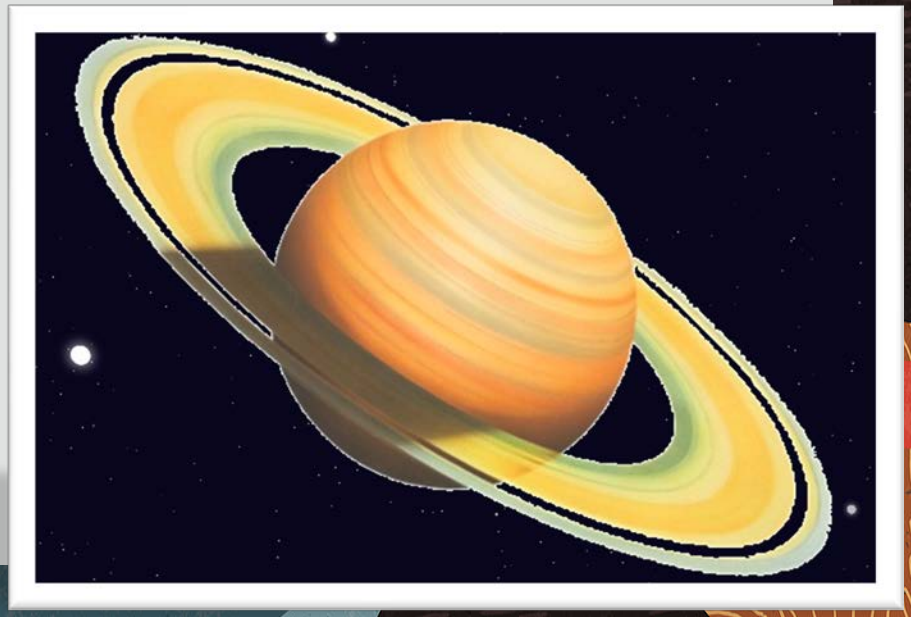
Java for AP Computer Science A

6-1

for Loops



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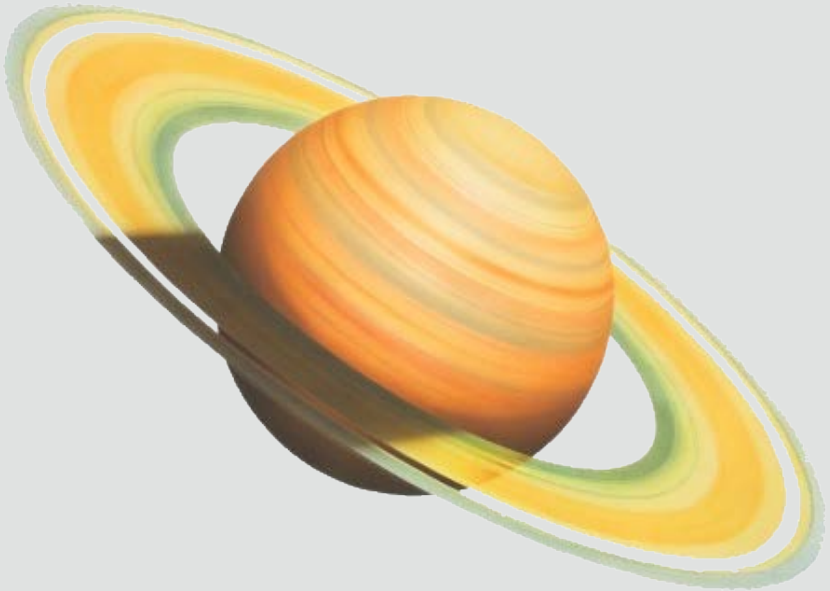
Objectives:

- 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

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?

