COMP30820
Java Programming (Conv)

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Chapter 3 Selections

Objectives

- To declare `boolean` variables and write Boolean expressions using relational operators (§3.2).
- To implement selection control using one-way `if` statements (§3.3).
- To implement selection control using two-way `if-else` statements (§3.4).
- To implement selection control using multi-way `if` statements (§3.5).
- To program using selection statements (§§3.7–3.9).
- To combine conditions using logical operators (`&&`, `||`, and `!`) (§3.10).
- To program using selection statements with combined conditions (§§3.11–3.12).
- To implement selection control using `switch` statements (§3.13).
- To write expressions using the conditional expression (§3.14).
- To examine the rules governing operator precedence and associativity (§3.15).

Relational Operators

Java provides six *relational operators* (also known as *comparison operators*) that can be used to compare two values.

Java	Mathematics	Name	Example	Result
Operator	**Symbol**		(radius is 5)	
`<`	<	less than	`radius < 0`	`false`
`<=`	≤	less than or equal to	`radius <= 0`	`false`
`>`	>	greater than	`radius > 0`	`true`
`>=`	≥	greater than or equal to	`radius >= 0`	`true`
`==`	=	equal to	`radius == 0`	`false`
`!=`	≠	not equal to	`radius != 0`	`true`

The `boolean` Type

The result of the comparison is a Boolean value: `true` or `false`.

The `boolean` data type:

```
boolean b = true;
```

A *Boolean expression* is an expression that evaluates to a Boolean value – for example:

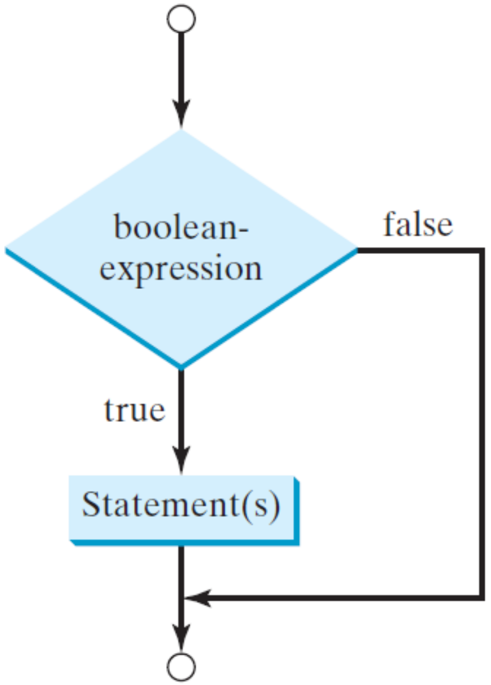
```
5 > 2
```

What is the value of `b`?

```
boolean b = 1 > 2;
```

One-way `if` Statement

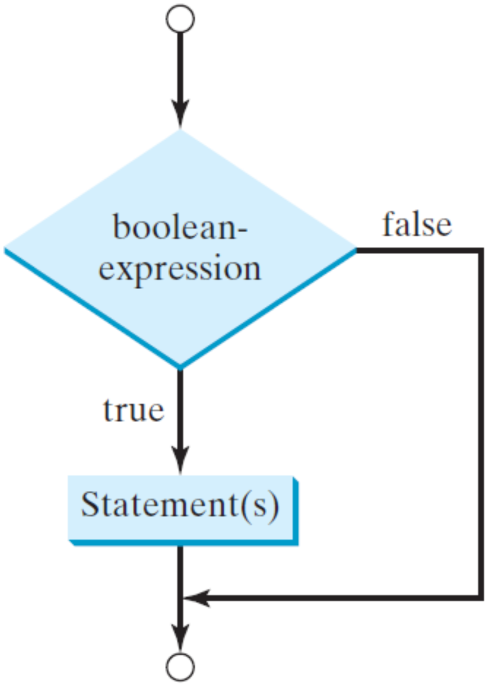
```
if (boolean-expression) {
  statement(s);
}
```

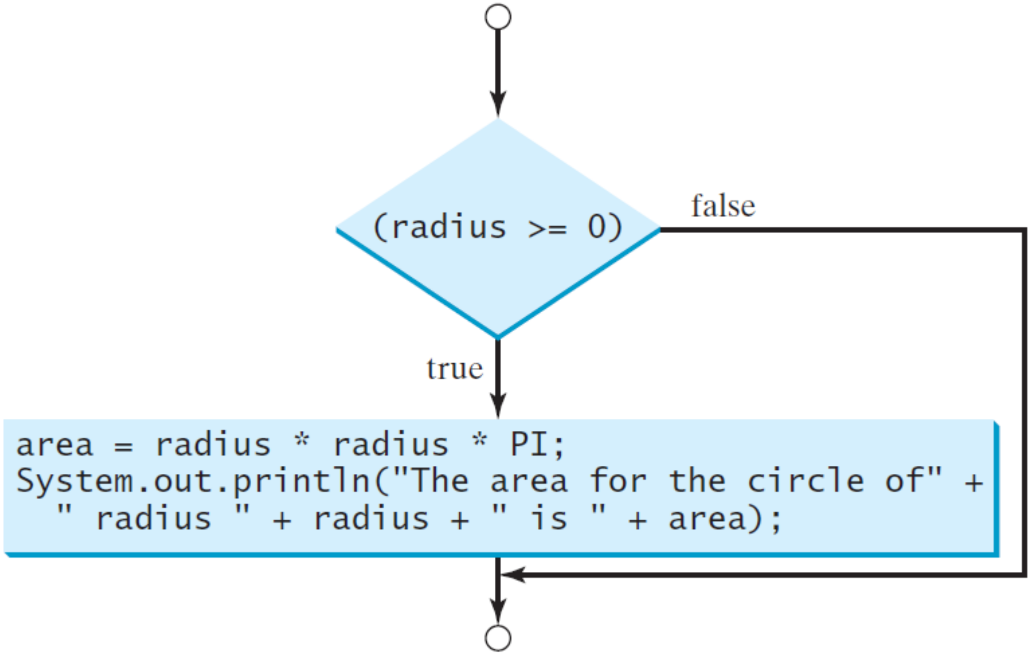


One-way `if` Statement

```
if (boolean-expression) {
  statement(s);
}
```

```
if (radius >= 0) {
  area = radius * radius * PI;
  System.out.println(…);
}
```





```
area = radius * radius * PI;
System.out.println("The area for the circle of" +
  " radius " + radius + " is " + area);
```

