Lambda Expressions

The full syntax of lambda expressions: parameter-writing rules, expression body vs. block body, the compiler inferring a lambda's type from context (target typing), capturing effectively final variables, and how a lambda differs from an anonymous inner class.

Intermediate 20 min

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Lambda Expressions

In the "Interface" lesson's "Functional Interfaces and Lambdas" section we met lambdas briefly: a functional interface (an interface with exactly one abstract method) being instantiated directly with an expression, with no named class needed. This lesson is the first topic of the Java course's new category, **Functional Interfaces & Streams** -- and it opens up the syntax that section deliberately kept short: how parameters are written, the two shapes a body can take, when `return` is mandatory, and how a lambda reaches variables in its enclosing scope. This category's code examples are a bit different from the rest of this course -- since `java.util.function` / `java.util.stream` are pure JDK (unlike Spring Boot), no external dependency is required.

What Is a Lambda Expression?

A lambda expression is a short, nameless function definition that can be assigned directly to a variable or passed as an argument to a method. Functions can't exist independently of classes in Java -- a lambda isn't really a class either, it's, as we saw in "Functional Interfaces and Lambdas", an **instance, on the spot**, of a functional interface with exactly one abstract method. This short `parameter -> body` syntax gives Java the ability (many other languages already had) to **carry functions around as data** -- you can hold a function in a variable, add it to a list, or pass it to another method.

Why Does It Exist?

Before lambdas, the only tool for "passing a piece of behavior as a parameter" was the anonymous inner class -- even a single line of logic needed five or six lines of boilerplate around it:

```
// Before lambdas: a whole anonymous inner class skeleton for a single line
// of comparison logic
Comparator<String> byLength = new Comparator<String>() {
    @Override
    public int compare(String a, String b) {
        return a.length() - b.length();
    }
};
```

The same logic collapses to one line with a lambda:

```
Comparator<String> byLength = (a, b) -> a.length() - b.length();
```

This isn't just "less typing" -- the code's actual **intent** (compare two strings by length) no longer gets buried under mandatory but meaning-free repetition like `@Override` / `public int compare(...)`. We'll see in "Anonymous Inner Classes vs. Lambdas" that this difference isn't just visual either -- `this` behaves differently too.

History

Lambda expressions arrived in Java with **Java 8** (2014) -- carried out under the name "Project Lambda", one of the biggest language changes in Java's history up to that point. Java itself had been a purely object-oriented language since 1995; the idea of "carrying functions around as data," which had existed for a long time in functional languages (Lisp, and later newer languages like Scala and Haskell), was relatively easy to integrate into Java precisely because single-method interfaces like `Comparator` / `Runnable` were already widely used -- the compiler could infer which interface a lambda should become an instance of purely from the shape of that interface (the signature of its one abstract method). The Stream API, which arrived in the same Java 8 release (the later topics in this category), is the API that revealed what lambdas were really for -- the two were designed together, and can't really be thought of separately.

Parameters: Zero, One, or Multiple

The parameter portion of lambda syntax looks different depending on how many parameters there are:

```
import java.util.function.BinaryOperator;

// A functional interface with one abstract method -- everything this file's lambdas
// need to demonstrate parameter/return syntax against.
interface Greeting {
    String greet(String name);
}

// Every form lambda syntax can take, side by side: parameter count, parentheses
// rules, and expression-body vs block-body.
class LambdaSyntaxAndReturnExample {
    public static void main(String[] args) {
        // Zero parameters -- empty parentheses are required, never optional.
        Runnable sayHello = () -> System.out.println("Hello!");
        sayHello.run();

        // One parameter -- parentheses are OPTIONAL when there's exactly one and it
        // has no type annotation, so both of these compile:
        Greeting shout = name -> name.toUpperCase() + "!";
        Greeting shoutParens = (name) -> name.toUpperCase() + "!";
        System.out.println(shout.greet("ayse"));

        // Two or more parameters -- parentheses become MANDATORY.
        BinaryOperator<Integer> max = (a, b) -> a > b ? a : b;
        System.out.println(max.apply(3, 7));

        // Expression body: a single expression, its value IS the return value --
        // no "return" keyword, no braces, no semicolon inside.
        Greeting expressionBody = name -> "Hi, " + name;
        System.out.println(expressionBody.greet("Fatma"));

        // Block body: braces required as soon as you need more than one statement --
        // and once you're in a block body, "return" becomes EXPLICIT and mandatory
        // for every path that produces a value.
        Greeting blockBody = name -> {
            String trimmed = name.trim();
            if (trimmed.isEmpty()) {
                return "Hi, stranger";
            }
            return "Hi, " + trimmed;
        };
        System.out.println(blockBody.greet("  Mehmet  "));
        System.out.println(blockBody.greet("   "));
    }
}
```