The Countdown

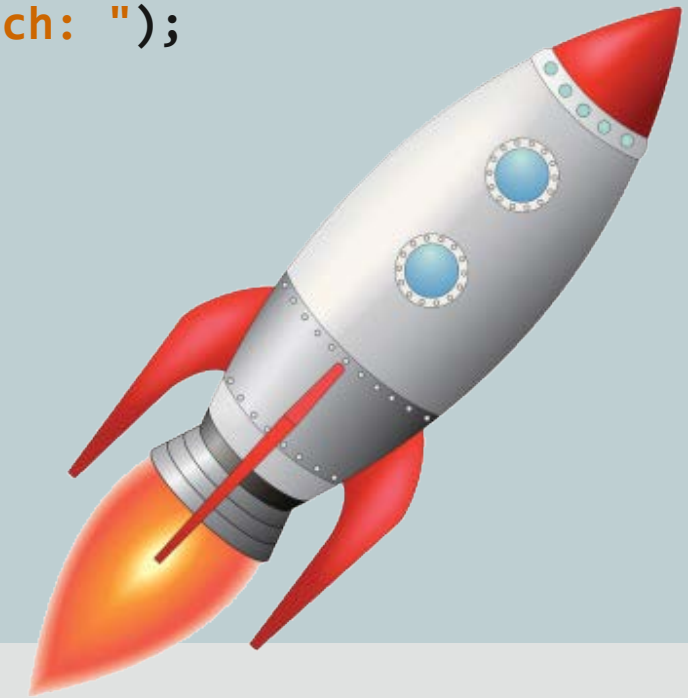
```
System.out.println("Countdown to Launch: ");
System.out.println(100);
System.out.println(99);
System.out.println(98);
System.out.println(97);
System.out.println(96);
System.out.println(95);
…
…
…
…
…
…
System.out.println(2);
System.out.println(1);
System.out.println("Blast Off!");
```

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!");
```



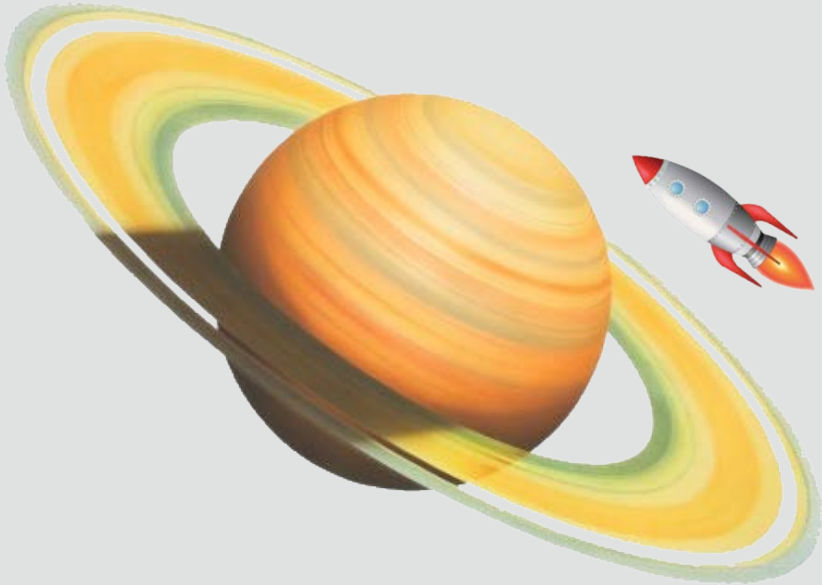
Repeating Code

- 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   }
```

Loop Statements

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



Repeating Behavior


```
while (!areWeThereYet) {

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

}

Woohoo!;
Get out of car;
```