Notes

The boolean-expression must be enclosed in parentheses. The code in (a) is incorrect. The code in (b) is correct.

```
if i > 0 {
  System.out.println("i is positive");
}
```

(a) Incorrect

```
if (i > 0) {
  System.out.println("i is positive");
}
```

(b) Correct

Notes

The block braces can be omitted if they enclose a *single* statement. The code shown in (a) and (b) is equivalent.

```java
if (i > 0) {
  System.out.println("i is positive");
}
```

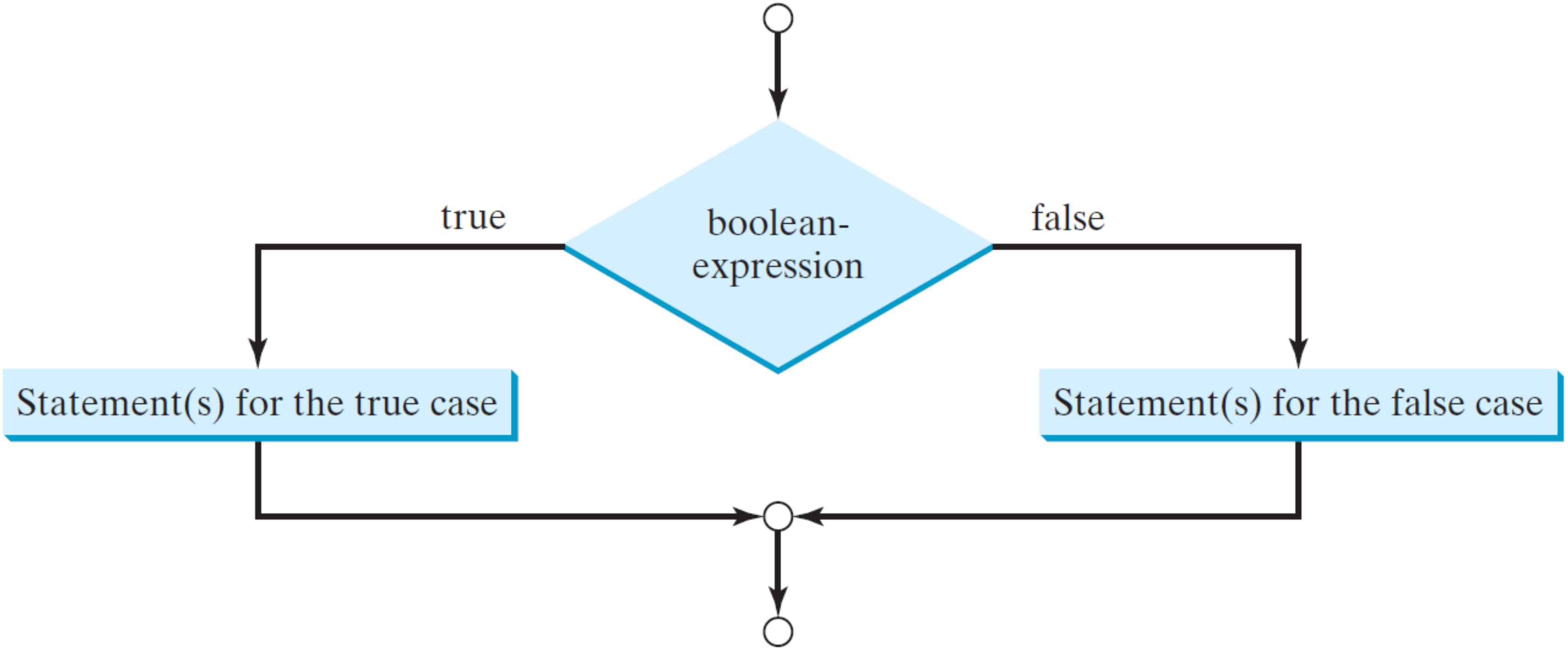
(a)

```java
if (i > 0)
  System.out.println("i is positive");
```

(b)

Two-way `if` Statement

```
if (boolean-expression) {
  statement(s) for the true case;
}
else {
  statement(s) for the false case;
}
```


boolean-expression
true
false
Statement(s) for the true case
Statement(s) for the false case

`if-else` Example

Write a program to calculate the area of a circle:

- Prompt the user to enter the radius from the keyboard
- If the radius is >= 0; calculate the area and print the output
- If the radius is negative, display a suitable message to the user

ComputeArea

Multiple Alternative `if-else` Statements

Suppose you wish to print a letter grade corresponding to a score.

Use a multi-way `if-else` statement as follows:

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace `if-else` statement

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace `if-else` statement

Suppose score is 75.0

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace `if-else` statement

Suppose score is 75.0

The condition is false

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace `if-else` statement

Suppose score is 75.0

The condition is false

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace `if-else` statement

Suppose score is 75.0

The condition is true

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

Trace `if-else` statement

Suppose score is 75.0

Execute statement – print "C"

