

ELEMENTARY PROGRAMMING

Motivations

In the preceding lesson, you learned

how to create, compile, and run a Java program.

Starting from this chapter, you will learn how to solve practical problems programmatically. Through these problems, you will learn Java primitive data types and related subjects, such as variables, constants, data types, operators, expressions, and input and output.

Introducing Programming with an Example

Computing the Area of a Circle

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);  
    }  
}
```

allocate memory
for radius

radius

no value

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

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

radius

20

area

no value

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**

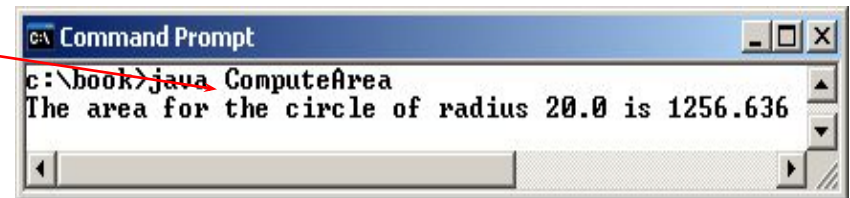
Trace a Program Execution

```
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



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


1. Create a Scanner object

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

2. Use the methods next(), nextByte(), nextShort(), nextInt(), nextLong(), nextFloat(), nextDouble(), or nextBoolean() to obtain to a string, byte, short, int, long, float, double, or boolean value. 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 keyword: **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)

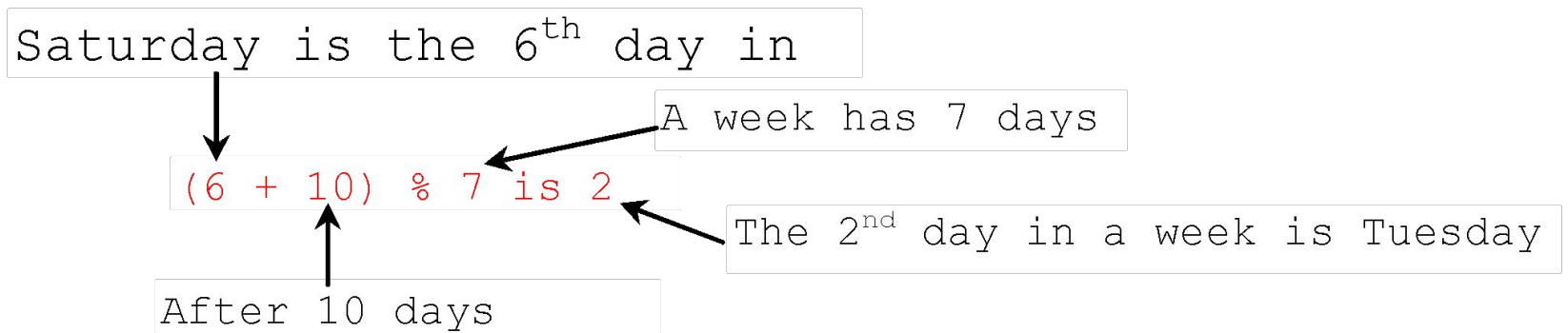
Remainder Operator

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:



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 0.50000000000000000001, not 0.5, and

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

displays 0.099999999999999999998, 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

