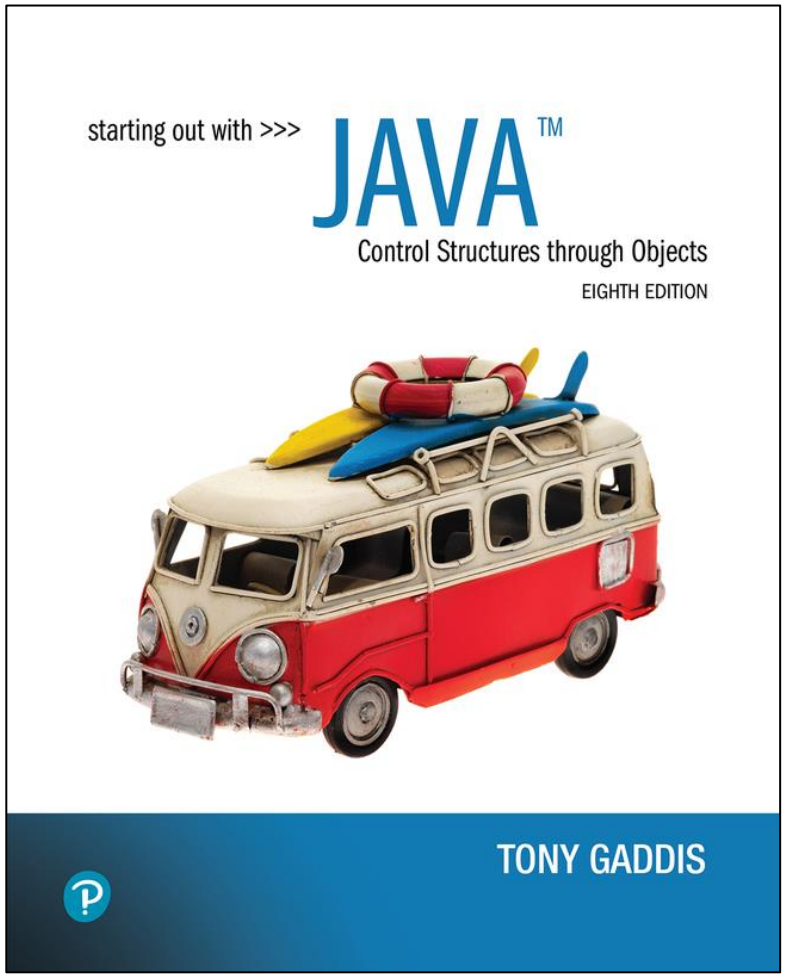
Starting Out with Java Control Structures Through Objects

Eighth Edition



Chapter 3

Decision Structures

Chapter Topics (1 of 2)

- Chapter 3 discusses the following main topics:
  - The `if` Statement
  - The `if-else` Statement
  - Nested `if` statements
  - The `if-else-if` Statement
  - Logical Operators
  - Comparing `String` Objects

Chapter Topics (2 of 2)

- Chapter 3 discusses the following main topics:
  - More about Variable Declaration and Scope
  - The Conditional Operator
  - The `switch` Statement
  - Displaying Formatted Output with `System.out.printf` and `String.format`

The `if` Statement

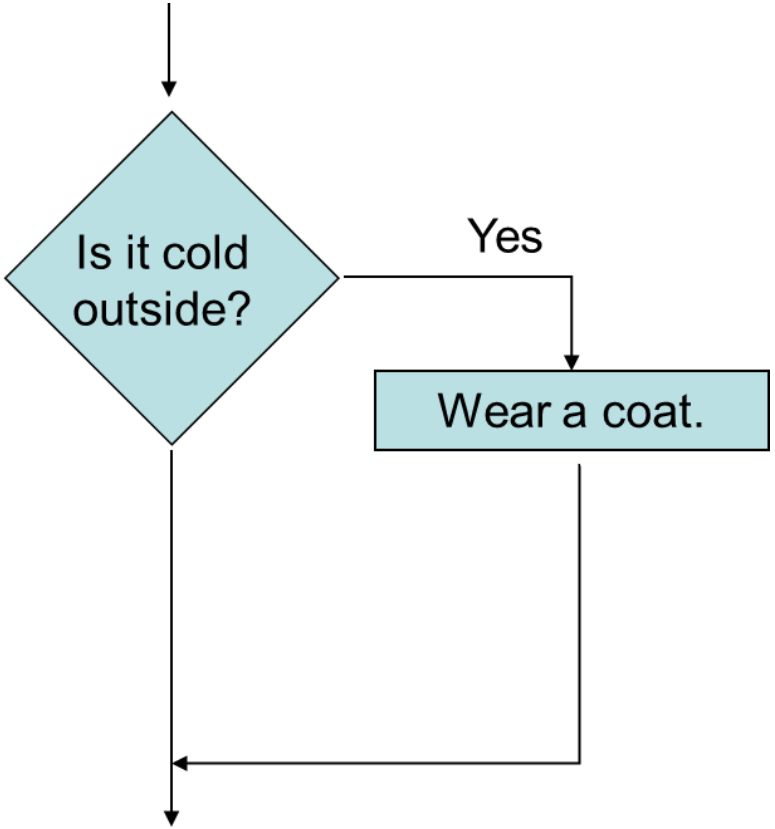
- The `if` statement decides whether a section of code executes or not.
- The `if` statement uses a `boolean` to decide whether the next statement or block of statements executes.

```
if (boolean expression is true)
    execute next statement.
```

Flowcharts (1 of 2)

- If statements can be modeled as a flow chart.