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

animation

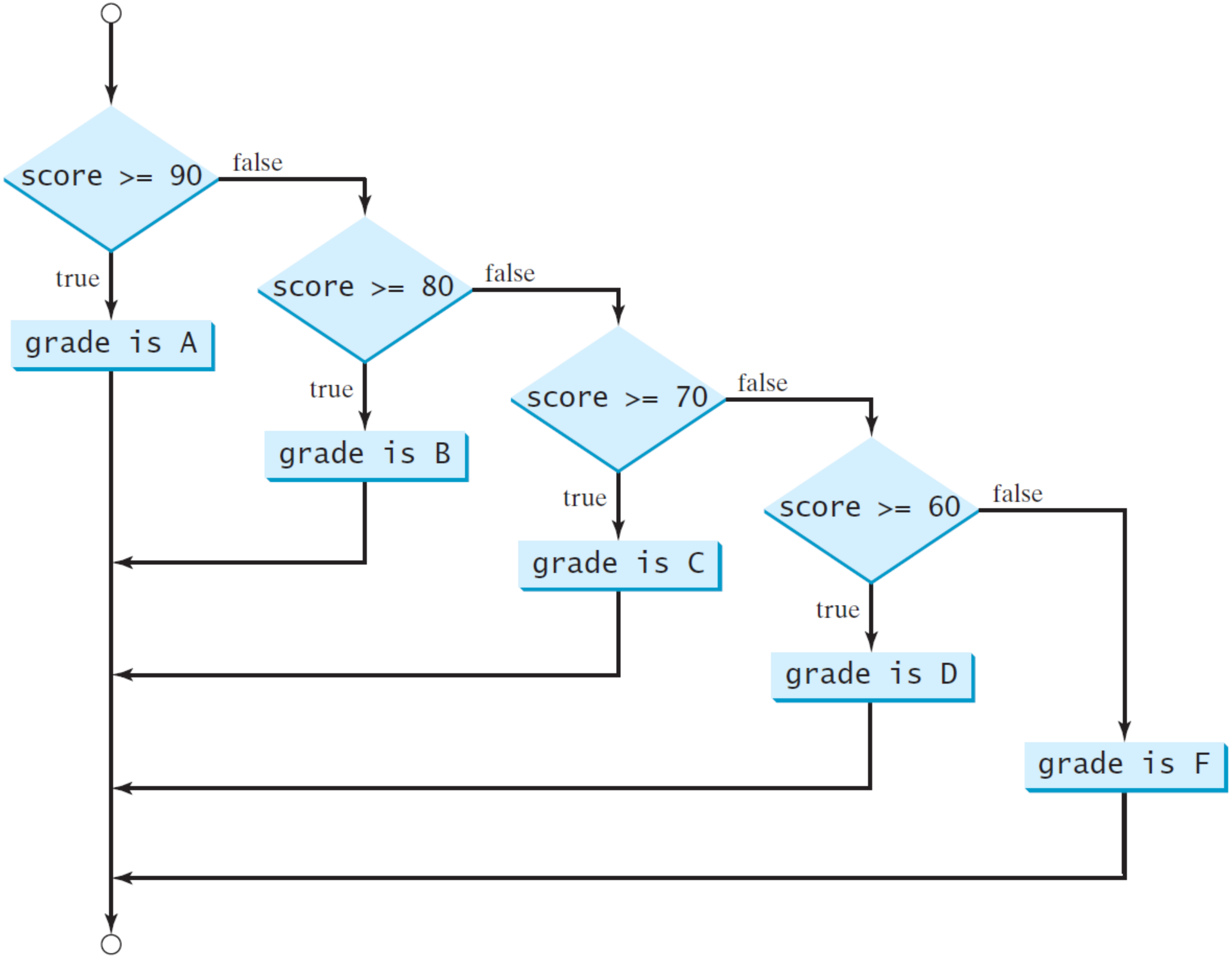
Trace `if-else` statement

Suppose score is 75.0

Exit the `if-else` statement

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B")
else if (score >= 70.0)
  System.out.print("C"
else if (score >= 60.
  System.out.print("D");
else
  System.out.print("F");
```

Multi-way `if-else` Statements



Common Errors

Adding a semicolon at the end of an `if` clause is a common error.

```
if (radius >= 0);
{
  area = radius * radius * PI;
  System.out.println("The area is " + area);
}
```

Error

This mistake is hard to find – it is a logic error, not a compilation error or a runtime error.

This error often occurs when you use the next-line block style.

Equality Test: Floating-Point Values

Floating-point numbers have a limited precision and calculations involving floating-point numbers can introduce round-off errors.

Hence, equality test of two floating-point values should be avoided.

For example – is `b` equal to `true` or `false` in the below?

```
double x = 1.0 - 0.1 - 0.1 - 0.1 - 0.1 - 0.1;
boolean b = x == 0.5;
```

Equality Test: Floating-Point Values

Floating-point numbers have a limited precision and calculations involving floating-point numbers can introduce round-off errors.

Hence, equality test of two floating-point values should be avoided.

For example – is `b` equal to `true` or `false` in the below?

```
double x = 1.0 - 0.1 - 0.1 - 0.1 - 0.1 - 0.1;
boolean b = x == 0.5;
```

`b` is `false` because `x` is not exactly 0.5, but is 0.5000000000000001

Equality Test: Floating-Point Values

But you can compare whether two floating point values are *close enough*: i.e. two numbers `x` and `y` are close if `|x-y| < ε`.

Set `ε` to 10^{-14} for comparing two values of the `double` type and to 10^{-7} for comparing two values of the `float` type.

For example, the following code…

```
final double EPSILON = 1E-14;
double x = 1.0 - 0.1 - 0.1 - 0.1 - 0.1 - 0.1;
if (Math.abs(x - 0.5) < EPSILON)
  System.out.println(x + " is approximately 0.5");
```

…will display: 0.5000000000000001 is approximately 0.5

TIPS

Suppose we wish to check whether `number` is even or odd.

