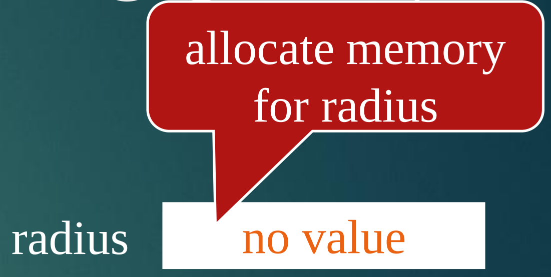
Chapter 2 Elementary Programming

animation

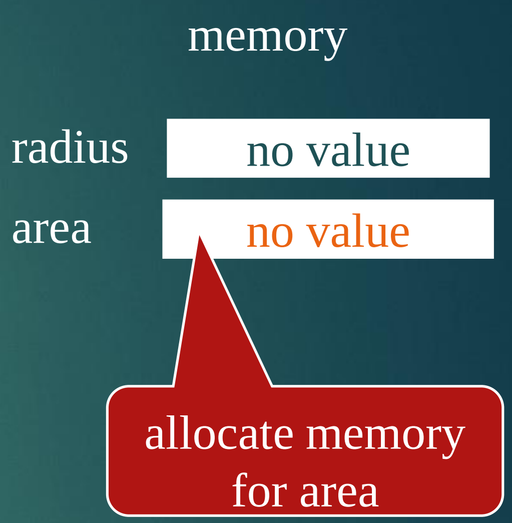
Example: ComputeArea

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of
     radius " +
     radius + " is " + area);
  }
}
```


allocate memory for radius

Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of
     radius " +
     radius + " is " + area);
  }
}
```



memory

radius no value

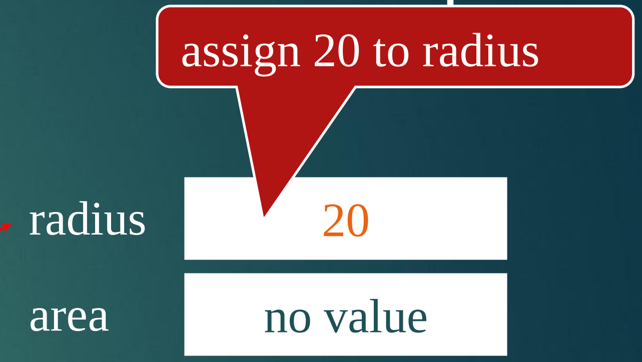
area no value

allocate memory for area

animation

Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of
      radius " +
      radius + " is " + area);
  }
}
```

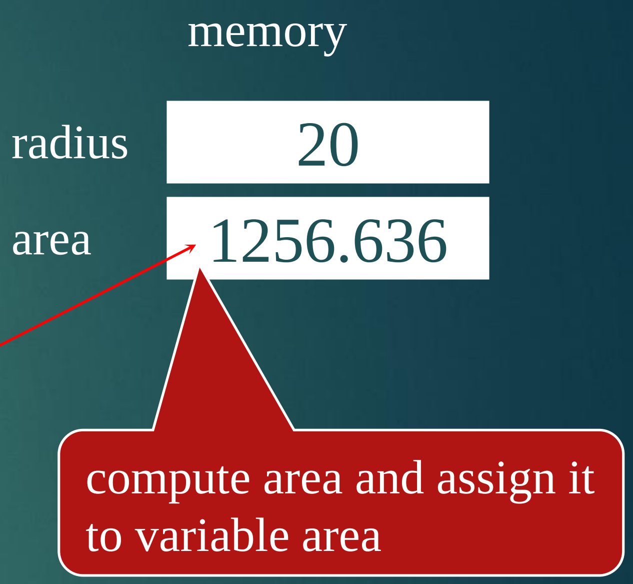


assign 20 to radius

animation

Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of
     radius " +
     radius + " is " + area);
  }
}
```



memory

radius 20

area 1256.636

compute area and assign it to variable area

animation

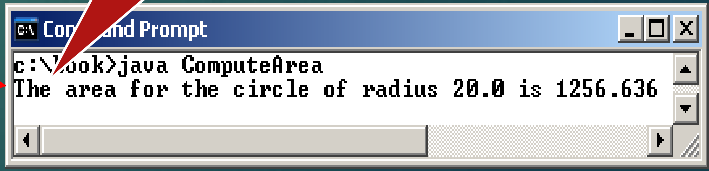
Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```

memory

radius	20
area	1256.636

print a message to the console



```
c:\book>java ComputeArea
The area for the circle of radius 20.0 is 1256.636
```

Reading Input from the Console

1. Create a Scanner object

```
Scanner input = new Scanner(System.in);
```

2. Use the methods nextInt(), nextFloat(), nextDouble(), to obtain to an int, float, or double. For example,

```
System.out.print("Enter a double value: ");
Scanner input = new Scanner(System.in);
double d = input.nextDouble();
```

Identifiers

- An identifier is a sequence of characters that consist of letters, digits, underscores (_), and dollar signs ($).
- An identifier must start with a letter, an underscore (_), or a dollar sign ($). It cannot start with a digit.
  - An identifier cannot be a reserved word. (See Appendix A, “Java Keywords,” for a list of reserved words).
- An identifier cannot be `true`, `false`, or `null`.
- An identifier can be of any length.

