Conditionals and Looping

Decision making with `if` statements. Iteration with the `while` and `for` loops

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Conditional Statements

The `if` statement

- The `if` statement in `Java` consists of 2 distinct parts: a **condition** and a **body**.

```
if (condition)
{
    body
}
```

- The `(condition)` must be enclosed by parentheses, unlike other programming languages such as `Python`.
- Omitting the parentheses is a common error.

Conditional Statements

The `if` statement

- The **condition** is a `boolean` expression that evaluates to either `true` or `false`.
- The **body** is the block of code that will be executed if the condition is `true`.
- Note that if the condition evaluates as `false`, then this code block will be completely skipped over.

```
if (age >= 18)
{
    System.out.println("You can drive.");
}
```

The if-else statement

- Java's if-else statement is used when you want to do one thing if a condition is true, and another thing if a condition is false.
- An if-else statement will execute either the if section or the else section, but never both.

```
if (condition)
{
    body1 // evaluated when condition is true
}
else
{
    body2 // evaluated when condition is false
}
```

An if-else Example

- If the condition is `true`, then the assignment statement is executed.
- If the condition is `false`, then the `println` statement is executed. Only one of the statements can be executed.

```
if (amount <= balance)
{
   balance = balance - amount;
}
else
{
   System.out.println("Insufficient balance.");
}
```

The extended `if` statement

- Java's extended `if` statement can be used if we have a series of `if-else` statements, and only one of them can evaluate as `true`.

```
if (condition)
{ ... }
else if (other condition)
{ ... }
else
{ ... }
```

- Generally, it has an `else` condition at the very end. This becomes the default choice for the entire structure.
- If all of the other conditions evaluate as `false`, then this default `else` condition has its code block executed.

An extended if Example

```
if (temp > 100)
{
    System.out.println("Stifling heat!");
}
else if (temp > 50)
{
    System.out.println("Warm environment.");
}
else
{
    System.out.println("Freezing cold!");
}
```

Relational Operators

- A **relational operator** tests the relationship between two values.
- Java has six relational operators:

Java Operator	Description
>	greater than
>=	greater than or equal to
<	less than
<=	less than or equal to
==	equal to
!=	not equal to

These operators are mathematical in nature:

```
boolean result = 8 > 5; // result is true
```

The Equality Operator: ==

- The **equality** operator(==) is very confusing to most Java beginners, because it is easy to mix up with the **assignment** operator(=).
- The == operator denotes equality testing.

```
if (age == 65)
{
    System.out.println("You can retire.");
}
```

- In the above example, the age variable is compared to 65, to see if they are equal.
- **Note:** you can only use == to test primitive data types, not objects such as Strings.

Logical Operators

- There are three logical operators in `Java`.

Op.	Description	Example	Result
`!`	not	`!a`	`true` if `a` is `false`, and `false` if `a` is `true`.
`&&`	and	`a && b`	`true` if `a` and `b` are both `true`, and `false` otherwise.
`||`	or	`a || b`	`true` if either `a` or `b` are `true`, and `false` otherwise.

- Order of precedence: not, and, or.

Truth Tables

- A logical operation can be described by a **truth table** that lists all of the possible combinations of values for the input variables involved in an expression.
- The following is a two-valued truth table. It shows the outputs for the && and || operators.

		logical and	**logical or**
a	b	a && b	a || b
false	false	false	false
false	true	false	true
true	false	false	true
true	true	true	true

The not Operator: !

- The not operator gives the logical complement of a boolean value.
- It does not alter the variable upon which it acts.
- The following is the truth table for the not operator:

	logical not
a	!a
false	true
true	false

```
if (!lights)
{
    System.out.println("The room is dark.");
}
```

The and Operator: &&

- The result of a logical and(&&) operation is `true` if both operands are `true`, but `false` otherwise.

```
if (chips > 0 && soda > 0)
{
    System.out.println("You have snacks.");
}
```

The or Operator: ||

- The result of a logical or(||) operation is `true` if one or the other or both of the operands are `true`, but `false` otherwise.

```
if (money > 1000 || creditCard == true)
{
    System.out.println("You can buy an iPhone.");
}
```