```
int number = 2;
```

TIPS

Suppose we wish to check whether `number` is even or odd.

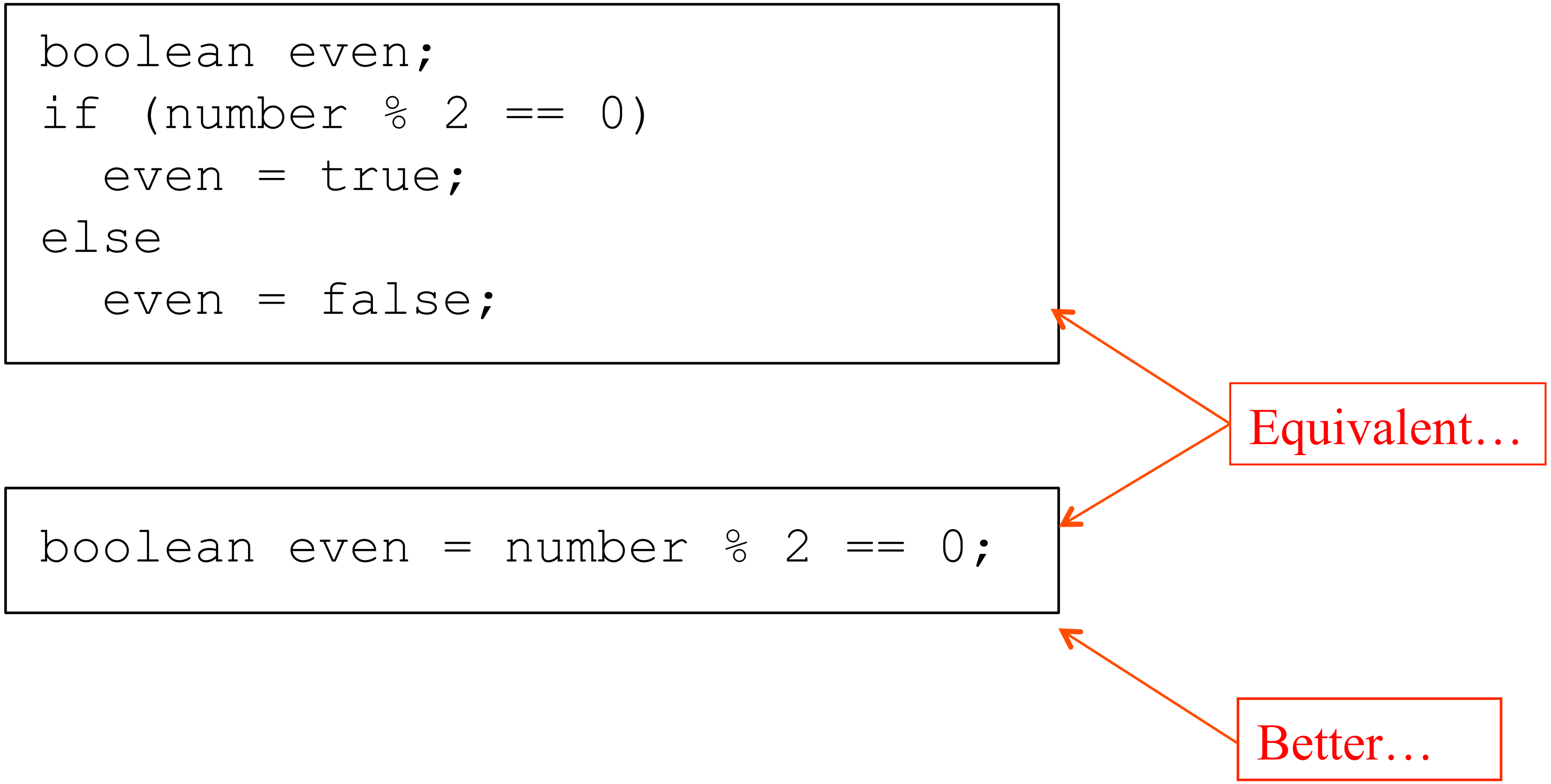
```
int number = 2;
```

```
boolean even;
if (number % 2 == 0)
  even = true;
else
  even = false;
```

TIPS

Suppose we wish to check whether `number` is even or odd.

```
int number = 2;
```



```
boolean even;
if (number % 2 == 0)
   even = true;
else
   even = false;
```

```
boolean even = number % 2 == 0;
```

Equivalent…

Better…

TIPS

To test whether a boolean variable is `true` or `false`, it is redundant to use the equality testing operator (==):

```
if (even == true)
  System.out.println(
    "It is even.");
```

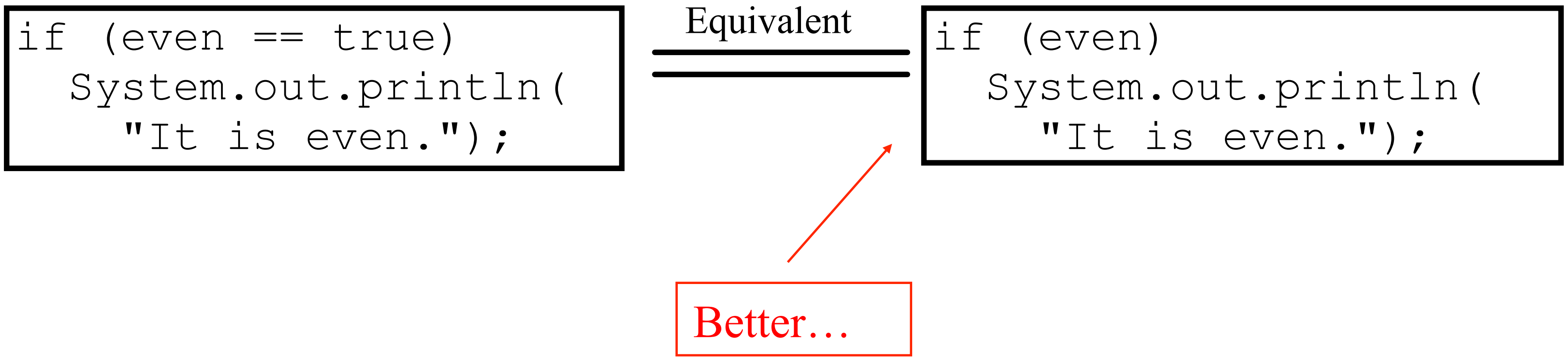
Equivalent

```
if (even)
  System.out.println(
    "It is even.");
```

Better…

TIPS

To test whether a boolean variable is `true` or `false`, it is redundant to use the equality testing operator (==):