Variables

```
// Compute the first area
radius = 1.0;
area = radius * radius * 3.14159;
System.out.println("The area is “ +
  area + " for radius "+radius);

// Compute the second area
radius = 2.0;
area = radius * radius * 3.14159;
System.out.println("The area is “ +
  area + " for radius "+radius);
```

Declaring Variables

```
int x;         // Declare x to be an
               // integer variable;
double radius; // Declare radius to
               // be a double variable;
char a;        // Declare a to be a
               // character variable;
```

Assignment Statements

```
x = 1;          // Assign 1 to x;

radius = 1.0;   // Assign 1.0 to radius;

a = 'A';        // Assign 'A' to a;
```

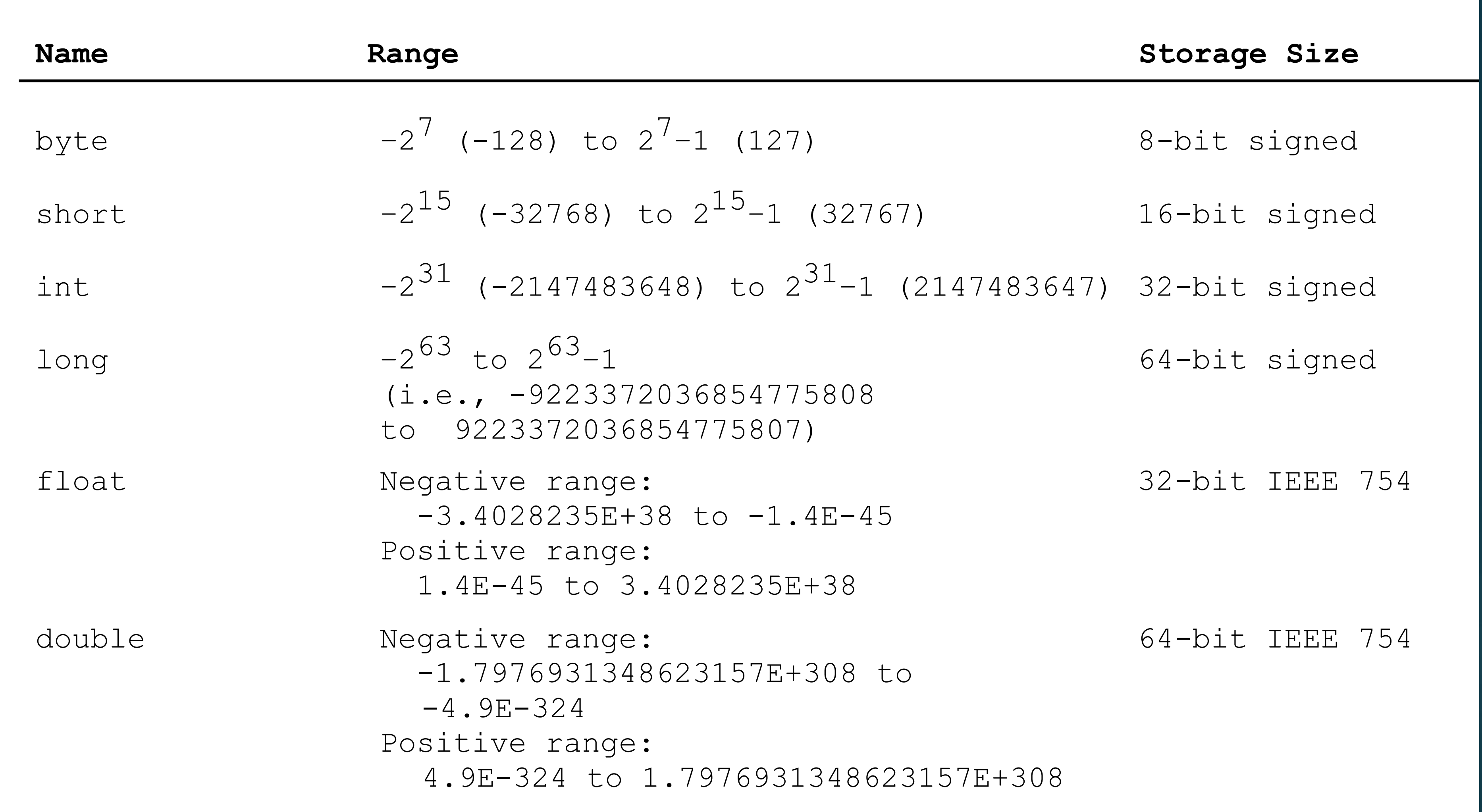
Declaring and Initializing in One Step

```
int x = 1;
double d = 1.4;
```

Constants

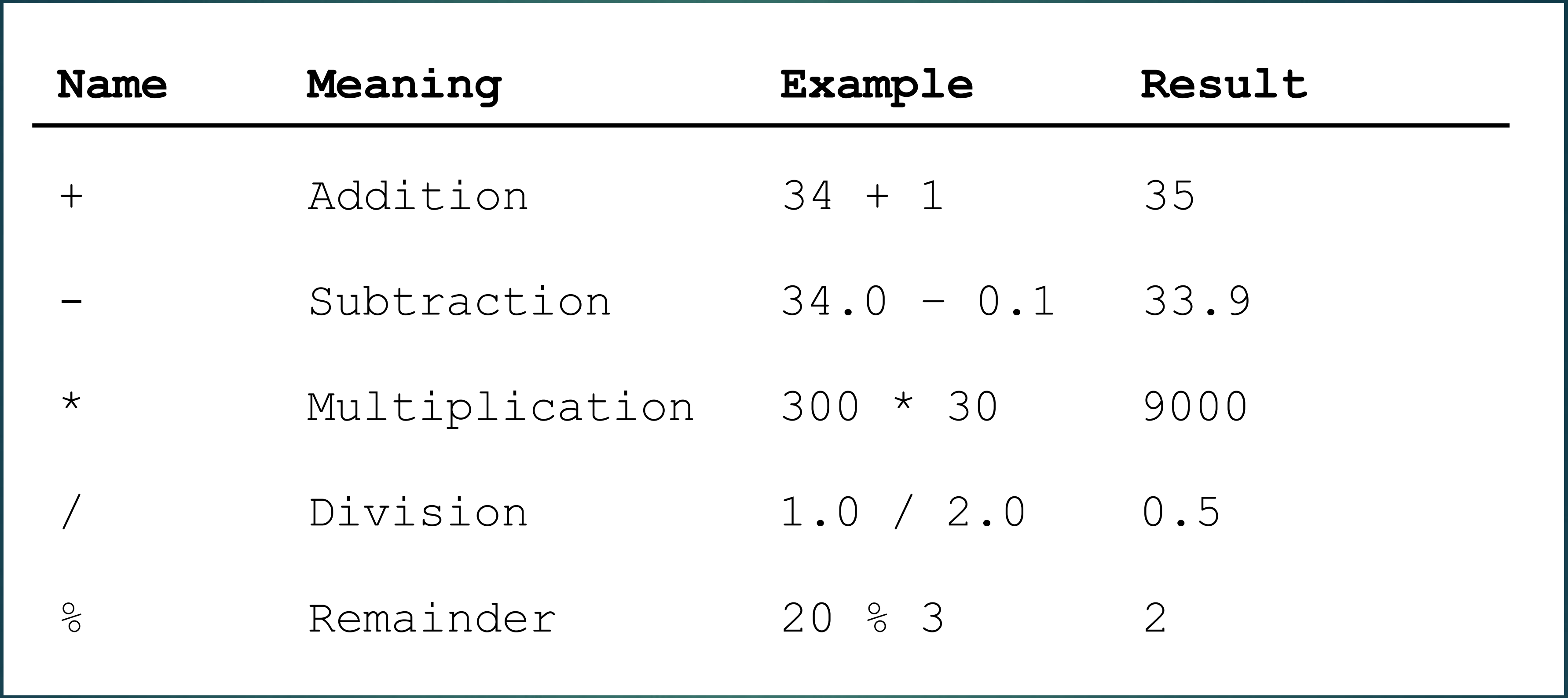
```
final datatype CONSTANTNAME = VALUE;

final double PI = 3.14159;
final int SIZE = 3;
```