Compound Logical Conditions

- A condition can be formed by using more than one logical operator.
- This is known as, "chaining together" the operators.

```
if (month == 3 || month == 4 || month == 5)
{
    System.out.println("It is spring.");
}
```

- Note that you can't chain together relational operators.

```
boolean result = 5 <= 8 < 12; // error
```

DeMorgan's Laws

Negating a logical expression

- DeMorgan's laws allow us to simplify a boolean expression by distributing the negation operator.
- An interesting outcome is that all `or`'s are converted to `and`'s, and all `and`'s are converted to `or`'s.

```
!(A or B) = !A and !B
!(A and B) = !A or !B
```

For example, the statement, "I don't like chocolate **or** vanilla." is exactly the same as, "I do not like chocolate **and** I do not like vanilla."

Short-Circuit Evaluation

Logical efficiency

- The `&&` and `||` operators are **short-circuited**.
- This means that if the left-hand operand in an boolean expression can decide the entire expression's outcome, then the right-hand side is not evaluated.

Consider the following example:

```
boolean a = false;
boolean result = a && (b || c && (p && q) || m);
```

- `result` will always evaluate as `false`, regardless of the other boolean values.

Short-Circuit Evaluation

Short-circuit evaluation with and: &&

If the left-hand operand is `false`, then the result of the entire boolean expression will be `false`, no matter what the right-hand operand is.

```
boolean a = false;
boolean result = a && (p && q); // a is false
```

Short-circuit evaluation with or: ||

If the left-hand operand is `true`, then the result of the entire boolean expression will be `true`, no matter what the right-hand operand is.

```
boolean b = true;
boolean result = b || (p && q); // b is true
```

The `while` Loop

The indefinite loop

- Recall that a **boolean condition** is a statement that evaluates to either `true` or `false`.
- A `while` loop repeates looping as long as its boolean condition is `true`. It is also known as an **indefinite loop**.
- Java's `while` loop has the following structure:

```
while (boolean condition)
{
    code block of statements;
}
```

The Counter-controlled Loop

Looping a given number of times

- A counter-controlled loop is one that repeats a predetermined number of times.
- The condition in this loop is controlled by a counter variable.
- The counter variable keeps track of the number of times that a loop is executed.

```
int count = 0;
while (count < 5)
{
    System.out.println(count);
    count++;
}
```

The Infinite Loop

Beware the endless loop

- A common mistake is when a programmer forgets to increment the counter variable within the body of the `while` loop.
- If this case occurs, then the boolean condition will always evaluate as `true`. It will never become `false`.
- Therefore, the code block of statements within the `while` loop will execute indefinitely.

```
int count = 0;
while (count < 100)
{
    System.out.println("Hi"); // indefinite loop
}
```

Summing a Sequence of Integers with `while`

This Java program uses a `while` statement to sum the following sequence of integers:

$$1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10$$

```
int count = 1;
int sum = 0;
while (count <= 10)
{
    sum += count;
    count++;
}
System.out.println(sum);
```

Incrementing by a Different Amount

- A counter variable can be incremented by a value other than one.
- For example, the following counter is incremented by 10, each time through the loop.

```
int count = 0;
while (count < 100)
{
    System.out.println(count);
    count += 10;
}
```

The `for` Loop

The definite loop

- Counter-controlled loops are so frequently used, that programming languages have developed a special structure for them.
- The `for` statement combines counter initialization, condition testing, and counter updating into a single expression.
- It is also known as a **definite** loop.

```
for (initialize counter; test counter; update counter)
{
    code block of statements;
}
```

while and for Loop Equivalence

Consider the following while loop:

```
int count = 0;
while (count < 5)
{
    System.out.println("Hello");
    count++;
}
```

This while loop can be equivalently expressed as the following for loop:

```
for (int count = 0; count < 5; count++)
{
    System.out.println("Hello");
}
```

Counting Through a Sequence of Integers

- The following `for` loop counts from `0` to `9`.
- The counter variable `i` is declared as part of the `for` loop, therefore it only exists in that code block.
- Attempting to use `i` outside the `for` loop would result in an error.

```
for (int i = 0; i < 10; i++)
{
    System.out.println(i);
}
```