```
if (even == true)
  System.out.println(
    "It is even.");
```

Equivalent

```
if (even)
  System.out.println(
    "It is even.");
```

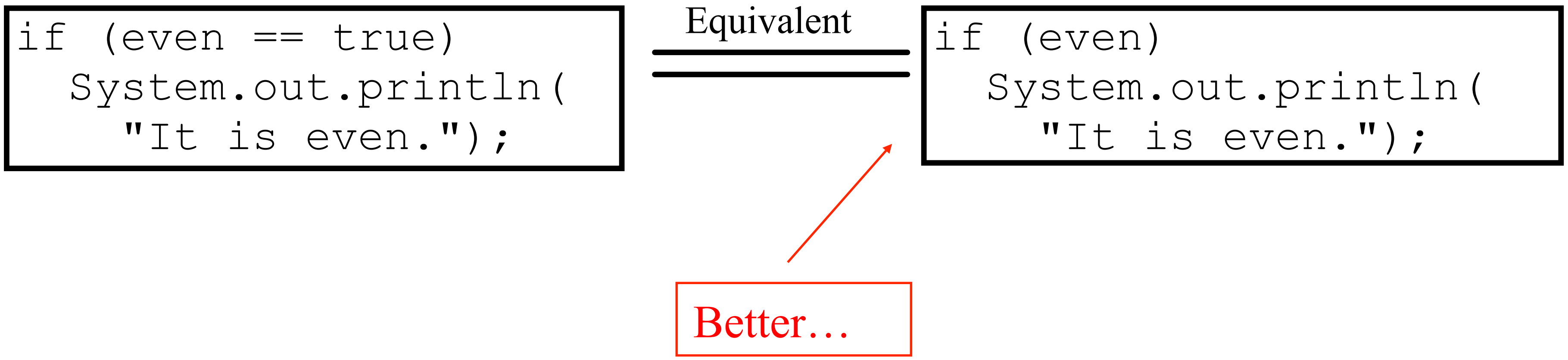
Better…

What happens here?

```
if (even = true)
  System.out.println("It is even.");
```

TIPS

To test whether a boolean variable is `true` or `false`, it is redundant to use the equality testing operator (==):



```
if (even == true)
  System.out.println(
    "It is even.");
```

Equivalent

```
if (even)
  System.out.println(
    "It is even.");
```

Better…

What happens here?

```
if (even = true)
  System.out.println("It is even.");
```

This statement assigns `true` to `even`, so that `even` is always true…

Problem: A Mathematics Learning Tool

Write a program to teach a first grade child how to learn subtractions:

- Prompt the user to enter two integers, `n1` and `n2`
- To avoid dealing with negative numbers, if `n1` < `n2` then swap the numbers
- Prompt the user to answer the question: What is `n1` – `n2` ?
- Display whether the answer is correct

SubtractionTest

Logical Operators

Operator	**Name**	**Description**
&&	and	logical conjunction
||	or	logical disjunction
^	exclusive or	logical exclusion
!	not	logical negation

Truth Table for Operator &&

p_1	p_2	p_1 && p_2
false	false	false
false	true	false
true	false	false
true	true	true

Truth Table for Operator ||

p_1	p_2	$p_1 \mid\mid p_2$
false	false	false
false	true	true
true	false	true
true	true	true

Truth Table for Operator ^

p_1	**p_2**	**p_1 ^ p_2**
false	false	false
false	true	true
true	false	true
true	true	false

Truth Table for Operator !

p	**!p**
true	false
false	true

Example: Logical Operators

Write a program that reads in a number and checks whether the number is:

- Divisible by both 2 and 3
- Divisible by 2 or 3 or both
- Divisible by 2 or 3 but not both

TestBooleanOperators

Example: Leap Year

Write a program that prompts the user to enter a year as an `int` value and checks if it is a leap year.

Solution:

- A year is a leap year if it is divisible by 4 but not by 100, or it is divisible by 400

Example: Leap Year

Write a program that prompts the user to enter a year as an `int` value and checks if it is a leap year.

Solution:

- A year is a leap year if it is divisible by 4 but not by 100, or it is divisible by 400

Example: Leap Year

Write a program that prompts the user to enter a year as an `int` value and checks if it is a leap year.

Solution:

- A year is a leap year if it is divisible by 4 but not by 100, or it is divisible by 400

```
boolean isLeapYear =
   (year % 4 == 0 && year % 100 != 0) || (year % 400 == 0);
```

LeapYear

`switch` Statement

Overuse of multiple `if-else` statements can make a program difficult to read.

Java provides a `switch` statement to simplify coding for multiple conditions.

switch Statement Rules

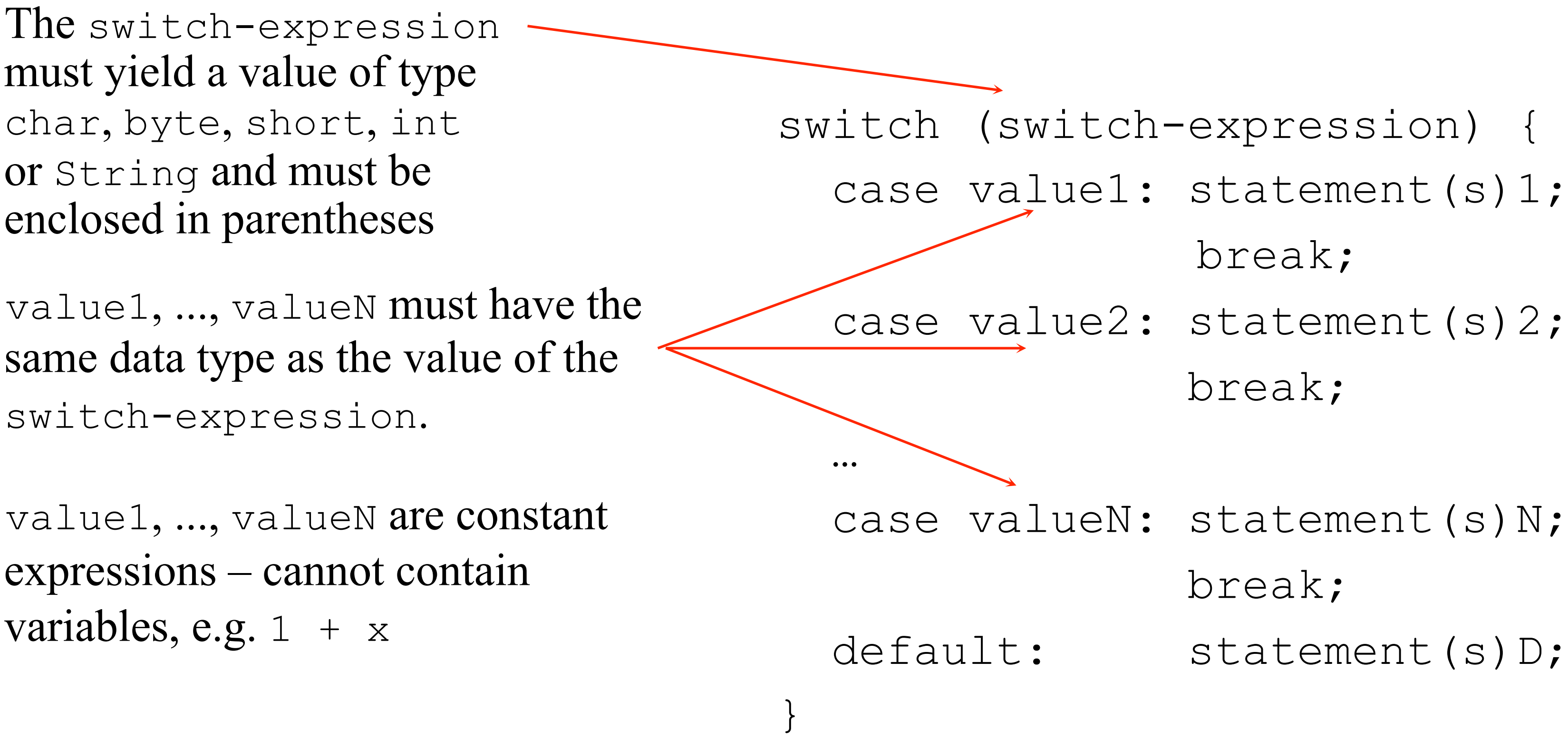
```
switch (switch-expression) {
  case value1: statement(s)1;
               break;
  case value2: statement(s)2;
               break;
  …
  case valueN: statement(s)N;
               break;
  default:     statement(s)D;
}
```

`switch` Statement Rules

The `switch-expression` must yield a value of type `char`, `byte`, `short`, `int` or `String` and must be enclosed in parentheses