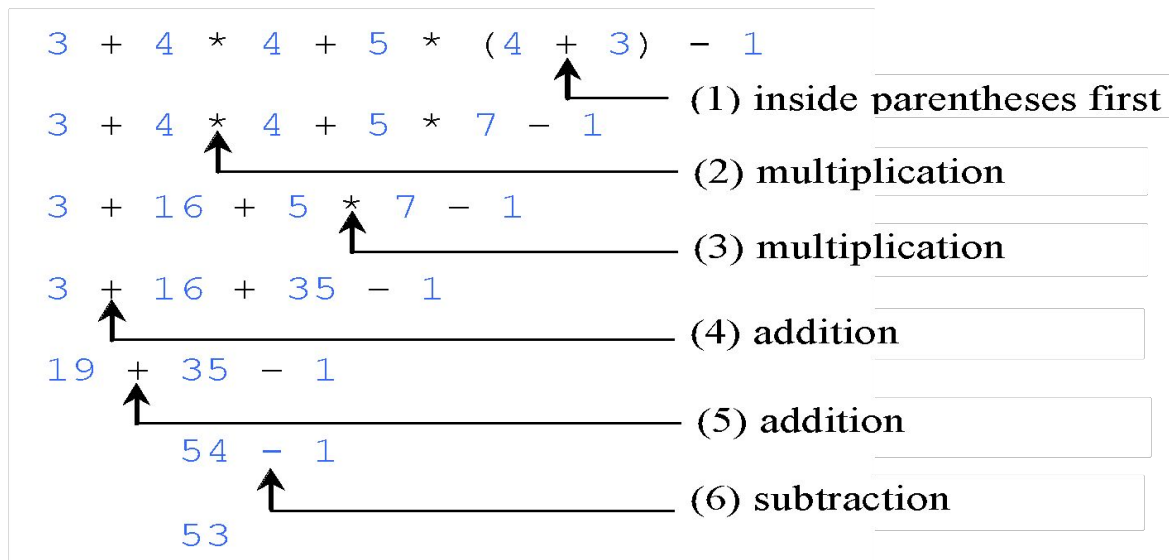
$$\frac{3 + 4x}{5} - \frac{10(y - 5)(a + b + c)}{x} + 9\left(\frac{4}{x} + \frac{9 + x}{y}\right)$$

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.



Problem: Converting Temperatures

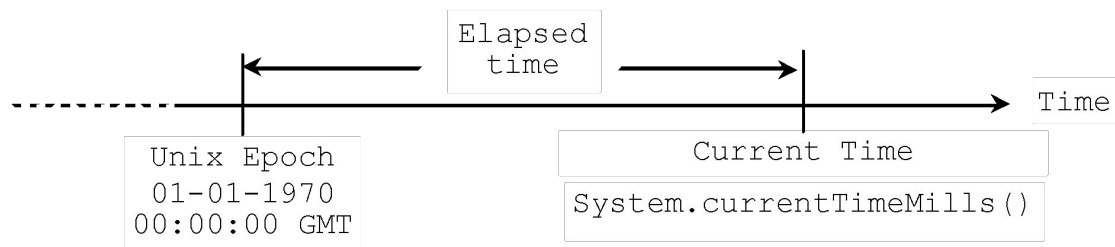
Write a program that converts a Fahrenheit degree to Celsius using the formula:

$$celsius = \left(\frac{5}{9}\right)(fahrenheit - 32)$$

Problem: Displaying Current Time

Write a program that displays current time in GMT in the format hour:minute:second such as 1:45:19.

The **currentTimeMillis** method in the System class returns the current time in milliseconds since the midnight, January 1, 1970 GMT. (1970 was the year when the Unix operating system was formally introduced.) You can use this method to obtain the current time, and then compute the current second, minute, and hour as follows.



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	pre increment	The expression (++var) increments <u>var</u> by 1 and evaluates to the newvalue in <u>var</u> after the increment.
var++	post increment	The expression (var++) evaluates to the original value in <u>var</u> and increments <u>var</u> by 1.
--var	pre decrement	The expression (--var) decrements <u>var</u> by 1 and evaluates to the new value in <u>var</u> after the decrement.
var--	post decrement	The expression (var--) evaluates to the original value in <u>var</u> and decrements <u>var</u> 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;
```

Increment and Decrement Operators, cont.

Using increment and decrement operators makes expressions short, but it also makes them complex and difficult to read. Avoid using these operators in expressions that modify multiple variables, or the same variable for multiple times such as this: `int k = ++i + i.`

Assignment Expressions and Assignment Statements

Prior to Java 2, all the expressions can be used as statements. Since Java 2, only the following types of expressions can be statements:

variable op= expression; // Where op is **+**, **-**, *****, **/**, or **%**

++variable;

variable++;

--variable;

variable--;

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:

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.

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

Character Data Type

`char letter = 'A'; (ASCII)`

`char numChar = '4'; (ASCII)` Four hexadecimal digits.

`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.

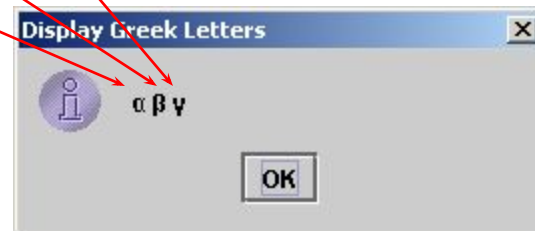
```
char ch = 'a';
```