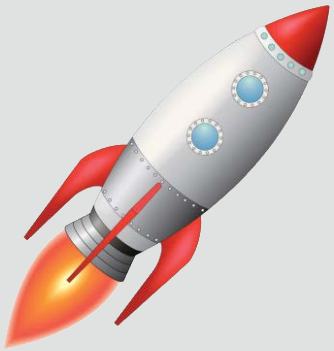
Loops

- 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)
}//end for
```

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);
}//end for

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);
}//end for

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

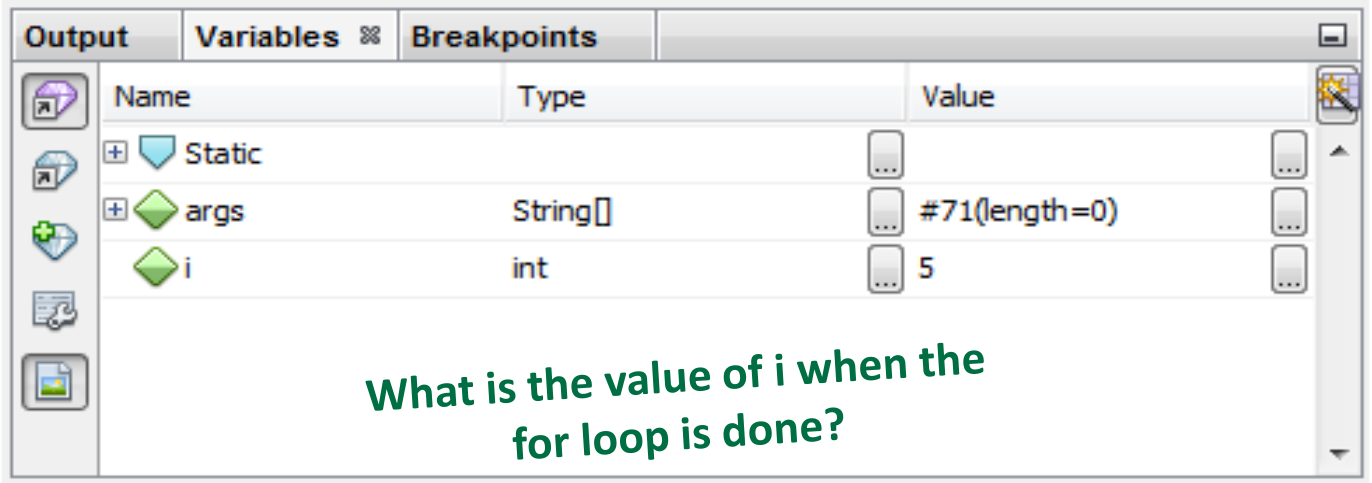
```
System.out.println("Countdown to Launch: ");

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

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

Exercise 1, Part 1

- Create a new project and add the `Countdown.java` file to the 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--;
}//end for
```

- 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");
}//end for
```

Exercise 2

- Add the file `InfiniteLoop.java` to the project you created for exercise 1
- 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
```

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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);
}//end for
```

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);
}//end for
```

- 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);
}//end for
```