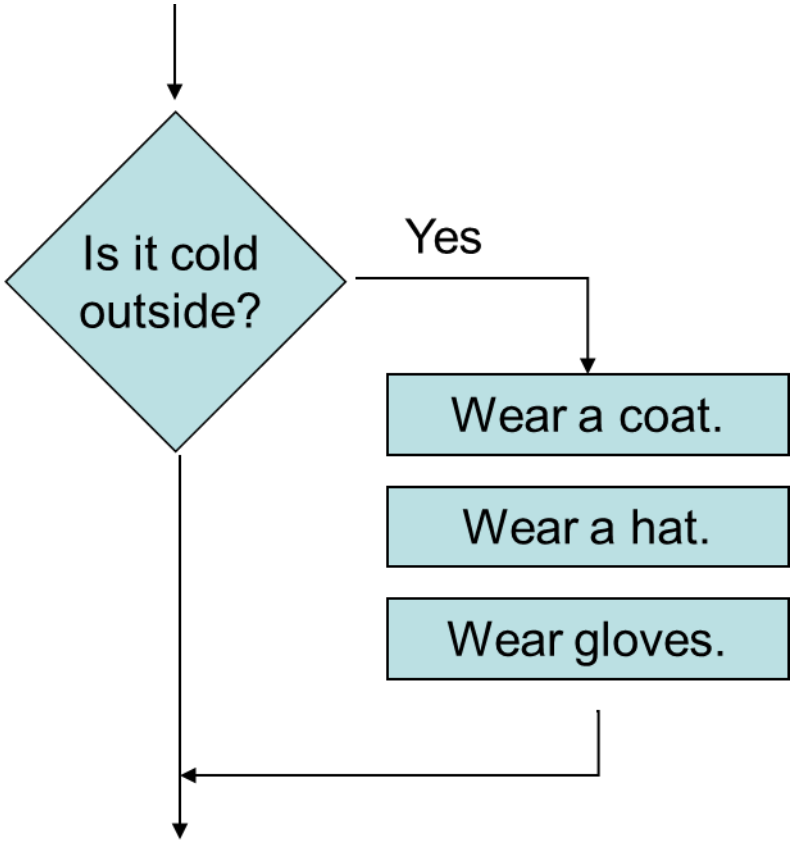
```
if (coldOutside)
  wearCoat();
```



Flowcharts (2 of 2)

- A block `if` statement may be modeled as:

```
if (coldOutside)
  {
   wearCoat();
   wearHat();
   wearGloves();
 }
```



Note the use of curly braces to block several statements together.

Relational Operators

- In most cases, the `boolean` expression, used by the `if` statement, uses **relational operators**.

Relational Operator	Meaning
>	is greater than
<	is less than
>=	is greater than or equal to
<=	is less than or equal to
==	is equal to
!=	is not equal to

Boolean Expressions

- A **boolean expression** is any variable or calculation that results in a **true** or **false** condition.

Expression	Meaning
`x > y`	Is x greater than y?
`x < y`	Is x less than y?
`x >= y`	Is x greater than or equal to y?
`x <= y`	Is x less than or equal to y.
`x == y`	Is x equal to y?
`x != y`	Is x not equal to y?

Equality Operators == !=

- Comparing two numeric or character primitive types. If the numeric values are of different data types, the values are automatically promoted. For example, 5 == 5.00 returns true since the left side is promoted to a double.
- Comparing two boolean values
- Comparing two objects, including null and String values

Which of the following will NOT compile

```
1. boolean a = true == 3;
2. boolean b = false;
3. boolean c = false != "false";
4. boolean flag = 10==10.0;
5. boolean d = (flag = true);
```

`if` Statements and Boolean Expressions

```
if (x > y)
   System.out.println("X is greater than Y");

if (x == y)
   System.out.println("X is equal to Y");

if (x != y)
{
   System.out.println("X is not equal to Y");
   x = y;
   System.out.println("However, now it is.");
}
```

Example: AverageScore.java

`if` Statements and Boolean Expressions

int x = 15;

double y = 21.25;

Will the following code compile?

```
if (x > y)
   System.out.println("X is greater than Y");

if(x == y)
   System.out.println("X is equal to Y");

if(x != y)
{
   System.out.println("X is not equal to Y");
   x = y;
   System.out.println("However, now it is.");
}
```

Programming Style and `if` Statements (1 of 2)

- An `if` statement can span more than one line; however, it is still one statement.

```
if (average > 95)
   grade = 'A';
```

is functionally equivalent to

```
if (average > 95) grade = 'A';
```

Programming Style and `if` Statements (2 of 2)

- Rules of thumb:
  - The conditionally executed statement should be on the line after the `if` condition.
  - The conditionally executed statement should be indented one level from the `if` condition.
  - If an `if` statement does not have the block curly braces, it is ended by the first semicolon encountered after the `if` condition.

```
if (expression)
  statement;
```

No semicolon here.

Semicolon ends statement here.

Block `if` Statements (1 of 2)

- Conditionally executed statements can be grouped into a block by using curly braces **{ }** to enclose them.
- If curly braces are used to group conditionally executed statements, the `if` statement is ended by the closing curly brace.

```
if (expression)
{
  statement1;
  statement2;
}
```

Curly brace ends the statement.

Block `if` Statements (2 of 2)

- Remember that when the curly braces are not used, then only the next statement after the `if` condition will be executed conditionally.

```
if (expression)
  statement1;
  statement2;
  statement3;
```

← **Only this statement is conditionally executed.**

Flags

- A flag is a `boolean` variable that monitors some condition in a program.
- When a condition is true, the flag is set to `true`.
- The flag can be tested to see if the condition has changed.

```
if (average > 95)
  highScore = true;
```

- Later, this condition can be tested:

```
if (highScore)
  System.out.println("That's a high score!");
```

Comparing Characters

- Characters can be tested with relational operators.
- Characters are stored in memory using the Unicode character format.
- Unicode is stored as a sixteen (16) bit number.
- Characters are **ordinal**, meaning they have an order in the Unicode character set.
- Since characters are ordinal, they can be compared to each other.

```
char c = 'A';
if(c < 'Z')
  System.out.println("A is less than Z");
```

`if-else` Statements

- The `if-else` statement adds the ability to conditionally execute code when the `if` condition is false.