```
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



Problem: Displaying Unicodes

Write a program that displays two Chinese characters and three Greek letters.



Escape Sequences for Special Characters

<i>Description</i>	<i>Escape Sequence</i>	<i>Unicode</i>
Backspace	<code>\b</code>	<code>\u0008</code>
Tab	<code>\t</code>	<code>\u0009</code>
Linefeed	<code>\n</code>	<code>\u000A</code>
Carriage return	<code>\r</code>	<code>\u000D</code>
Backslash	<code>\\</code>	<code>\u005C</code>
Single Quote	<code>\'</code>	<code>\u0027</code>
Double Quote	<code>\"</code>	<code>\u0022</code>

Appendix B: ASCII Character Set

ASCII Character Set is a subset of the Unicode from \u0000 to \u007f

TABLE B.1 ASCII Character Set in the Decimal Index

	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>
0	nul	soh	stx	etx	eot	enq	ack	bel	bs	ht
1	nl	vt	ff	cr	so	si	dle	dcl	dc2	dc3
2	dc4	nak	syn	etb	can	em	sub	esc	fs	gs
3	rs	us	sp	!	"	#	\$	%	&	'
4	()	*	+	,	-	.	/	0	1
5	2	3	4	5	6	7	8	9	:	;
6	<	=	>	?	@	A	B	C	D	E
7	F	G	H	I	J	K	L	M	N	O
8	P	Q	R	S	T	U	V	W	X	Y
9	Z	[\]	^	_	`	a	b	c
10	d	e	f	g	h	i	j	k	l	m
11	n	o	p	q	r	s	t	u	v	w
12	x	y	z	{		}	~	del		

ASCII Character Set, cont.

ASCII Character Set is a subset of the Unicode from \u0000 to \u007f

TABLE B.2 ASCII Character Set in the Hexadecimal Index

	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>
0	nul	soh	stx	etx	eot	enq	ack	bel	bs	ht	nl	vt	ff	cr	so	si
1	dle	dcl	dc2	dc3	dc4	nak	syn	etb	can	em	sub	esc	fs	gs	rs	us
2	sp	!	"	#	\$	%	&	'	()	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[\]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{		}	~	del

Casting between char and Numeric Types

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

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

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 is actually a predefined class in the Java library just like the **System** class and **JOptionPane** class. The **String** type is not a primitive type. It is known as a *reference type*. Any Java class can be used as a reference type for a variable. Reference data types will be thoroughly discussed in Chapter 7, “Objects and Classes.” For the time being, you just need to know how to declare a **String** variable, how to assign a string to the variable, and how to concatenate strings.

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: **ComputeArea**.

- **Constants:**

- Capitalize all letters in constants, and use underscores to connect words. For example: **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.

*Next-line
style*

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

*End-of-line
style*

```
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);
    }
}
```


Debugging

- Logic errors are called *bugs*.
- The process of finding and correcting errors is called debugging.
- A common approach to debugging is to use a combination of methods to narrow down to the part of the program where the bug is located.
- You can hand-trace the program (i.e., catch errors by reading the program), or you can insert print statements in order to show the values of the variables or the execution flow of the program.
- This approach might work for a short, simple program.
- For a large, complex program, the most effective approach for debugging is to use a debugger utility.