Numerical Data Types



Name	Range	Storage Size
byte	-2^{7} (-128) to $2^{7}-1$ (127)	8-bit signed
short	-2^{15} (-32768) to $2^{15}-1$ (32767)	16-bit signed
int	-2^{31} (-2147483648) to $2^{31}-1$ (2147483647)	32-bit signed
long	-2^{63} to $2^{63}-1$ (i.e., -9223372036854775808 to 9223372036854775807)	64-bit signed
float	Negative range: -3.4028235E+38 to -1.4E-45 Positive range: 1.4E-45 to 3.4028235E+38	32-bit IEEE 754
double	Negative range: -1.7976931348623157E+308 to -4.9E-324 Positive range: 4.9E-324 to 1.7976931348623157E+308	64-bit IEEE 754

Numeric Operators



Name	Meaning	Example	Result
+	Addition	34 + 1	35
-	Subtraction	34.0 – 0.1	33.9
*	Multiplication	300 * 30	9000
/	Division	1.0 / 2.0	0.5
%	Remainder	20 % 3	2

Integer Division

+, -, *, /, and %

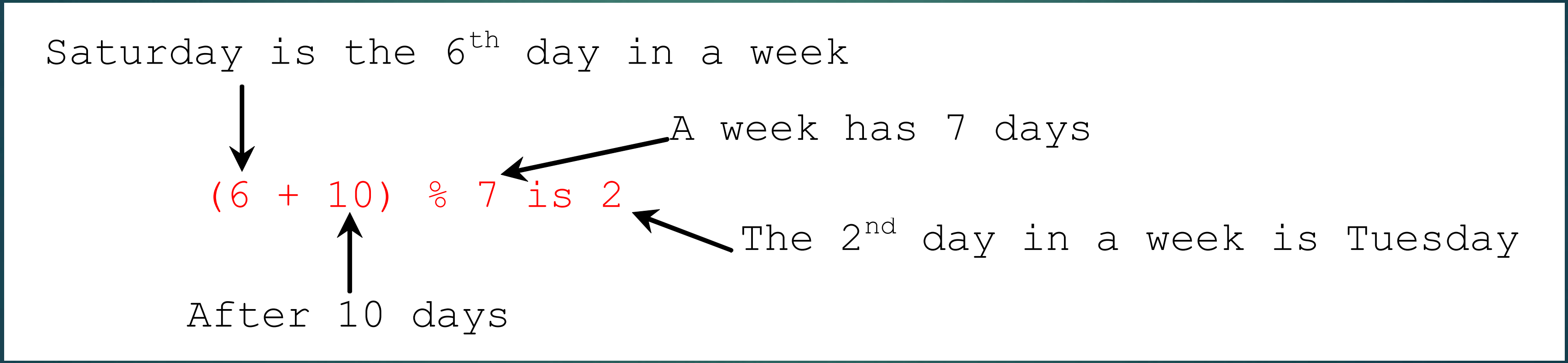
5 / 2 yields an integer 2.

5.0 / 2 yields a double value 2.5

5 % 2 yields 1 (the remainder of the division)

Remainder Operator

Remainder is very useful in programming. For example, an even number % 2 is always 0 and an odd number % 2 is always 1. So you can use this property to determine whether a number is even or odd. Suppose today is Saturday and you and your friends are going to meet in 10 days. What day is in 10 days? You can find that day is Tuesday using the following expression:



Saturday is the 6th day in a week

A week has 7 days

`(6 + 10) % 7 is 2`

The 2nd day in a week is Tuesday

After 10 days

Problem: Displaying Time

Write a program that obtains hours and minutes from seconds.

DisplayTime.java

```java
import java.util.Scanner;
public class DisplayTime {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);
    // Prompt the user for input
    System.out.print("Enter an integer for seconds: ");
    int seconds = input.nextInt();
    int minutes = seconds / 60; // Find minutes in seconds
    int remainingSeconds = seconds % 60; // Seconds remaining
    System.out.println(seconds + " seconds is " + minutes +
                  " minutes and " + remainingSeconds + " seconds");
  }
}
```

NOTE

Calculations involving floating-point numbers are approximated because these numbers are not stored with complete accuracy. For example,

```
System.out.println(1.0 - 0.1 - 0.1 - 0.1 - 0.1 - 0.1);
```

displays 0.5000000000000001, not 0.5, and

```
System.out.println(1.0 - 0.9);
```

displays 0.09999999999999998, not 0.1. Integers are stored precisely. Therefore, calculations with integers yield a precise integer result.

Number Literals

A *literal* is a constant value that appears directly in the program. For example, 34, 1,000,000, and 5.0 are literals in the following statements:

```
int i = 34;
long x = 1000000;
double d = 5.0;
```

Integer Literals

An integer literal can be assigned to an integer variable as long as it can fit into the variable. A compilation error would occur if the literal were too large for the variable to hold. For example, the statement byte b = 1000 would cause a compilation error, because 1000 cannot be stored in a variable of the byte type.