Summing a Sequence of Integers with `for`

This Java program uses a `for` statement to sum the following sequence of integers:

$$1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10$$

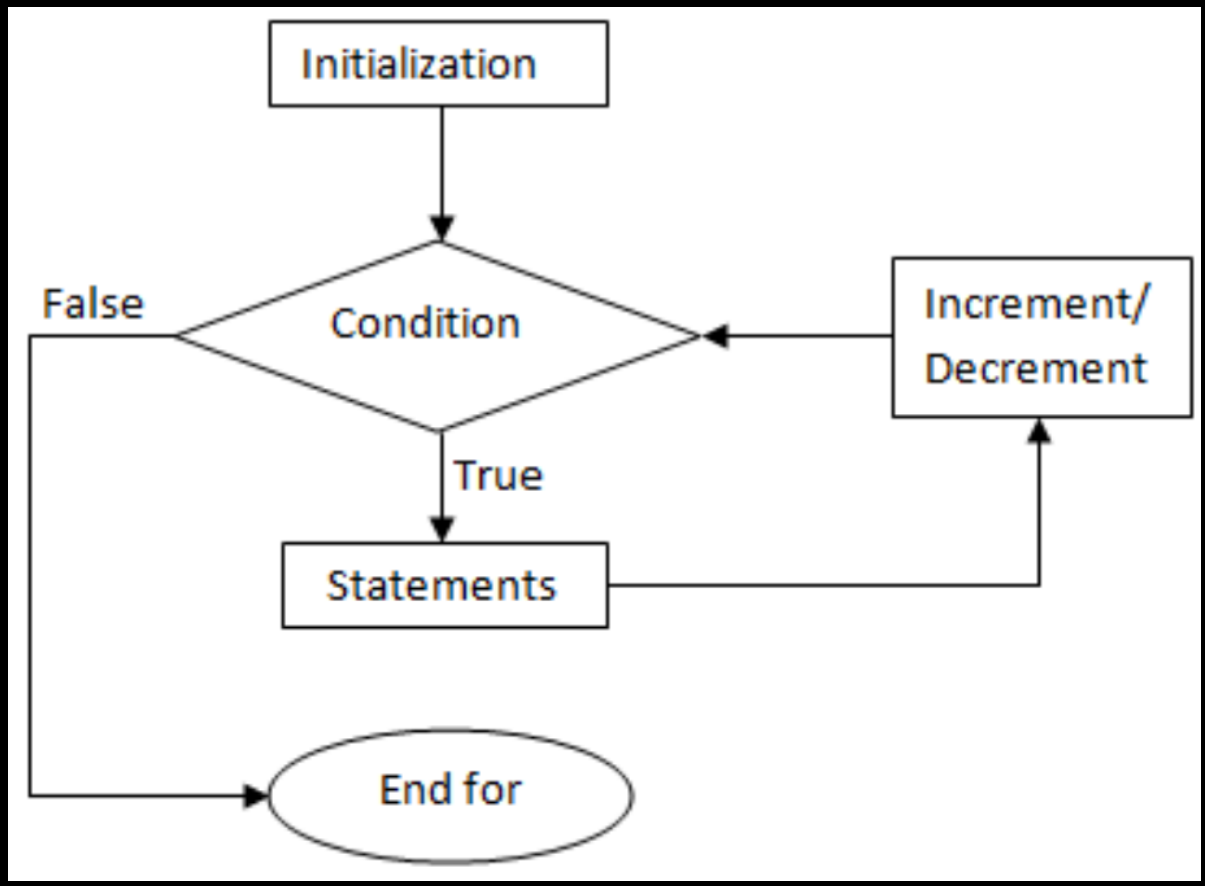
```
int sum = 0;
for (int i = 1; i <= 10; i++)
{
    sum += i;
}
System.out.println(sum);
```

Incrementing by a Different Amount

- The counter variable can be incremented by a value other than one.
- For example, the following counter is incremented by 10, each time through the loop.

```
for (int i = 0; i < 100; i += 10)
{
    System.out.println(i);
}
```

Flowchart representation of a `for` Loop



Conditionals and Looping: End of Notes