

## Control structures: if

Like a recipe tells the cook what to do, a program tells the computer what to do; in *imperative languages* like Java, lines in the program are imperative *statements* and you can imagine the computer running the program by pointing to each line in turn, like a cook follows the statements one after the other.

In a recipe, sometimes you find conditional instructions: “if you have parsley available, use three ounces of parsley; otherwise, use a branch of thyme.” This instructs the cook to do different things depending on what he/she has available at the moment the recipe is used.

The corresponding construct in imperative language is the *conditional statement*, defined as follows:

*Conditional statement:*

Syntax:

```
if ( <expression> ) <block-or-statement>
[ else <block-or-statement> ]?
```

(the keyword “if” followed by an expression between parentheses, followed by either a statement block between “{” and “}” or a single statement, followed optionally by the keyword “else”, followed by either a statement block or a single statement.)

Semantics:

The expression between parentheses, also called *conditional expression*, is evaluated first. If its value is equivalent to `true`, the first block-or-statement is executed, otherwise, the first block-or-statement is skipped, and if there is a “else” part, its block-or-statement is executed instead.

For example:

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

(if x is positive, the program prints “x is positive”; otherwise, nothing is printed)  
or:

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

```

else
{
    System.out.println("x is zero or negative");
}

```

(if *x* is positive, the program prints “*x* is positive”; otherwise, the program prints “*x* is zero or negative”)

## Relational operators

The condition can contain any *expression*, or formula, that computes a value that is either “true” or “false”. For this you can use the following operators in most programming languages, also called *relational operators*:

Operator	Description
<code>x == y</code>	tests if <i>x</i> is equal to <i>y</i>
<code>x != y</code>	tests if <i>x</i> is different from <i>y</i>
<code>x &gt; y</code>	tests if <i>x</i> is strictly greater than <i>y</i>
<code>x &lt; y</code>	tests if <i>x</i> is strictly lower than <i>y</i>
<code>x &gt;= y</code>	tests if <i>x</i> is greater or equal to <i>y</i>
<code>x &lt;= y</code>	tests if <i>x</i> is lower or equal to <i>y</i>

### Note

Beware of the difference between the single “=” and the double “==”. The first is the *assignment* operator, and “*x* = 3” means “change the value of the variable *x* to become 3”; the second is the *test for equality* operator, and “*x* == 3” means “test whether the value of variable *x* is equal to 3”.

In Java, the relational operators are designed primarily to compare numbers; in particular you cannot use them to compare character strings (`String`). You will see later how to compare strings in Java.

Also, you must compare things that are comparable; in particular, *both sides must have comparable types*. For example it is not possible in Java to compare a value of type `int` with a value of type `double`. When in doubt, always ensure both sides have the same type.

## Nested conditionals

The one or two “branches” of a `if` statement are themselves statements, so we can combine a `if` inside an `if`. This is called *nesting*: using a control structure “inside” of another. For example:

```

if (x == 0)
{
    System.out.println("x is zero");
}
else
{
    if (x > 0)
    {

```

```

        System.out.println("x is positive");
    }
    else
    {
        System.out.println("x is negative");
    }
}

```

In this example, the expression “ $x == 0$ ” is first evaluated. If it is true, the first message is printed. Otherwise, the second `if` is executed and the expression “ $x > 0$ ” is evaluated. If it is true, the 2nd message is printed. Otherwise, the 3rd message is printed. In this example, the 2nd `if-else` construct is *nested* within the 1st `if-else` construct; more specifically it is nested in its “else branch”.

## Conjunction, disjunction and negation

Say you want to write a program that prints a message “working age” if the age of a person is between 18 and 67. The relational operators seen above only have 2 operands left and right; to establish within the age falls within the range, you must thus combine two different conditions. For example:

```

if (age >= 18)
{
    if (age <= 67)
    {
        System.out.println("working age");
    }
}

```

This type of combination, called a *logical conjunction*, or “AND relation”, happens so often in programs that most languages have a simplified notation; in Java this is noted “`&&`”:

```

if (age >= 18 && age <= 67)
{
    System.out.println("working age");
}

```

Value of $x$	Value of $y$	Value of $x \ \&\& \ y$
false	N/A	false
true	false	false
true	true	true

Similarly, say you want to offer a reduced price for people under 18 or above 67. For this you need a *logical disjunction*, or “OR relation”. In Java, another operator exists for this and is noted “`||`”:

```

if (age <= 18 || age >= 67)
{
    System.out.println("reduced price");
}

```

Value of $x$	Value of $y$	Value of $x \    \ y$
false	false	false
false	true	true
true	N/A	true

To complete this set of logical operators, programming languages almost always also provide a general operator that “inverts” the truth value of a condition. This is called *negation*; in Java, this is noted using an exclamation mark (“!”) followed by the condition to invert:

Example	Equivalent to
$!(x == y)$	$x != y$
$!(x != y)$	$x == y$
$!(x < y)$	$x >= y$
$!(x \ \&\& \ y)$	$(!x) \    \ (!y)$
$!(x \    \ y)$	$(!x) \ \&\& \ (!y)$

Value of $x$	Value of $!x$
true	false
false	true

## Important concepts

- *conditional statement*
- syntax and semantics of `if ... else`
- relational operators: `==`, `!=`, `<`, `>`, `<=`, `>=`
- difference between “=” and “==”
- relational operators designed to work on numbers, in particular *cannot use on strings*
- *nesting*
- *conjunction “&&”, disjunction “||”*
- *negation with “!”*

## Further reading

- Think Java, sections 4.1-4.5 (pp. 39-42), section 6.6 (pp 62-63)
- Programming in Java, sections 3.1.1 (pp. 67-68), 3.1.3 (pp. 71-73), 3.5 (pp. 96-104)
- Absolute Java, section 3.1 (pp. 100-106)

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