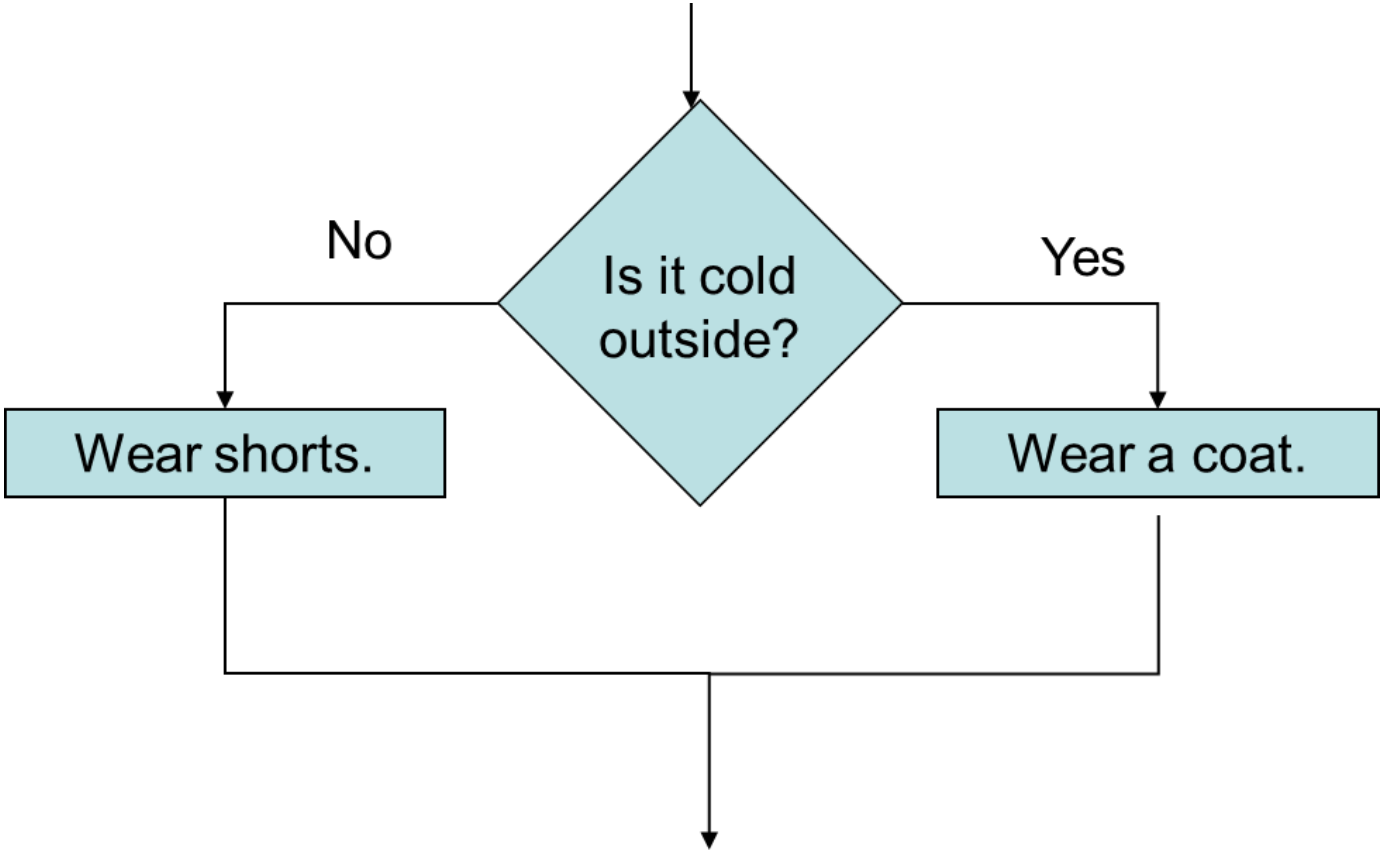
```
if (expression)
  statementOrBlockIfTrue;
else
  statementOrBlockIfFalse;
```

- See example: Division.java

What is the output?

```
boolean healthy = false;
if(healthy = true)
   System.out.print("Good!");
```

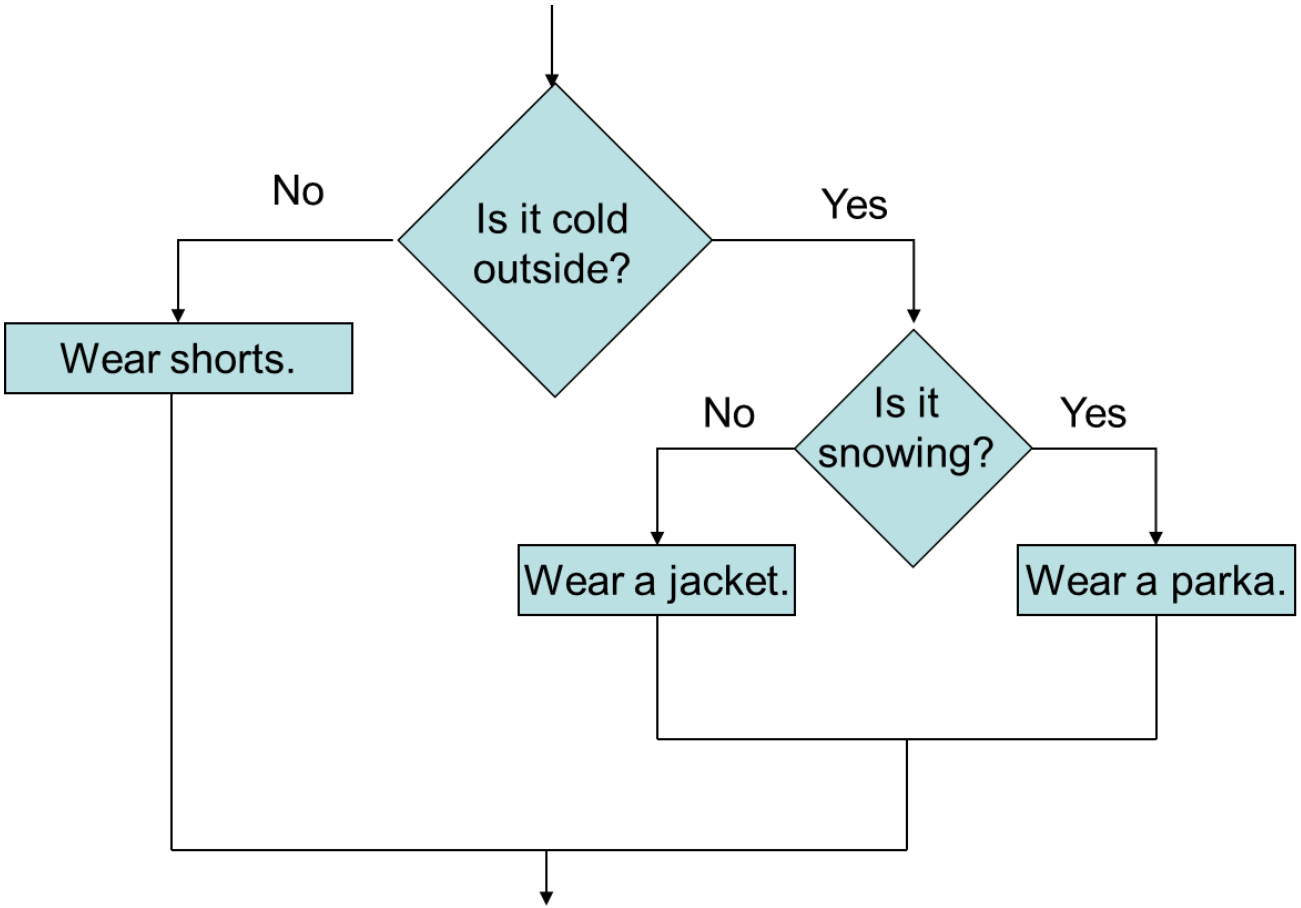
`if-else` Statement Flowcharts



Nested `if` Statements (1 of 2)

- If an `if` statement appears inside another `if` statement (single or block) it is called a **nested `if`** statement.
- The nested `if` is executed only if the outer `if` statement results in a true condition.
- See example: LoanQualifier.java

Nested `if` Statement Flowcharts



Nested `if` Statements (2 of 2)

```
if (coldOutside)
{
     if (snowing)
     {
          wearParka();
     }
     else
     {
          wearJacket();
     }
}
else
{
     wearShorts();
}
```

`if-else` Matching

- Curly brace use is not required if there is only one statement to be conditionally executed.
- However, sometimes curly braces can help make the program more readable.
- Additionally, proper indentation makes it much easier to match up else statements with their corresponding `if` statement.