```
switch (switch-expression) {
  case value1: statement(s)1;
               break;
  case value2: statement(s)2;
               break;
  …
  case valueN: statement(s)N;
               break;
  default:     statement(s)D;
}
```

`switch` Statement Rules



The `switch-expression` must yield a value of type `char`, `byte`, `short`, `int` or `String` and must be enclosed in parentheses

`value1`, ..., `valueN` must have the same data type as the value of the `switch-expression`.

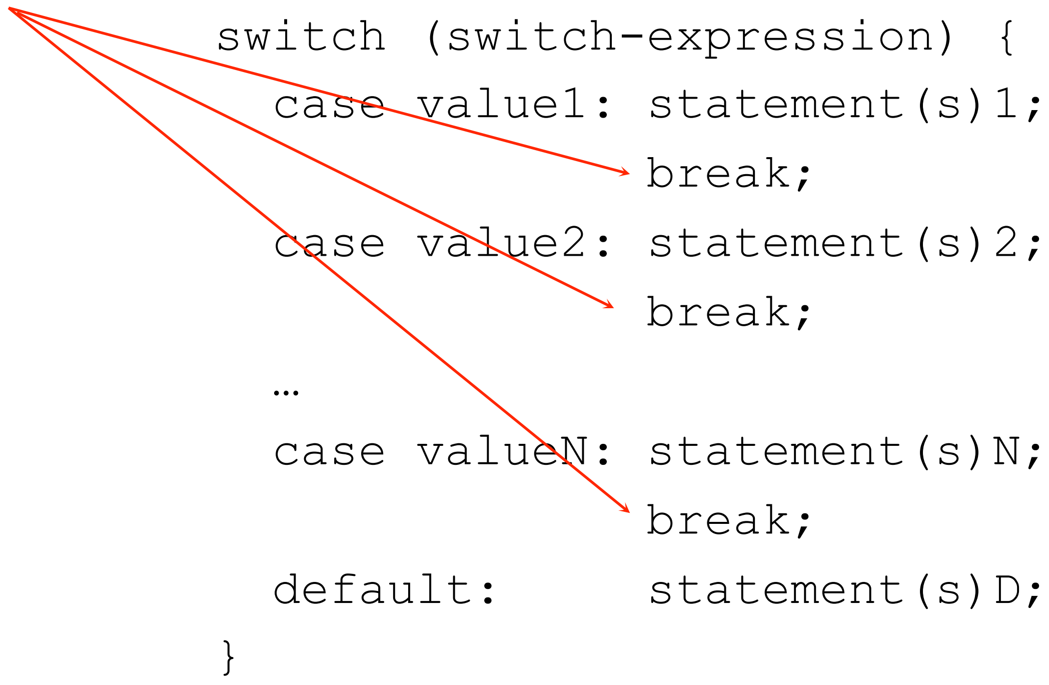
`value1`, ..., `valueN` are constant expressions – cannot contain variables, e.g. `1 + x`

```
switch (switch-expression) {
  case value1: statement(s)1;
               break;
  case value2: statement(s)2;
               break;
  …
  case valueN: statement(s)N;
               break;
  default:     statement(s)D;
}
```

`switch` Statement Rules

The keyword `break` is optional.

When the value in the `case` statement matches the value of the `switch-expression`, the statements *starting from this case* are executed until either a `break` statement or the end of the `switch` statement is reached.



```
switch (switch-expression) {
  case value1: statement(s)1;
               break;
  case value2: statement(s)2;
               break;
  …
  case valueN: statement(s)N;
               break;
  default:     statement(s)D;
}
```

`switch` Statement Rules

The keyword `break` is optional.

When the value in the `case` statement matches the value of the `switch-expression`, the statements *starting from this case* are executed until either a `break` statement or the end of the `switch` statement is reached.

```
switch (switch-expression) {
  case value1: statement(s)1;
               break;
  case value2: statement(s)2;
               break;
  …
  case valueN: statement(s)N;
               break;
  default:     statement(s)D;
}
```

The `default` case, which is optional, can be used to perform actions when none of the specified cases matches the `switch-expression`.

animation

Trace `switch` statement

The following code displays "Weekday" for day values of 1 to 5 and "Weekend" for day values of 0 and 6.

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

animation

Trace `switch` statement

Suppose day is 2

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

animation

Trace switch statement

Match case 2

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

animation

Trace `switch` statement

Fall through case 3

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

animation

Trace `switch` statement

Fall through case 4

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

Trace `switch` statement

Fall through case 5

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

animation

Trace `switch` statement

Execute statement(s)

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

animation

Trace `switch` statement

Encounter break

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

animation

Trace `switch` statement

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5: System.out.println("Weekday"); break;
  case 0:
  case 6: System.out.println("Weekend");
}
```

Exit the statement

Conditional Expressions

A *conditional expression* evaluates an expression based on a condition.