An integer literal is assumed to be of the int type, whose value is between -2^{31} (-2147483648) to $2^{31}–1$ (2147483647). To denote an integer literal of the long type, append it with the letter L or l. L is preferred because l (lowercase L) can easily be confused with 1 (the digit one).

Floating-Point Literals

Floating-point literals are written with a decimal point. By default, a floating-point literal is treated as a double type value. For example, 5.0 is considered a double value, not a float value. You can make a number a float by appending the letter f or F, and make a number a double by appending the letter d or D. For example, you can use 100.2f or 100.2F for a float number, and 100.2d or 100.2D for a double number.

Scientific Notation

Floating-point literals can also be specified in scientific notation, for example, 1.23456e+2, same as 1.23456e2, is equivalent to 123.456, and 1.23456e-2 is equivalent to 0.0123456. E (or e) represents an exponent and it can be either in lowercase or uppercase.

Arithmetic Expressions

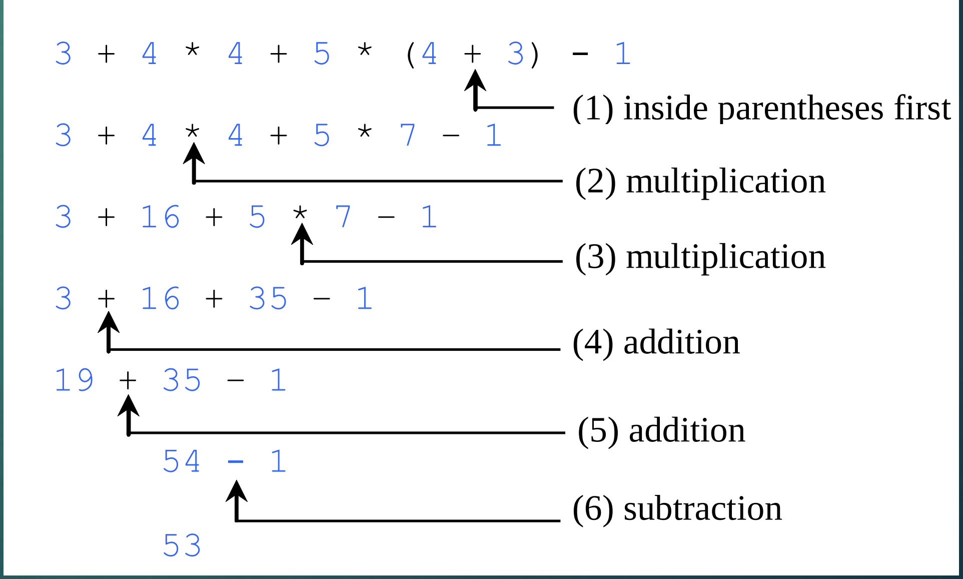
$$\frac{3+4x}{5}-\frac{10(y-5)(a+b+c)}{x}+9(\frac{4}{x}+\frac{9+x}{y})$$

is translated to

(3+4*x)/5 – 10*(y-5)*(a+b+c)/x + 9*(4/x + (9+x)/y)

How to Evaluate an Expression

Though Java has its own way to evaluate an expression behind the scene, the result of a Java expression and its corresponding arithmetic expression are the same. Therefore, you can safely apply the arithmetic rule for evaluating a Java expression.



```
3 + 4 * 4 + 5 * (4 + 3) - 1
3 + 4 * 4 + 5 * 7 – 1
3 + 16 + 5 * 7 – 1
3 + 16 + 35 – 1
19 + 35 – 1
     54 - 1
     53
```

(1) inside parentheses first

(2) multiplication

(3) multiplication

(4) addition

(5) addition

(6) subtraction

Problem: Converting Temperatures

Write a program that converts a Fahrenheit degree to Celsius using the formula:

$$celsius = (\tfrac{5}{9})(fahrenheit - 32)$$

```
import java.util.Scanner;
public class FahrenheitToCelsius {
        public static void main(String[] args) {
                Scanner input = new Scanner(System.in);
                System.out.print("Enter a degree in Fahrenheit: ");
                double fahrenheit = input.nextDouble();
                                // Convert Fahrenheit to Celsius
                double celsius = (5.0 / 9) * (fahrenheit - 32);
                System.out.println("Fahrenheit " + fahrenheit + " is " +
                                        celsius + " in Celsius");
        }
}
```

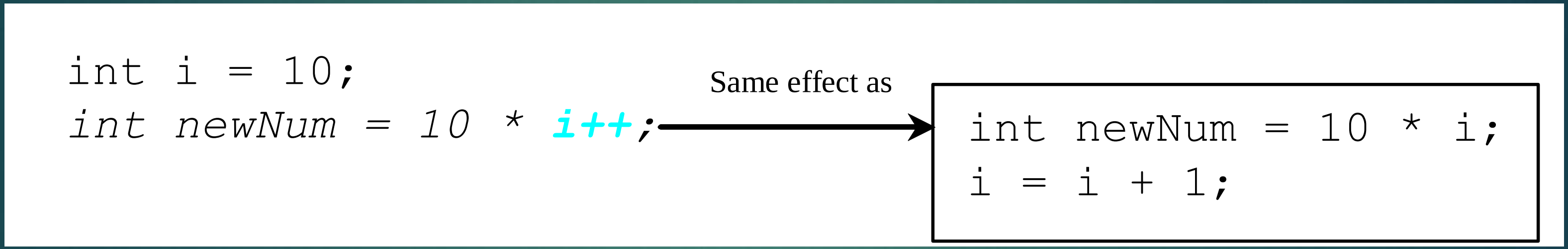
Shortcut Assignment Operators

Operator	*Example*	*Equivalent*
`+=`	`i += 8`	`i = i + 8`
`-=`	`f -= 8.0`	`f = f - 8.0`
`*=`	`i *= 8`	`i = i * 8`
`/=`	`i /= 8`	`i = i / 8`
`%=`	`i %= 8`	`i = i % 8`

Increment and Decrement Operators

Operator	Name	Description
++var	preincrement	The expression (++var) increments var by 1 and evaluates to the *new* value in var *after* the increment.
var++	postincrement	The expression (var++) evaluates to the *original* value in var and increments var by 1.
--var	predecrement	The expression (--var) decrements var by 1 and evaluates to the *new* value in var *after* the decrement.
var--	postdecrement	The expression (var--) evaluates to the *original* value in var and decrements var by 1.