Alignment and Nested `if` Statements

This `if` and `else` go together.

This `if` and `else` go together.

```
if (coldOutside)
{
    if (snowing)
    {
        wearParka();
    }
    else
    {
        wearJacket();
    }
}
else
{
    wearShorts();
}
```

`if-else-if` Statements (1 of 3)

```
if (expression_1)
{
   statement;
   statement;
   etc.
}
```

If *expression_1* is true these statements are executed, and the rest of the structure is ignored.

```
else if (expression_2)
{
   statement;
   statement;
   etc.
}
```

Otherwise, if *expression_2* is true these statements are executed, and the rest of the structure is ignored.

`if-else-if` Statements (2 of 3)

Insert as many *`else if`* clauses as necessar

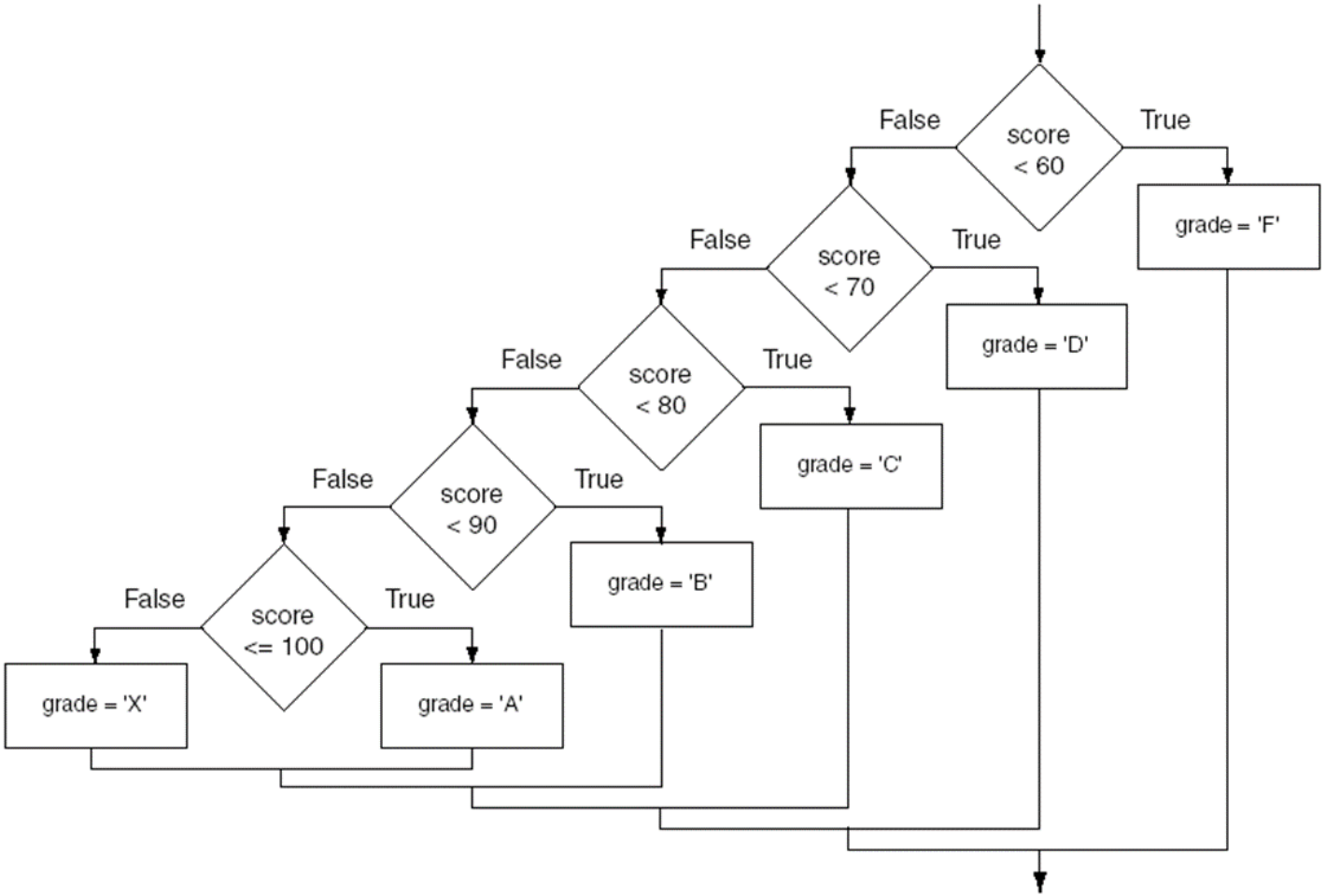
```
else
{
   statement;
   statement;
   etc.
}
```

These statements are executed if none of the expressions above are true.

`if-else-if` Statements (3 of 3)

- Nested `if` statements can become very complex.
- The `if-else-if` statement makes certain types of nested decision logic simpler to write.
- Care must be used since `else` statements match up with the immediately preceding unmatched `if` statement.
- See example: TestResults.java

`if-else-if` Flowchart



Logical Operators (1 of 2)

- Java provides two binary **logical operators** (`&&` and `||`) that are used to combine `boolean` expressions.
- Java also provides one **unary** (`!`) logical operator to reverse the truth of a `boolean` expression.

Logical Operators (2 of 2)

Operator	Meaning	Effect
&&	**AND**	Connects two Boolean expressions into one. Both expressions must be true for the overall expression to be true.
||	**OR**	Connects two Boolean expressions into one. One or both expressions must be true for the overall expression to be true. It is only necessary for one to be true, and it does not matter which one.
!	**NOT**	The ! operator reverses the truth of a Boolean expression. If it is applied to an expression that is true, the operator returns false. If it is applied to an expression that is false, the operator returns true.