For example:

```
if (x > 0)
  y = 1;
else
  y = -1;
```

is equivalent to:

```
y = (x > 0) ? 1 : -1;
```

The syntax is:

```
(boolean-expression) ? expression1 : expression2
```

The symbols `?` and `:` appear together in a conditional expression. They form a conditional operator, also called a ternary operator because three operands are involved. It is the only ternary operator in Java.

Conditional Operator

For example:

```
if (num % 2 == 0)
  System.out.println("num is even");
else
  System.out.println("num is odd");
```

Conditional Operator

For example:

```
if (num % 2 == 0)
  System.out.println("num is even");
else
  System.out.println("num is odd");
```

…can be written as…

```
System.out.println(
  (num % 2 == 0) ? "num is even" : "num is odd");
```

Conditional Operator

For example:

```
if (num % 2 == 0)
  System.out.println("num is even");
else
  System.out.println("num is odd");
```

…can be written as…

```
System.out.println(
  (num % 2 == 0) ? "num is even" : "num is odd");
```

What does the following do?

```
result = (num1 > num2) ? num1 : num2;
```

Operator Precedence and Associativity

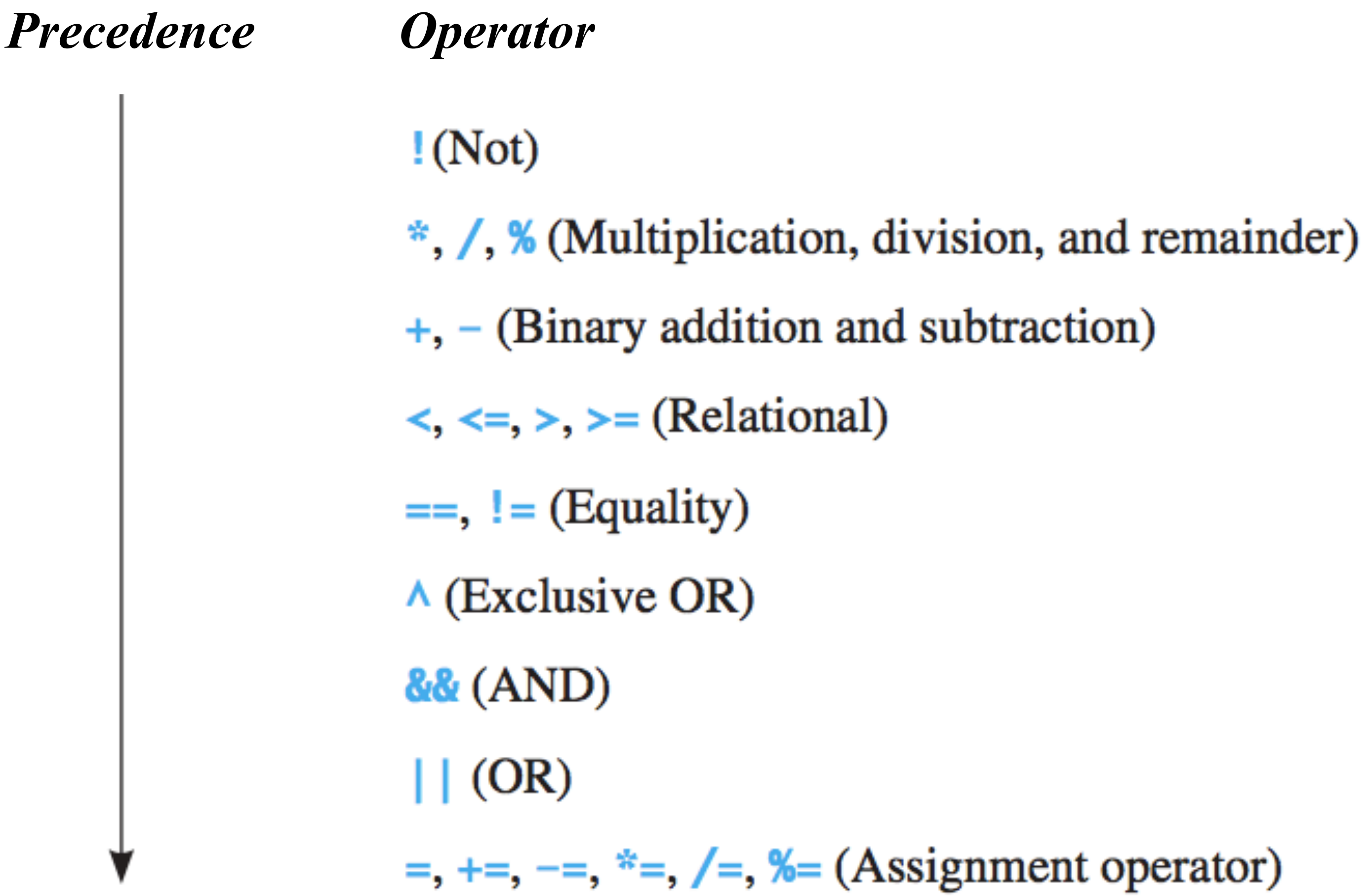
Operator *precedence* and *associativity* determine the order in which operators are evaluated.

Expressions within parentheses are evaluated first.

The *precedence rule* defines precedence for operators:

- Operators with the same precedence appear in the same group (see next slide)

Operator Precedence



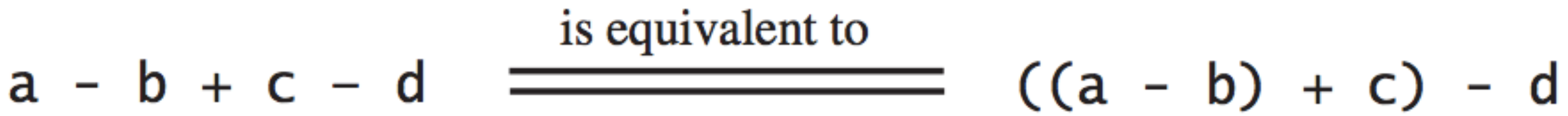
Precedence	*Operator*
↓	! (Not)
	*, /, % (Multiplication, division, and remainder)
	+, - (Binary addition and subtraction)
	<, <=, >, >= (Relational)
	==, != (Equality)
	^ (Exclusive OR)
	&& (AND)
	|| (OR)
	=, +=, -=, *=, /=, %= (Assignment operator)

Operator Precedence and Associativity

If multiple operators with the same precedence occur in a statement, their *associativity* determines the order of evaluation.