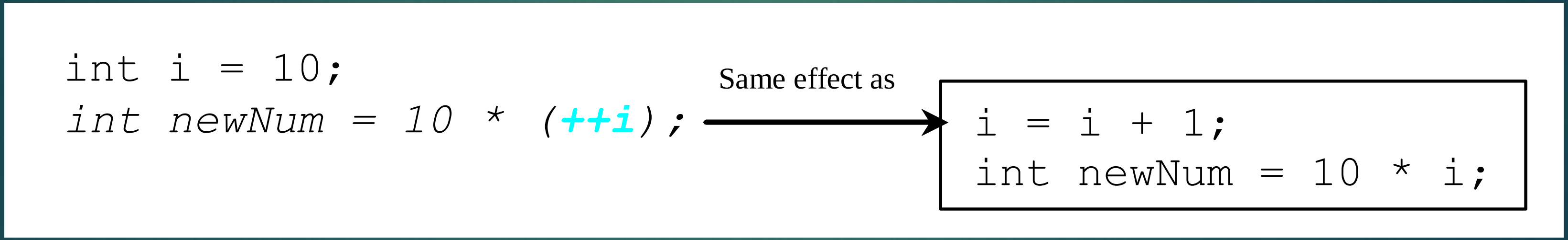
Increment and Decrement Operators, cont.



```
int i = 10;
int newNum = 10 * i++;
```

Same effect as

```
int newNum = 10 * i;
i = i + 1;
```



```
int i = 10;
int newNum = 10 * (++i);
```

Same effect as

```
i = i + 1;
int newNum = 10 * i;
```

Numeric Type Conversion

Consider the following statements:

```
byte i = 100;
long k = i * 3 + 4;
double d = i * 3.1 + k / 2;
```

Conversion Rules

When performing a binary operation involving two operands of different types, Java automatically converts the operand based on the following rules:

1. If one of the operands is double, the other is converted into double.
2. Otherwise, if one of the operands is float, the other is converted into float.
3. Otherwise, if one of the operands is long, the other is converted into long.
4. Otherwise, both operands are converted into int.

Type Casting

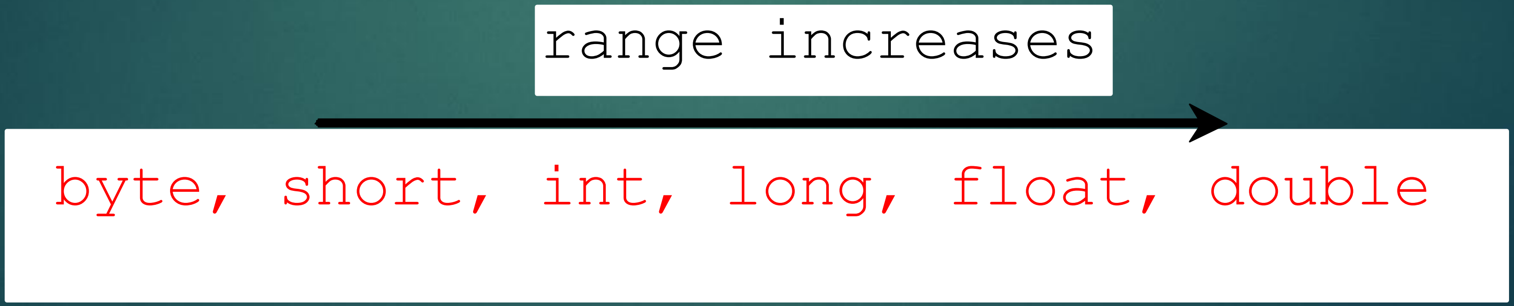
Implicit casting

```
   double d = 3;  (type widening)
```

Explicit casting

```
   int i = (int)3.0;  (type narrowing)
   int i = (int)3.9;  (Fraction part is
  truncated)
```

What is wrong?   int x = 5 / 2.0;



range increases

byte, short, int, long, float, double

Problem: Keeping Two Digits After Decimal Points

Write a program that displays the sales tax with two digits after the decimal point.

```
import java.util.Scanner;
public class SalesTax {
        public static void main(String[] args) {
                Scanner input = new Scanner(System.in);
                System.out.print("Enter purchase amount: ");
                double purchaseAmount = input.nextDouble();
                double tax = purchaseAmount * 0.06;
                System.out.println("Sales tax is " + (int)(tax * 100) / 100.0);
        }
}
```

Problem: Computing Loan Payments

This program lets the user enter the interest rate, number of years, and loan amount and computes monthly payment and total payment.

$$monthlyPayment = \frac{loanAmount \times monthlyInterestRate}{1 - \frac{1}{(1 + monthlyInterestRate)^{numberOfYears \times 12}}}$$

```java
import java.util.Scanner;
public class ComputeLoan {
  public static void main(String[] args) {
     Scanner input = new Scanner(System.in);
     // Enter yearly interest rate
     System.out.print("Enter yearly interest rate, for example 8.25: ");
     double annualInterestRate = input.nextDouble(); // Obtain monthly interest rate
     double monthlyInterestRate = annualInterestRate / 1200; // Enter number of years
     System.out.print( "Enter number of years as an integer, for example 5: ");
     int numberOfYears = input.nextInt(); // Enter loan amount
     System.out.print("Enter loan amount, for example 120000.95: ");
     double loanAmount = input.nextDouble(); // Calculate payment
     double monthlyPayment = loanAmount * monthlyInterestRate /
               (1 - 1 / Math.pow(1 + monthlyInterestRate, numberOfYears * 12));
     double totalPayment = monthlyPayment * numberOfYears * 12; // Display results
    System.out.println("The monthly payment is " + (int)(monthlyPayment * 100) / 100.0);
    System.out.println("The total payment is " + (int)(totalPayment * 100) / 100.0);
  }
}
```

Character Data Type

Four hexadecimal digits.

```
char letter = 'A'; (ASCII)
char numChar = '4'; (ASCII)
char letter = '\u0041'; (Unicode)
char numChar = '\u0034'; (Unicode)
```