The `&&` Operator

- The logical AND operator (`&&`) takes two operands that must both be `boolean` expressions.
- The resulting combined expression is true if (and **only** if) both operands are true.
- See example: LogicalAnd.java

Expression 1	Expression 2	Expression1 && Expression2
true	false	false
false	true	false
false	false	false
true	true	true

The `||` Operator

- The logical OR operator (`||`) takes two operands that must both be `boolean` expressions.
- The resulting combined expression is false if (and **only** if) both operands are false.
- Example: LogicalOr.java

Expression 1	Expression 2	Expression1 || Expression2
true	false	true
false	true	true
false	false	false
true	true	true

The ! Operator

- The `!` operator performs a logical NOT operation.
- If an *`expression`* is true, `!`*`expression`* will be false.

```
if (!(temperature > 100))
  System.out.println("Below the maximum temperature.");
```

- If **`temperature > 100`** evaluates to false, then the output statement will be run.

Expression 1	!Expression1
true	false
false	true

Short Circuiting

- Logical AND and logical OR operations perform **short-circuit evaluation** of expressions.
- Logical AND will evaluate to false as soon as it sees that one of its operands is a false expression.
- Logical OR will evaluate to true as soon as it sees that one of its operands is a true expression.

Design an example to demonstrate short circuiting

Order of Precedence (1 of 2)

- The `!` operator has a higher order of precedence than the `&&` and `||` operators.
- The `&&` and `||` operators have a lower precedence than relational operators like `<` and `>`.
- Parenthesis can be used to force the precedence to be changed.

Order of Precedence (2 of 2)

Order of Precedence	Operators	Description
1	(unary negation) !	Unary negation, logical NOT
2	* / %	Multiplication, Division, Modulus
3	+ −	Addition, Subtraction
4	< > <= >=	Less-than, Greater-than, Less-than or equal to, Greater-than or equal to
5	== !=	Is equal to, Is not equal to
6	&&	Logical AND
7	||	Logical NOT
8	= += −= *= /= %=	Assignment and combined assignment operators.

Comparing `String` Objects

- In most cases, you cannot use the relational operators to compare two `String` objects.
- Reference variables contain the address of the object they represent.
- Unless the references point to the same object, the relational operators will not return true.
- See example: StringCompare.java
- See example: StringCompareTo.java

Ignoring Case in String Comparisons

- In the `String` class the `equals` and `compareTo` methods are case sensitive.
- In order to compare two `String` objects that might have different case, use:
  - `equalsIgnoreCase`, or
  - `compareToIgnoreCase`
- See example: SecretWord.java

Variable Scope

- In Java, a local variable does not have to be declared at the beginning of the method.
- The scope of a local variable begins at the point it is declared and terminates at the end of the method.
- When a program enters a section of code where a variable has scope, that variable has **come into scope**, which means the variable is visible to the program.
- See example: VariableScope.java

The Conditional Operator (1 of 4)

- The **conditional operator** is a ternary (three operand) operator.
- You can use the conditional operator to write a simple statement that works like an `if-else` statement.

The Conditional Operator (2 of 4)

- The format of the operators is:

  `BooleanExpression ? Value1 : Value2`

- This forms a conditional expression.
- If *`BooleanExpression`* is true, the value of the conditional expression is *`Value1`*.
- If *`BooleanExpression`* is false, the value of the conditional expression is *`Value2`*.

The Conditional Operator (3 of 4)

- Example:

```
z = x > y ? 10 : 5;
```

- This line is functionally equivalent to:

```
if(x > y)
  z = 10;
else
  z = 5;
```

The Conditional Operator (4 of 4)

- Many times the conditional operator is used to supply a value.

```
number = x > y ? 10 : 5;
```

- This is functionally equivalent to:

```
if(x > y)
  number = 10;
else
  number = 5;
```

- See example: ConsultantCharges.java

The `switch` Statement (1 of 4)

- The `if-else` statement allows you to make true / false branches.
- The `switch` statement allows you to use an ordinal value to determine how a program will branch.
- The `switch` statement can evaluate a variable or an expression that gives a `char`, `byte`, `short`, `int`, or string value, and make decisions based on the value.

The `switch` Statement (2 of 4)

- The `switch` statement takes the form:

```
switch (TestExpression)
{
  case CaseExpression:
    // place one or more statements here
    break;
  case CaseExpression:
    // place one or more statements here
    break;

    // case statements may be repeated
    //as many times as necessary
  default:
    // place one or more statements here
}
```

The `switch` Statement (3 of 4)

```
switch (TestExpression)
{
    …
}
```

- The `switch` statement will evaluate the **TestExpression**, which can be a `char`, `byte`, `short`, `int`, or string.
- If there is an associated `case` statement that matches that value, program execution will be transferred to that `case` statement.

The `switch` Statement (4 of 4)

- Each `case` statement will have a corresponding **CaseExpression** that must be unique.

```
case CaseExpression:
    // place one or more statements here
    break;
```

- If the **TestExpression** matches the **CaseExpression**, the Java statements between the colon and the `break` statement will be executed.

The `case` Statement

- The `break` statement ends the `case` statement.
- The `break` statement is optional.
- If a `case` does not contain a `break`, then program execution continues into the next `case`.
  - See example: NoBreaks.java
  - See example: PetFood.java
- The `default` section is optional and will be executed if no **CaseExpression** matches the **TestExpression**.
- See example: SwitchDemo.java

Multi Value `case` Statements

- With Java 12 or later, you can specify multiple values separated by commas in a `case` statement.

```
switch (number)
{
   case 1, 3, 5, 7, 9:
      System.out.println("Odd");
      break;
   case 2, 4, 6, 8, 10:
      System.out.println("Even");
      break;
   default:
      System.out.println("Number out of range");
}
```

- When any of the `case` values match the `switch` statement's **TestExpression**, the statements in the `case` section are executed.

Arrow `case` Syntax (1 of 4)

- With Java 12 or later, you can use arrow `case` syntax in a `switch` statement.

```
case value -> statement;
```

- The `case` value is followed by the arrow operator (`->`) which is followed by a single statement.
- When the `case` value matches the `switch` statement's **TestExpression**, the statement to the right of the arrow operator is executed and the program breaks out of the `switch` statement.