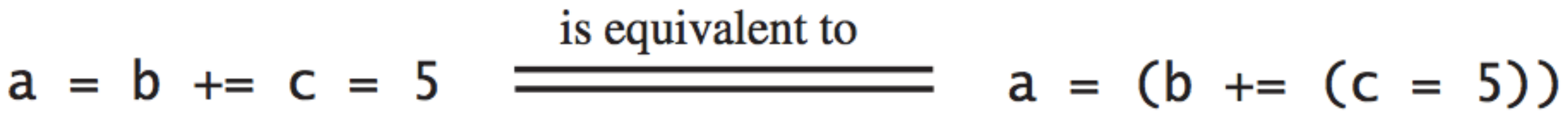
All binary operators, except assignment operators, are left-associative.

For example, since + and – are of the same precedence and are left associative, the expression:



`a - b + c - d` is equivalent to `((a - b) + c) - d`

Assignment operators are right associative:



`a = b += c = 5` is equivalent to `a = (b += (c = 5))`

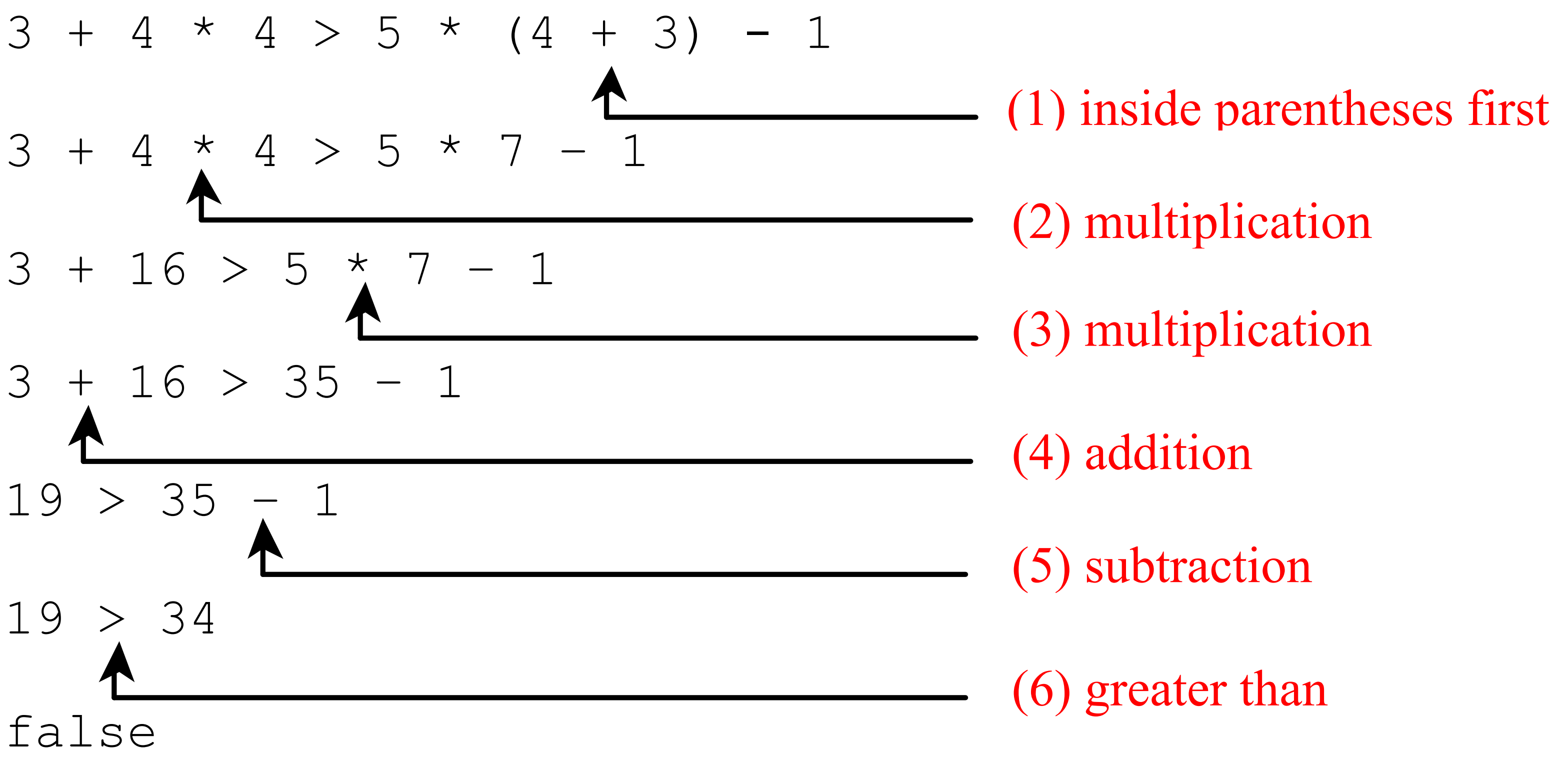
Example

Applying the operator precedence and associativity rule, evaluate the following expression:

```
    3 + 4 * 4 > 5 * (4 + 3) - 1
```

Example

Applying the operator precedence and associativity rule, evaluate the following expression:



```
3 + 4 * 4 > 5 * (4 + 3) - 1
```

(1) inside parentheses first

```
3 + 4 * 4 > 5 * 7 – 1
```

(2) multiplication

```
3 + 16 > 5 * 7 – 1
```

(3) multiplication

```
3 + 16 > 35 – 1
```

(4) addition

```
19 > 35 – 1
```

(5) subtraction

```
19 > 34
```

(6) greater than

```
false
```

Next Topics…

Chapter 4

- Explore the `Math` class in more detail.
- Encoding characters using ASCII and Unicode, using escape characters.
- Introduce objects and instance methods.
- Represent strings using `String` objects.