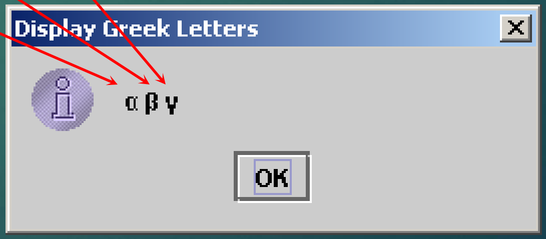
NOTE: The increment and decrement operators can also be used on char variables to get the next or preceding Unicode character. For example, the following statements display character b.

```
char ch = 'a';
System.out.println(++ch);
```

Unicode Format

Java characters use *Unicode*, a 16-bit encoding scheme established by the Unicode Consortium to support the interchange, processing, and display of written texts in the world’s diverse languages. Unicode takes two bytes, preceded by \u, expressed in four hexadecimal numbers that run from '\u0000' to '\uFFFF'. So, Unicode can represent `65535 + 1 characters.`

Unicode \u03b1 \u03b2 \u03b3 for three Greek letters



α β γ

Escape Sequences for Special Characters

Description	*Escape Sequence*	*Unicode*
Backspace	`\b`	`\u0008`
Tab	`\t`	`\u0009`
Linefeed	`\n`	`\u000A`
Carriage return	`\r`	`\u000D`
Backslash	`\\`	`\u005C`
Single Quote	`\'`	`\u0027`
Double Quote	`\"`	`\u0022`

Casting between char and Numeric Types

```
int i = 'a'; // Same as int i = (int)'a';
```

```
char c = 97; // Same as char c = (char)97;
```

Problem: Monetary Units

This program lets the user enter the amount in decimal representing dollars and cents and output a report listing the monetary equivalent in single dollars, quarters, dimes, nickels, and pennies. Your program should report maximum number of dollars, then the maximum number of quarters, and so on, in this order.

Trace ComputeChange

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;

// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

remainingAmount 1156

remainingAmount initialized

Trace ComputeChange

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;

// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

remainingAmount	1156
numberOfOneDollars	11

numberOfOneDollars assigned

animation

Trace ComputeChange

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;

// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

remainingAmount	56
numberOfOneDollars	11

remainingAmount updated

animation

Trace ComputeChange

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;

// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

remainingAmount	56
numberOfOneDollars	11
numberOfOneQuarters	2

numberOfOneQuarters assigned

Trace ComputeChange

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;

// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

remainingAmount	6
numberOfOneDollars	11
numberOfQuarters	2

remainingAmount updated

The String Type

The char type only represents one character. To represent a string of characters, use the data type called String. For example,

```
String message = "Welcome to Java";
```

String Concatenation

```
// Three strings are concatenated
String message = "Welcome " + "to " + "Java";

// String Chapter is concatenated with number 2
String s = "Chapter" + 2; // s becomes Chapter2

// String Supplement is concatenated with character B
String s1 = "Supplement" + 'B'; // s1 becomes SupplementB
```

Programming Style and Documentation

- Appropriate Comments
- Naming Conventions
- Proper Indentation and Spacing Lines
- Block Styles

Appropriate Comments

Include a summary at the beginning of the program to explain what the program does, its key features, its supporting data structures, and any unique techniques it uses.

Include your name, class section, instructor, date, and a brief description at the beginning of the program.

Naming Conventions

- Choose meaningful and descriptive names.
- Variables and method names:
  - Use lowercase. If the name consists of several words, concatenate all in one, use lowercase for the first word, and capitalize the first letter of each subsequent word in the name. For example, the variables `radius` and `area`, and the method `computeArea`.

Naming Conventions, cont.

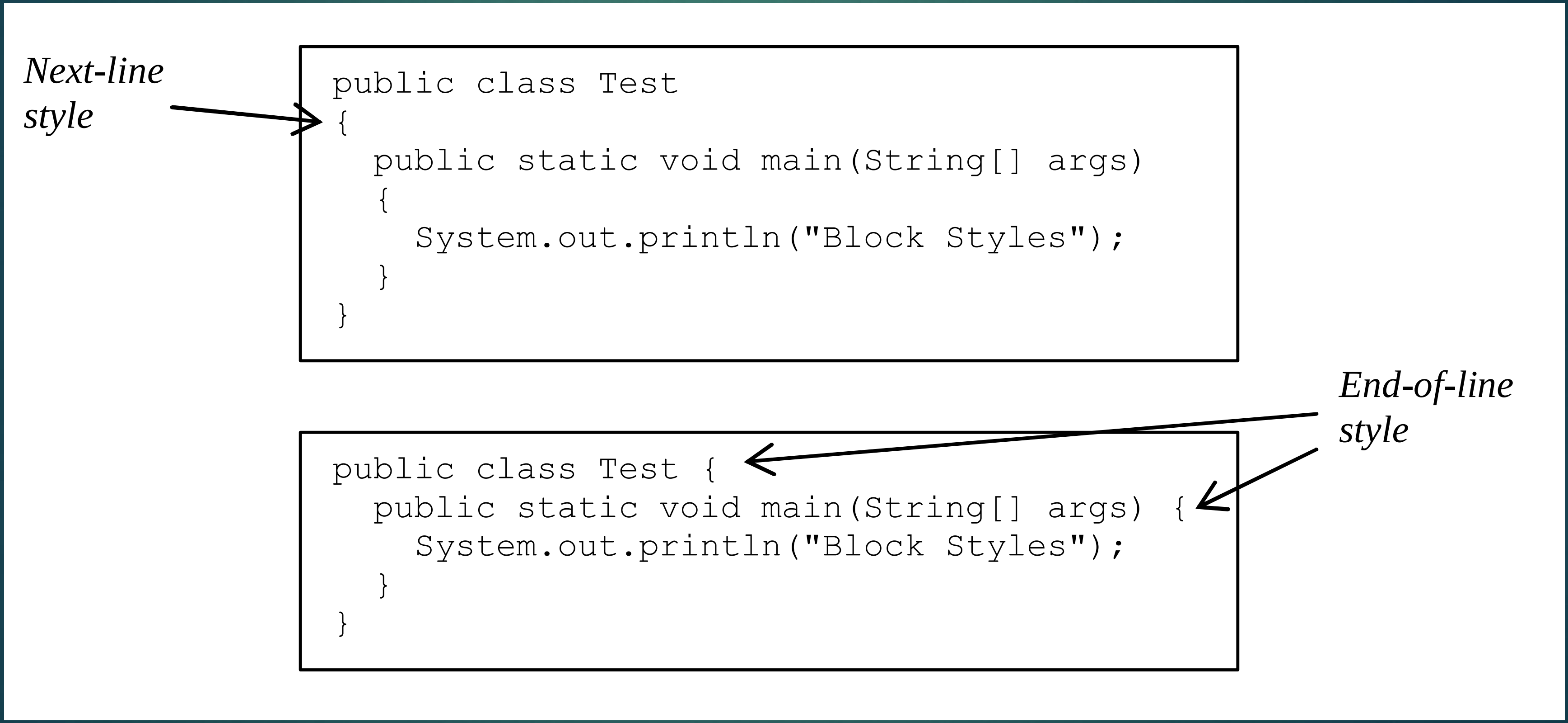
- Class names:
  - Capitalize the first letter of each word in the name. For example, the class name `ComputeArea`.
- Constants:
  - Capitalize all letters in constants, and use underscores to connect words. For example, the constant `PI and` MAX_VALUE