Arrow `case` Syntax (2 of 4)

- Example:

```
switch (month)
{
   case 1 -> System.out.println("January");
   case 2 -> System.out.println("February");
   case 3 -> System.out.println("March");
   default -> System.out.println("Error: Invalid
  month");
}
```

Arrow `case` Syntax (3 of 4)

- Arrow case syntax allows you to specify multiple values in a `case` statement.

```
switch (month)
{
   case 1, 2, 3, 4, 5 -> System.out.println("Spring Semester");
   case 6, 7 -> System.out.println("Summer Semester");
   case 8, 9, 10, 11, 12 -> System.out.println("Fall Semester");
   default -> System.out.println("Error: Invalid month");
}
```

Arrow `case` Syntax (4 of 4)

- If you need to write more than one statement in a `case` section, you must enclose those statements in curly braces

```
switch (month)
{
   case 1 ->
   {
      monthName = "January";
      System.out.println(monthName);
   }
   case 2 ->
   {
      monthName = "February";
      System.out.println(monthName);
   }
   case 3 ->
   {
      monthName = "March";
      System.out.println(monthName);
   }
   default ->
   {
      monthName = "Invalid";
      System.out.println("Error: Invalid month");
   }
}
```

`switch` Expressions (1 of 6)

- In Java 12 and later, the `switch` statement can be written as an expression that gives a value.
- Example:

```
String numstring;

numstring = switch(number)
  {
     case 0 -> "Zero";
     case 1 -> "One";
     case 2 -> "Two";
     default -> "Unknown";
  };
```

`switch` Expressions (2 of 6)

- If the value of `number` is 0, the string "Zero" will be assigned to `numstring`.
- If the value of `number` is 1, the string "One" will be assigned to `numstring`.
- If the value of `number` is 2, the string "Two". The string "Two" will be assigned to `numstring`.
- If the value of `number` is not 0, 1, or 2, the string "Unknown" will be assigned to `numstring`.

switch Expressions (3 of 6)

- Don’t forget the semicolon at the end of the statement!

```
String numstring;

numstring = switch(number)
  {
     case 0 -> "Zero";
     case 1 -> "One";
     case 2 -> "Two";
     default -> "Unknown";
  };
```

`switch` Expressions (4 of 6)

- A `switch` expression must be exhaustive.
- This means that it must have `case` statements that cover every possible value of the **TestExpression**.
- In most situations, this simply means that a `switch` expression must have a `default` section.

`switch` Expressions (5 of 6)

- If a `case` section in a `switch` expression has more than one statement, you must use the `yield` keyword to return a value from that `case` section.

switch Expressions (6 of 6)

```
message = switch(statusCode)
{
   case 200 ->
   {
      statusType = "Successful";
      yield "OK";
   }
   case 404 ->
   {
      statusType = "Client Error";
      yield "Not Found";
   }
   default ->
   {
      statusType = "Unsupported";
      yield "Unknown Status";
   }
};
```

The `System.out.printf` Method (1 of 15)

- You can use the `System.out.printf` method to perform formatted console output.
- The general format of the method is:

```
System.out.printf(FormatString, ArgList);
```

The `System.out.printf` Method (2 of 15)

```
System.out.printf(FormatString, ArgList);
```

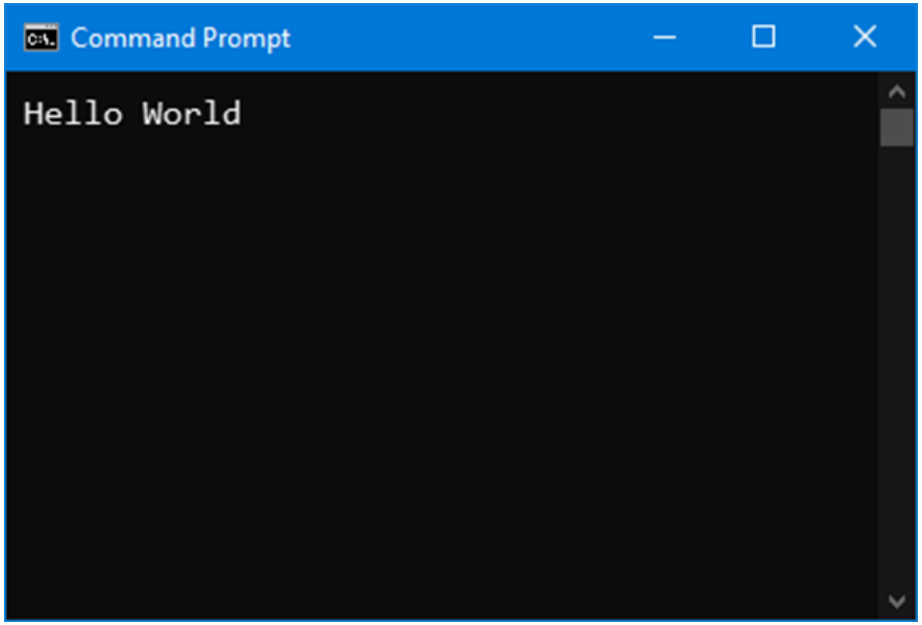
FormatString **is a string that contains text and/or special formatting specifiers.**

ArgList **is optional. It is a list of additional arguments that will be formatted according to the format specifiers listed in the format string.**

The `System.out.printf` Method (3 of 15)

- A simple example:

```
System.out.printf("Hello World\n");
```

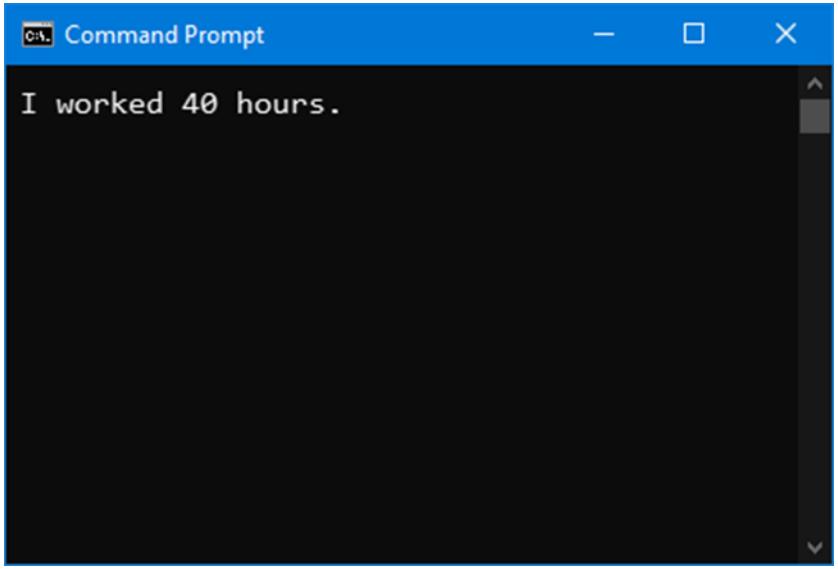


The `System.out.printf` Method (4 of 15)

- Another example:

```
int hours = 40;

System.out.printf("I worked %d hours.\n", hours);
```



The `System.out.printf` Method (5 of 15)

```
int hours = 40;
System.out.printf("I worked %d hours.\n", hours);
```

The %d format specifier indicates that a decimal integer will be printed.