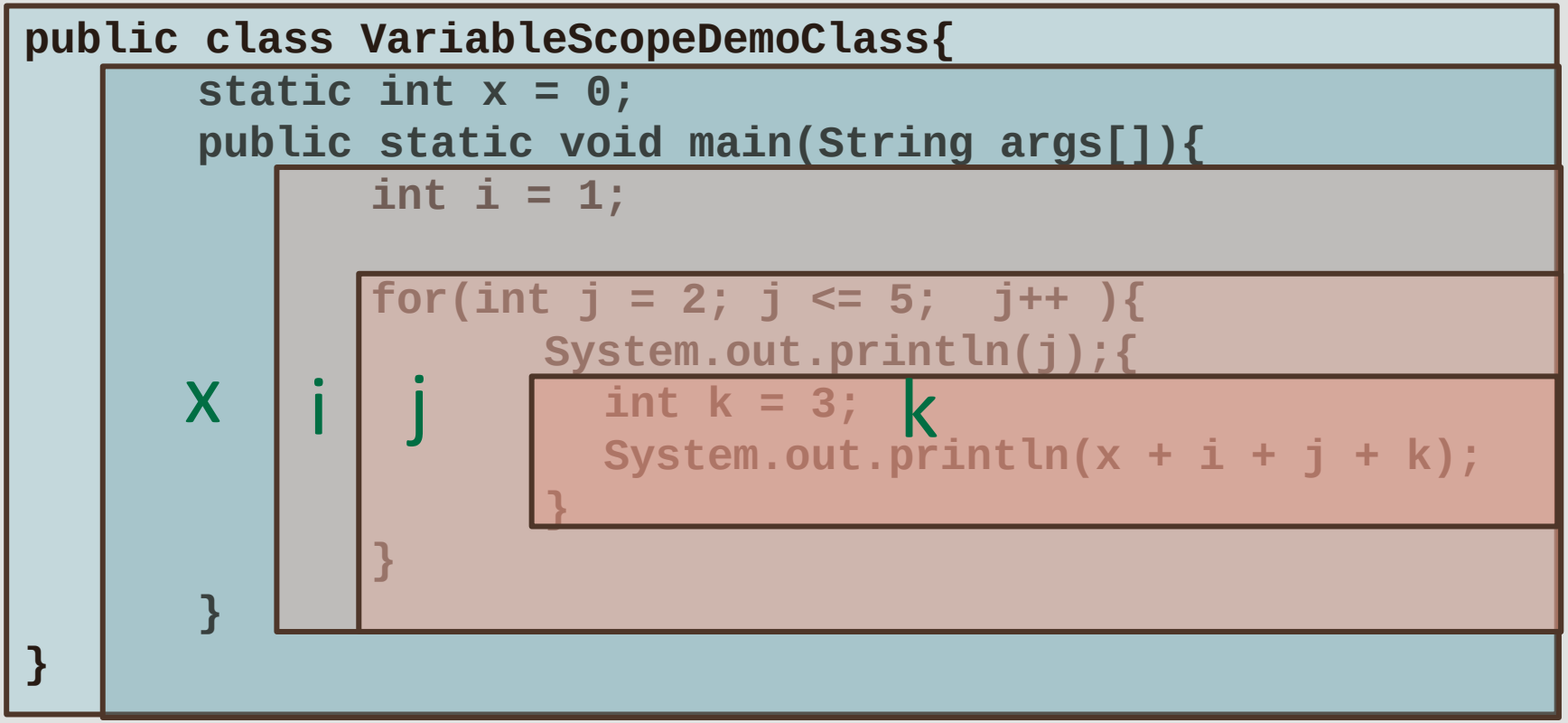
Variable Scope: Example

- 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          }//end for
8          System.out.println("i: " +i);
9      }//end method main
10 }//end class VariableScopeDemo
```

Variable Scope

- Variables cannot exist before or outside their block of code



Another Use - for Loops

- Suppose you need to find the sum of four numbers

```
import java.util.Scanner;
public class Add4Integers  {
    public static void main(String[] args){
        Scanner in = new Scanner(System.in);
        System.out.println("This program adds four numbers.");
        System.out.println("Type each number, followed by Enter.");
        int n1 = in.nextInt();
        int n2 = in.nextInt();
        int n3 = in.nextInt();
        int n4 = in.nextInt();
        int total = n1 + n2 + n3 + n4;
       System.out.println("The total is " + total + ".");
    }//end method main
}//end class Add4Integers
```

Another Use - for Loops

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

```
int n1 = in.nextInt();
int n2 = in.nextInt();
int n3 = in.nextInt();
int n4 = in.nextInt();
  …
int n100 = in.nextInt();
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?

Adding many numbers with a `for` Loop

- Yes! This can be solved using …
  - A `for` loop with variables of different scope

```
import java.util.Scanner;
public class PracticeCode {
public static void main(String[] args){
        Scanner in = new Scanner(System.in);
        int N = 100;
        int total = 0;
        System.out.println("This program adds " + N + " numbers.");
        for(int i = 0; i < N; i++){
        System.out.println(("Enter your next number:");
                int value = in.nextInt();
                total += value;
        }//end for
        System.out.println("The total is " + total + ".");
   }//end method main
```

Adding Numbers – Variable Scope

```
import java.util.Scanner;
public class PracticeCode {
public static void main(String[] args){
        Scanner in = new Scanner(System.in);
        int N = 100;
        int total = 0;
        System.out.println("This program adds " + N + " numbers.");
        for(int i = 0; i < N; i++){
        System.out.println(("Enter your next number:");
              int value = in.nextInt();
              total += value;
        }//end for
        System.out.println("The total is " + total + ".");
   }//end method main
```

N

i

value

Find the Average for a Set of Numbers

```
import java.util.Scanner;
public class PracticeCode {
public static void main(String[] args){
   Scanner in = new Scanner(System.in);
   int N = 10;
   int total = 0;
   System.out.println("This program finds the average of " + N + " numbers.");
   for(int i = 0; i < N; i++){
      System.out.println("Enter the next value: ");
            int value = in.nextInt();
            total += value;   }//end for
      System.out.println("The average is " + (double)total/N + ".");
}//end method main
```

How to Find a Minimum

- From a series of numbers, a minimum value can be found by comparing values as follows:

```
import java.util.Scanner;
public class PracticeCode {
public static void main(String[] args){
        Scanner in = new Scanner(System.in);
        int final N = 10;
        System.out.println("This program will find the minimum of " + N + " numbers.");
        System.out.println("Enter the first number:");
        int minimum = in.nextInt();
        for(int i = 0; i < N-1; i++){
        System.out.println("Enter the next number: ");
        int value = in.nextInt();
        if(value < minimum)
                minimum = value;    }//end for
      System.out.println("The minimum value is " + minimum + ".");
}//end method main
```

How to Find a Maximum?