Proper Indentation and Spacing

- Indentation
  - Indent two spaces.
- Spacing
  - Use blank line to separate segments of the code.

Block Styles

Use end-of-line style for braces.



```
public class Test
{
  public static void main(String[] args)
  {
    System.out.println("Block Styles");
  }
}
```

```
public class Test {
  public static void main(String[] args) {
    System.out.println("Block Styles");
  }
}
```

Programming Errors

- Syntax Errors
  - Detected by the compiler
- Runtime Errors
  - Causes the program to abort
- Logic Errors
  - Produces incorrect result

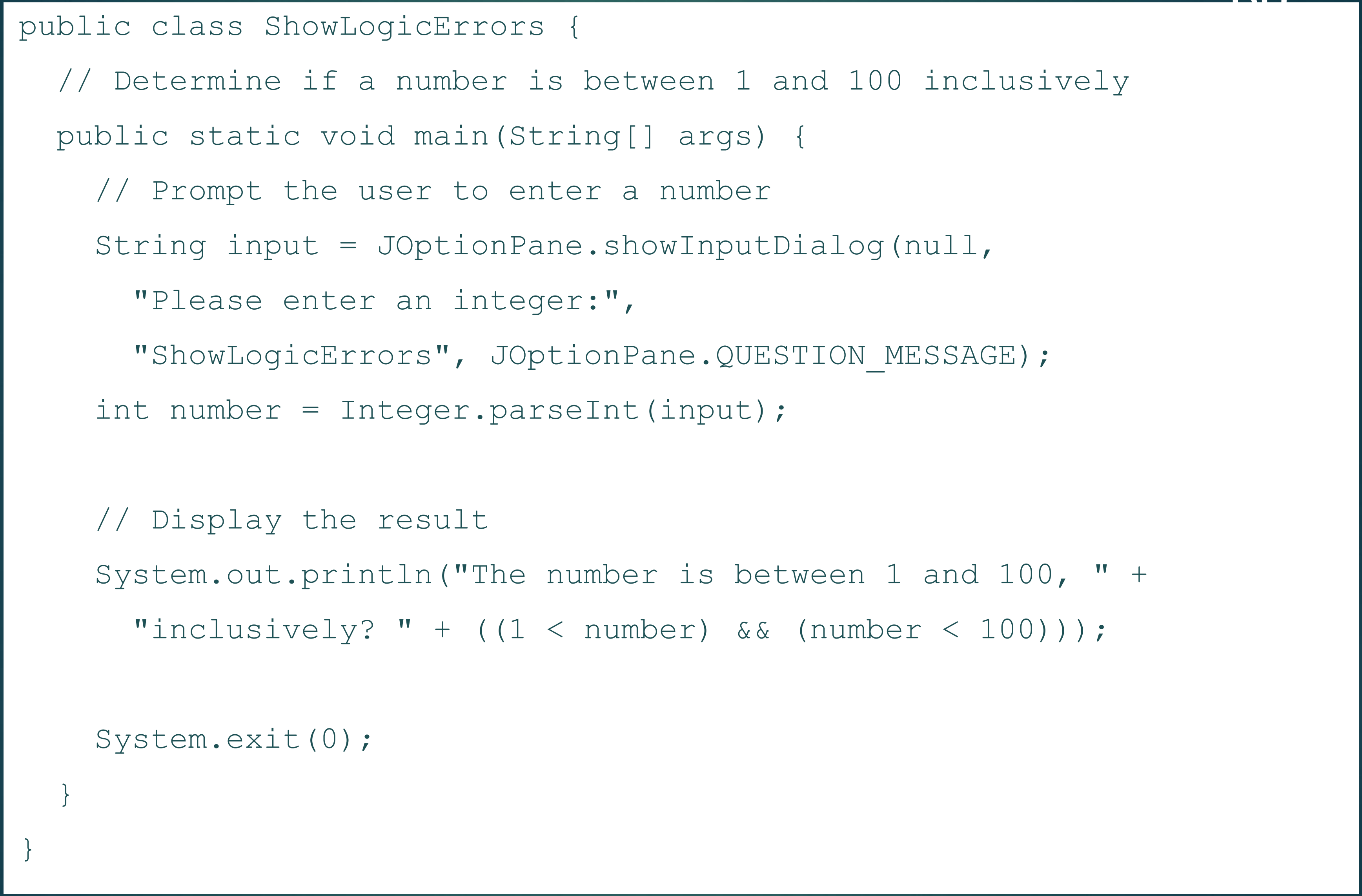
Syntax Errors

```
public class ShowSyntaxErrors {
  public static void main(String[] args) {
    i = 30;
    System.out.println(i + 4);
  }
}
```

Runtime Errors

```
public class ShowRuntimeErrors {
  public static void main(String[] args) {
    int i = 1 / 0;
  }
}
```