The contents of the hours variable will be printed in the location of the %d format specifier.

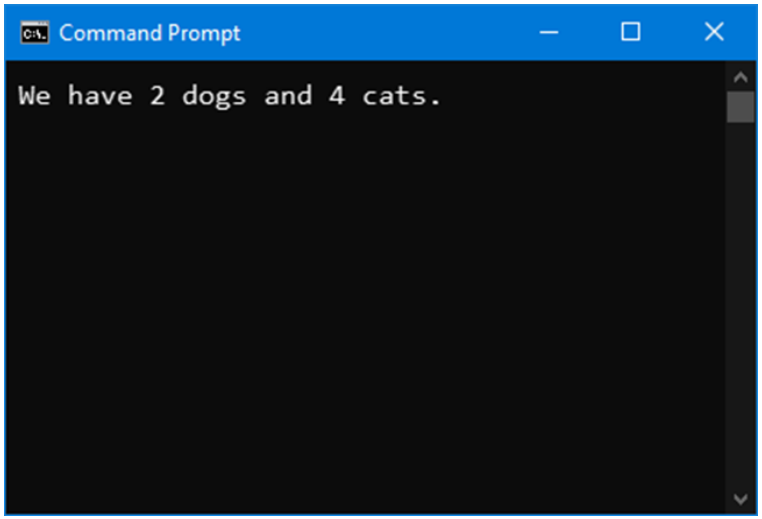
The `System.out.printf` Method (6 of 15)

- Another example:

```
int dogs = 2, cats = 4;

System.out.printf("We have %d dogs and %d cats.\n",

                  dogs, cats);
```

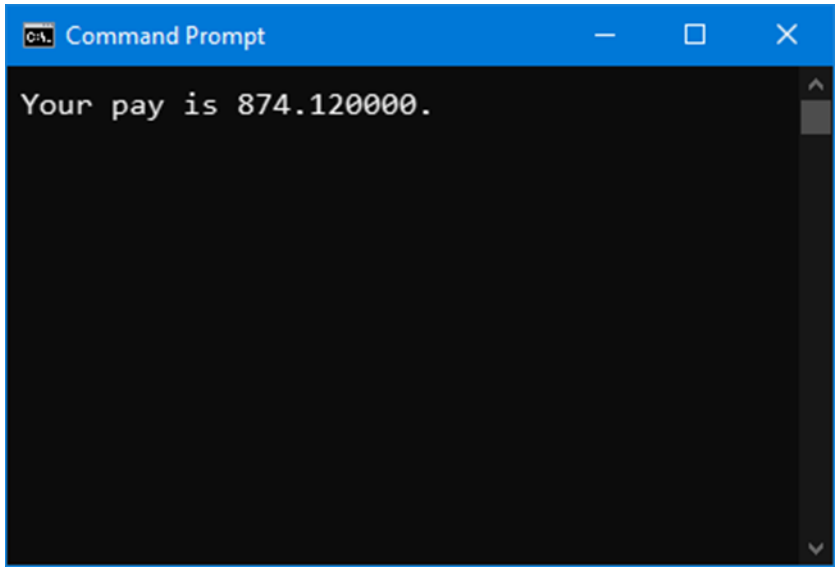


The `System.out.printf` Method (7 of 15)

- Another example:

```
double grossPay = 874.12;

System.out.printf("Your pay is %f.\n", grossPay);
```



The `System.out.printf` Method (8 of 15)

- Another example:

```
double grossPay = 874.12;
System.out.printf("Your pay is %f.\n", grossPay);
```

The `%f` format specifier indicates that a floating-point value will be printed.

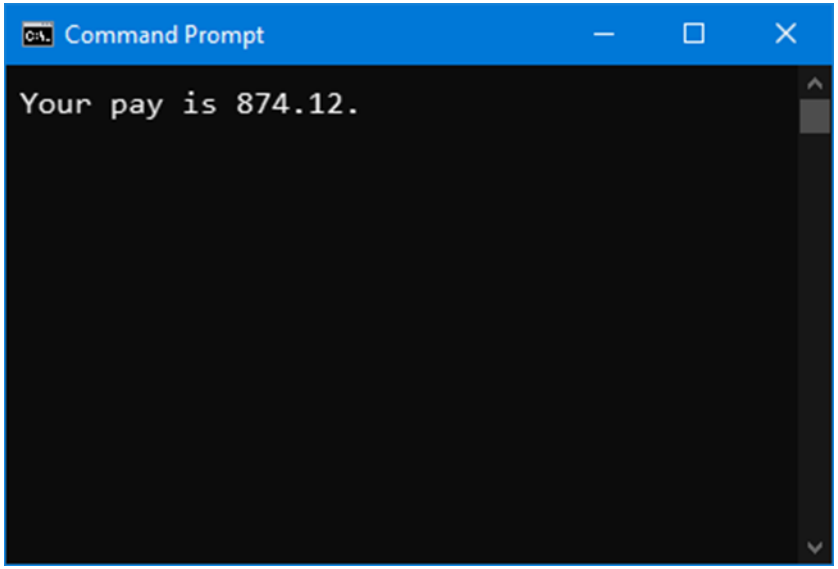
The contents of the `grossPay` variable will be printed in the location of the `%f` format specifier.

The `System.out.printf` Method (9 of 15)

- Another example:

```
double grossPay = 874.12;

System.out.printf("Your pay is %.2f.\n", grossPay);
```



The `System.out.printf` Method (10 of 15)

- Another example:

```
double grossPay = 874.12;
System.out.printf("Your pay is %.2f.\n", grossPay);
```

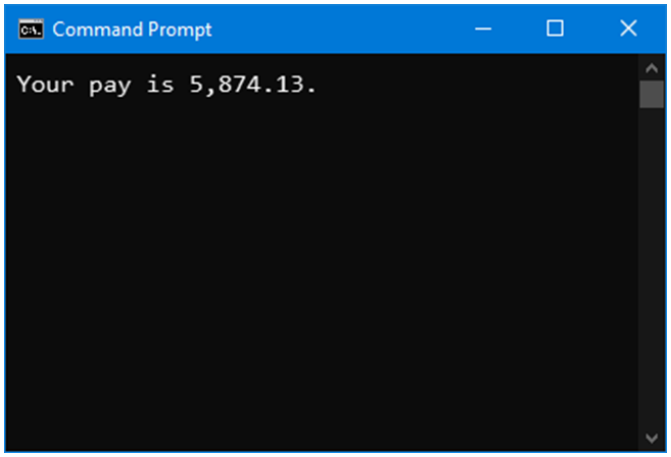
The `%.2f` format specifier indicates that a floating-point value will be printed, rounded to two decimal places.