Debugger

Debugger is a program that facilitates debugging.

You can use a debugger to:

- Execute a single statement at a time.
- Trace into or stepping over a method.
- Set breakpoints.
- Display variables.
- Display call stack.
- Modify variables.

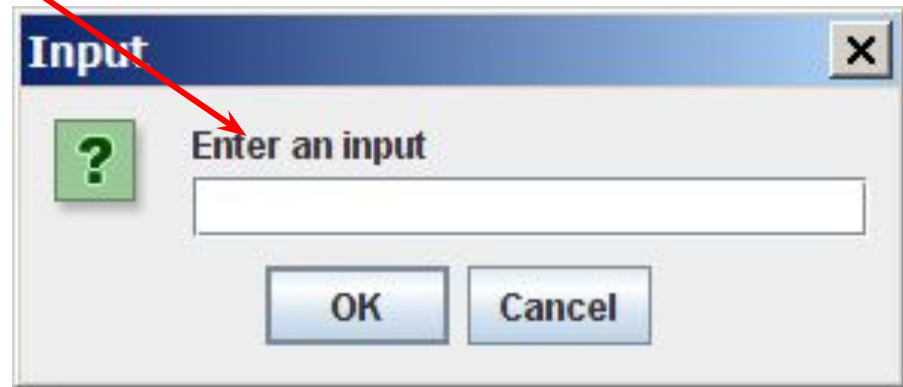
JOptionPane Input

Two ways of obtaining input.

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

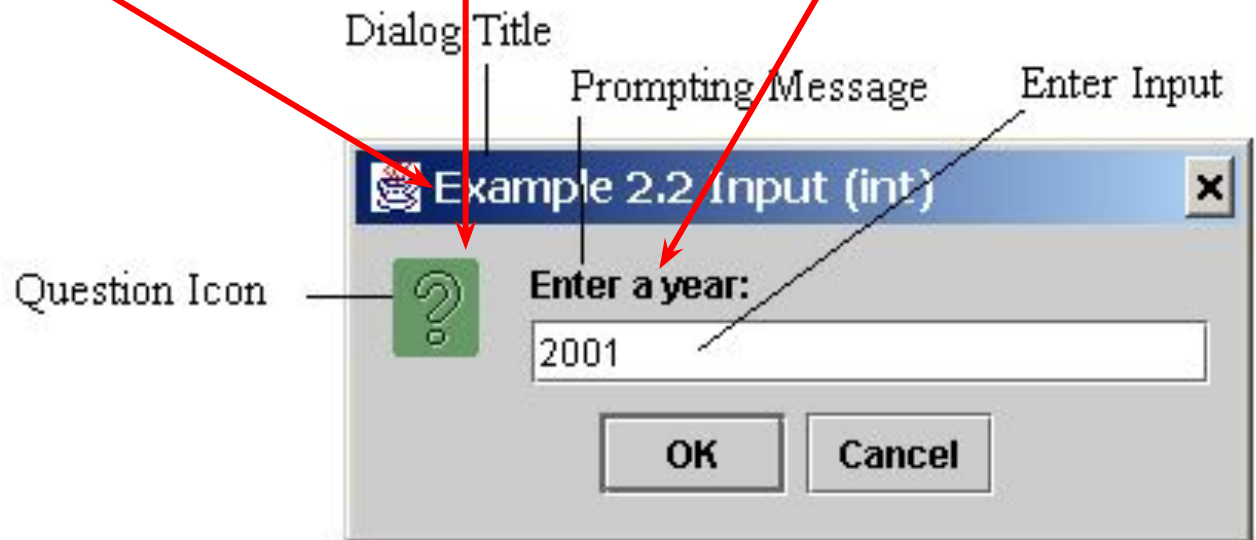
Getting Input from Input Dialog Boxes

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



Getting Input from Input Dialog Boxes

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



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, use the **static parseInt method** of **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.

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