- Use the code from the previous slide to find the maximum

Using a for Loop to Check Divisibility

- Is 6785 divisible by 7?
- Is 459 divisible by 3?
- Use the following example to check
- Test using 3 additional sets of numbers

Using a for Loop to Check Divisibility

```
import java.util.Scanner;
public class PracticeCode {
   public static void main(String[] args){
        Scanner in = new Scanner(System.in);
        int final N = 5;
        System.out.println("This program checks 5 sets of numbers to see " +
                           " if one number is evenly divisible by another.");
        for(int i = 0; i < N-1; i++){
            System.out.println("Enter a number: ");
            int num1 = in.nextInt();
            System.out.println("Enter the divisor: ");
            int num2 = in.nextInt();
            if(num1%num2 == 0)
                        System.out.println(num1 + "is divisible by " + num2);
            else
                         System.out.println(num1 + "is not divisible by " + num2);
        }
   }
}
```

Using a for Loop to Check Divisibility

- Edit the Java code on the previous slide to check if numbers are odd or even

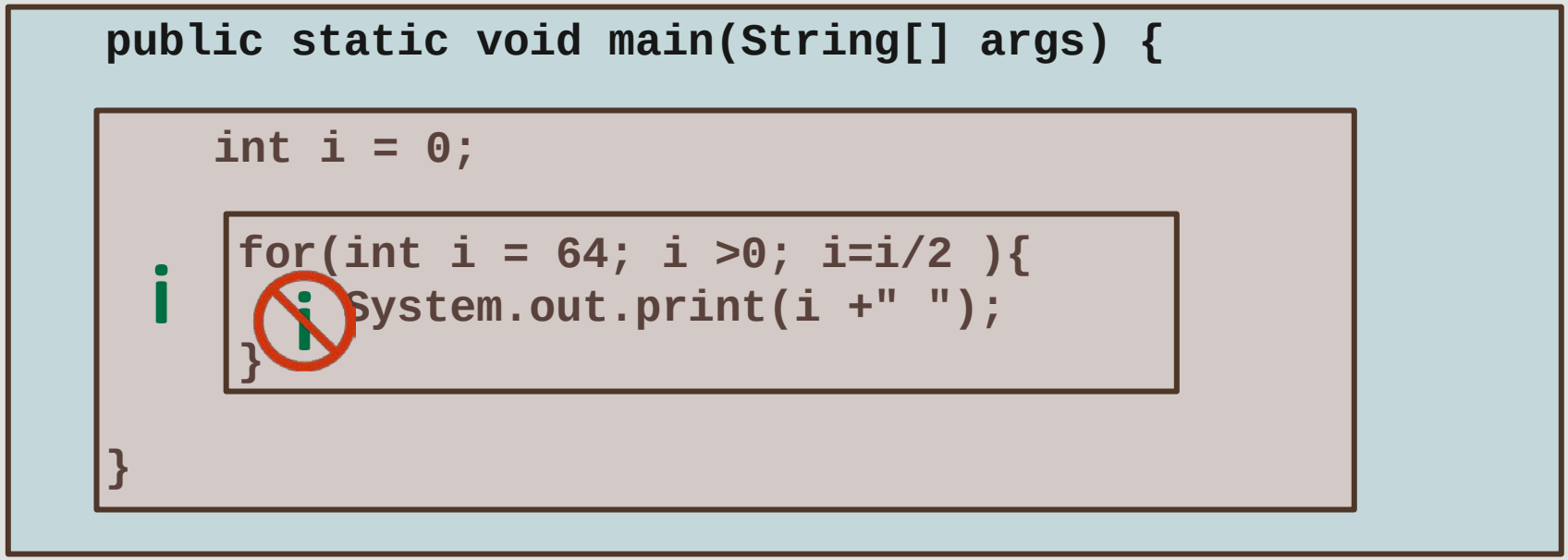
Exercise 3

- Add the file `ScopeTest.java` to the project you created for exercise 1
- `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);
}//end for
```

- 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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