The `System.out.printf` Method (11 of 15)

- Another example:

```
double grossPay = 5874.127;
System.out.printf("Your pay is %,.2f.\n", grossPay);
```

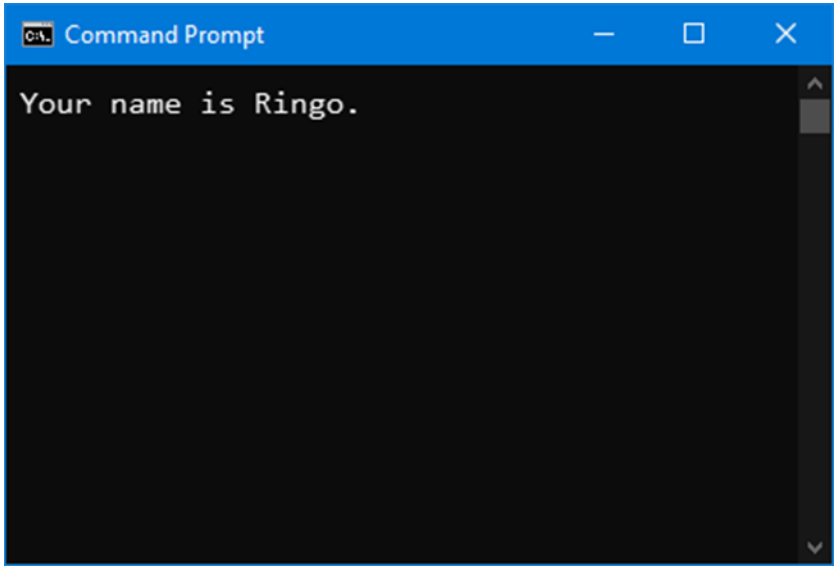
The `%,.2f` format specifier indicates that a floating-point value will be printed with comma separators, rounded to two decimal places.



The `System.out.printf` Method (12 of 15)

- Another example:

```
String name = "Ringo";
System.out.printf("Your name is %s.\n", name);
```

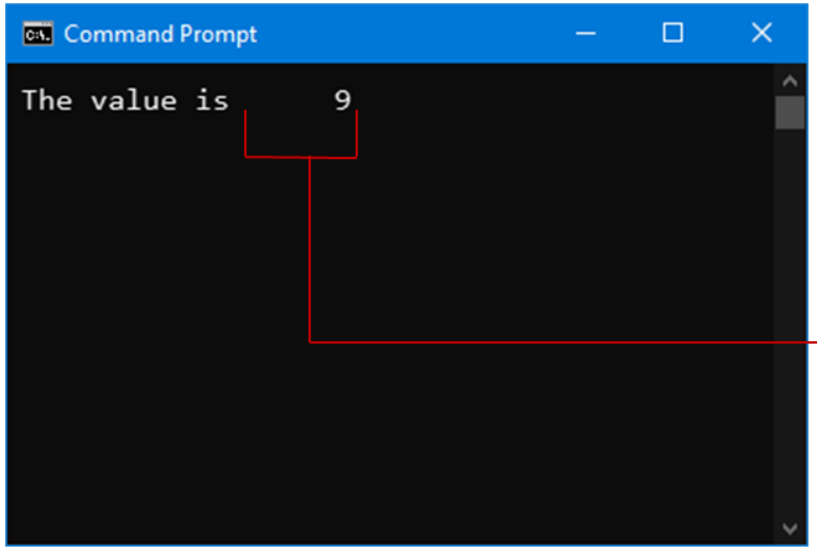


The `%s` format specifier indicates that a string will be printed.

The `System.out.printf` Method (13 of 15)

- Specifying a field width:

```
int number = 9;
System.out.printf("The value is %6d\n", number);
```

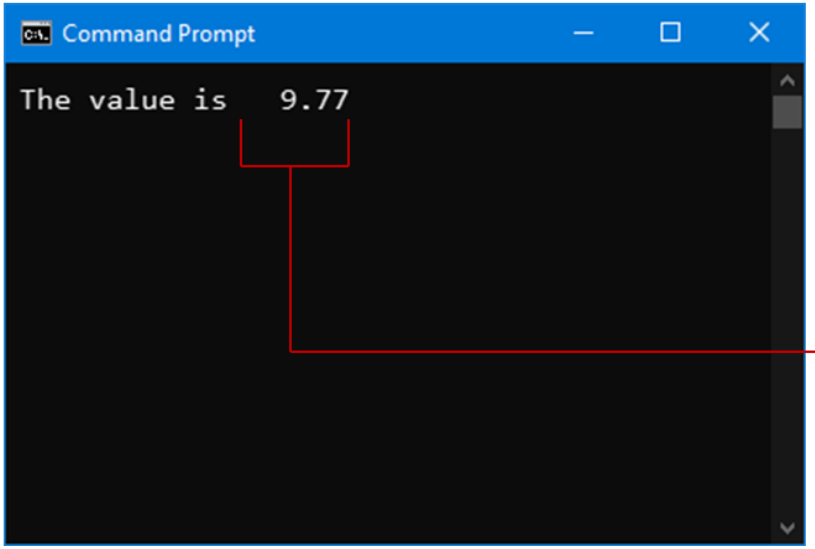


The %6d format specifier indicates the integer will appear in a field that is 6 spaces wide.

The `System.out.printf` Method (14 of 15)

- Another example:

```
double number = 9.76891;
System.out.printf("The value is %6.2f\n", number);
```



The `%6.2f` format specifier indicates the number will appear in a field that is 6 spaces wide and be rounded to 2 decimal places.

The `System.out.printf` Method (15 of 15)

- See examples:
  - Columns.java
  - CurrencyFormat.java

The `String.format` Method (1 of 3)

- The `String.format` method works exactly like the `System.out.printf` method, except that it does not display the formatted string on the screen.
- Instead, it returns a reference to the formatted string.
- You can assign the reference to a variable, and then use it later.

The `String.format` Method (2 of 3)

- The general format of the method is:

```
String.format(FormatString,ArgumentList);
```

FormatString **is a string that contains text and/or special formatting specifiers.**

ArgumentList **is optional. It is a list of additional arguments that will be formatted according to the format specifiers listed in the format string.**

The `String.format` Method (3 of 3)

- See examples:
  - CurrencyFormat2.java
  - CurrencyFormat3.java

Copyright