Logic Errors



```
public class ShowLogicErrors {
  // Determine if a number is between 1 and 100 inclusively
  public static void main(String[] args) {
    // Prompt the user to enter a number
    String input = JOptionPane.showInputDialog(null,
      "Please enter an integer:",
      "ShowLogicErrors", JOptionPane.QUESTION_MESSAGE);
    int number = Integer.parseInt(input);

    // Display the result
    System.out.println("The number is between 1 and 100, " +
      "inclusively? " + ((1 < number) && (number < 100)));

    System.exit(0);
  }
}
```

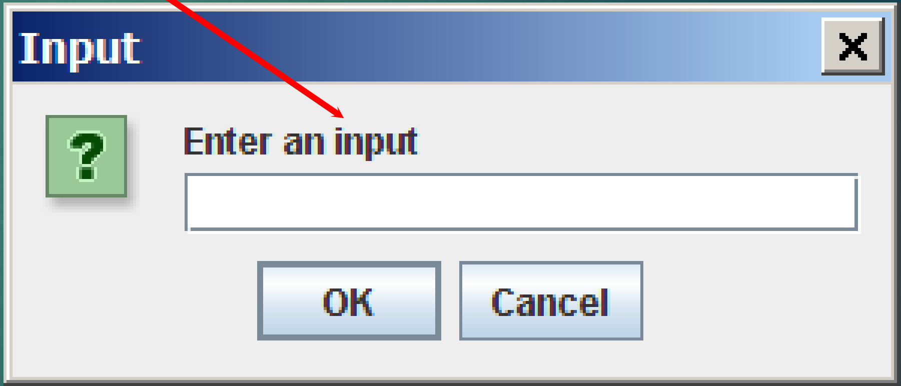
JOptionPane Input

This book provides two ways of obtaining input.

1. Using the Scanner class (console input)
2. Using JOptionPane input dialogs

Getting Input from Input Dialog Boxes

```
String input =  JOptionPane.showInputDialog(
  "Enter an input");
```

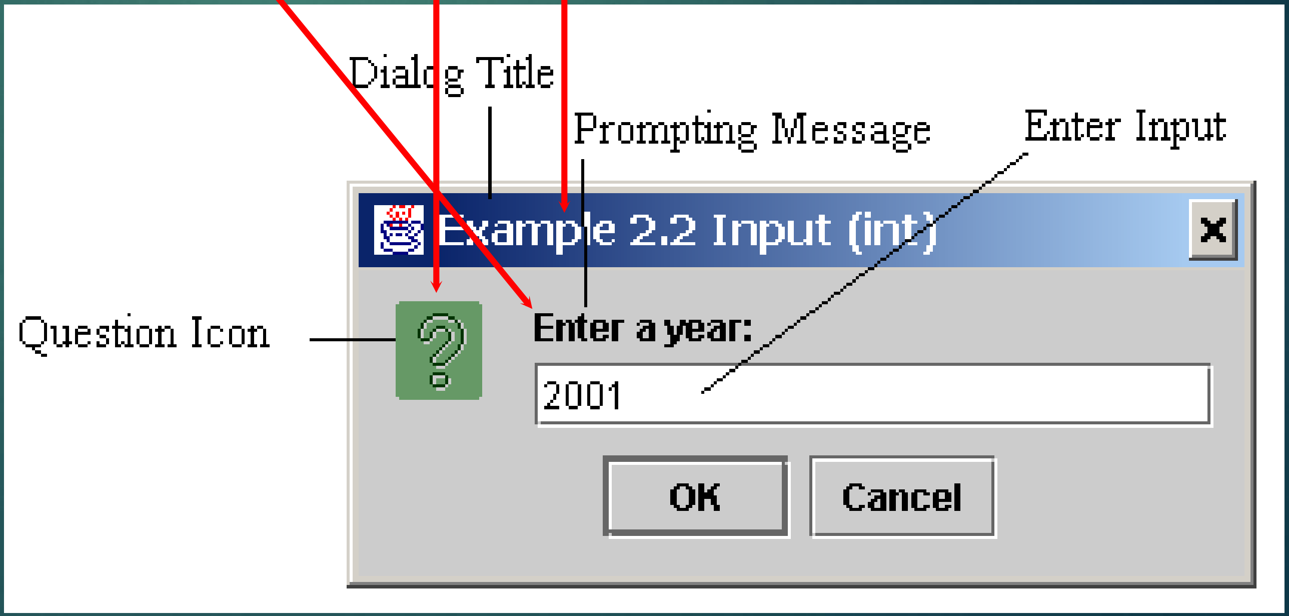


Input

Enter an input

Getting Input from Input Dialog Boxes

```
String string = JOptionPane.showInputDialog(
   null, “Prompting Message”,  “Dialog Title”,
   JOptionPane.QUESTION_MESSAGE);
```



Example 2.2 Input (int)

Enter a year:

2001

Two Ways to Invoke the Method

There are several ways to use the showInputDialog method. For the time being, you only need to know two ways to invoke it.

One is to use a statement as shown in the example:

```
String string = JOptionPane.showInputDialog(null, x,
  y, JOptionPane.QUESTION_MESSAGE);
```

where x is a string for the prompting message, and y is a string for the title of the input dialog box.

The other is to use a statement like this:

```
JOptionPane.showInputDialog(x);
```

where x is a string for the prompting message.

Converting Strings to Integers

The input returned from the input dialog box is a string. If you enter a numeric value such as 123, it returns "123". To obtain the input as a number, you have to convert a string into a number.

To convert a string into an int value, you can use the static parseInt method in the Integer class as follows:

```
int intValue = Integer.parseInt(intString);
```

where intString is a numeric string such as "123".

Converting Strings to Doubles

To convert a string into a double value, you can use the static parseDouble method in the Double class as follows:

```
double doubleValue
=Double.parseDouble(doubleString);
```

where doubleString is a numeric string such as "123.45".

Problem: Computing Loan Payments Using Input Dialogs

Same as the preceding program for computing loan payments, except that the input is entered from the input dialogs and the output is displayed in an output dialog.

$$\frac{loanAmount \times monthlyInterestRate}{1 - \frac{1}{(1 + monthlyInterestRate)^{numberOfYears \times 12}}}$$