Expected Output

```
Hello!
AYSE!
7
Hi, Fatma
Hi, Mehmet
Hi, stranger
```

For zero parameters, parentheses are **mandatory** -- you can't write an empty lambda without `() -> ...`. For exactly one parameter, parentheses are **optional** (both `name -> ...` and `(name) -> ...` compile), but for two or more parameters, parentheses become **mandatory again** -- `a, b -> ...` doesn't compile, you have to write `(a, b) -> ...`. You almost never need to write a parameter's type (the compiler infers it, as we'll see in "The Lambda-to-Functional-Interface Connection: Target Typing", from the target interface's method) -- but you're free to spell it out explicitly, like `(String name) -> ...`, if you want to.

The Body: Expression Body vs. Block Body

As you saw in the same example, a lambda's body can take one of two shapes. An **expression body** is a single expression -- `name -> "Hi, " + name` -- no braces, no `return`, no semicolon; the expression's value **is** the return value directly. A **block body** is one or more statements wrapped in `{ }` -- the moment you need more than one line you have to switch to this shape, and the instant you're in a block body, `return` becomes **explicit and mandatory** on every path that produces a value. This distinction looks small, but it's a common source of mistakes -- we'll come back to it in "Common Mistakes".

The Lambda-to-Functional-Interface Connection: Target Typing

A lambda has no type of its own -- the compiler assigns it one by looking at the **context** it appears in (its "target type"):

```
import java.util.ArrayList;
import java.util.Comparator;
import java.util.List;
import java.util.function.BiFunction;

// The SAME lambda literal has no type of its own -- the compiler decides what it
// becomes purely from context (its "target type": a variable's declared type, a
// method parameter's type, or a return type). Two functional interfaces with the
// exact same shape (two Strings in, one int out) can both host this literal.
class TargetTypingExample {
    public static void main(String[] args) {
        // Target type: Comparator<String> -- int compare(String, String)
        Comparator<String> byLength = (a, b) -> a.length() - b.length();
        System.out.println(byLength.compare("hi", "hello"));

        // Target type: BiFunction<String, String, Integer> -- structurally identical
        // shape, a completely different interface, the exact same lambda syntax.
        BiFunction<String, String, Integer> lengthDiff = (a, b) -> a.length() - b.length();
        System.out.println(lengthDiff.apply("hi", "hello"));

        // Passing a lambda directly as a method argument -- the target type comes
        // from the parameter's declared type, List.sort(Comparator<? super E>).
        List<String> names = new ArrayList<>(List.of("Ahmet", "Al", "Ayse"));
        names.sort((a, b) -> a.length() - b.length());
        System.out.println(names);
    }
}
```

Expected Output

```
-3
-3
[Al, Ayse, Ahmet]
```

The expression `(a, b) -> a.length() - b.length()` doesn't say anything on its own -- it becomes a `Comparator<String>` when assigned to a variable of that type, and a `BiFunction<String, String, Integer>` when assigned to that type instead; since both interfaces' single abstract method has the exact same shape (two `String`s in, one result out), the exact **same** lambda expression fits both. The same mechanism is at work when we pass a lambda directly into `List.sort(...)` -- the target type comes from the parameter's declared type, `Comparator<? super E>`. This is also the foundation of why the ready-made types we'll see in "Built-in Functional Interfaces" -- `Predicate`, `Function`, `Consumer` -- turn out to be so useful: one ready-made interface with a given shape can serve many completely different scenarios.

Capturing Variables: Effectively Final

A lambda can read local variables from its enclosing scope -- but only if that variable is **effectively final**, meaning it's never reassigned after its first assignment, even if it's never explicitly marked `final`:

```
import java.util.ArrayList;
import java.util.List;
import java.util.function.Supplier;

// A lambda can read any local variable from its enclosing scope -- but ONLY if that
// variable is "effectively final": never reassigned after its first assignment, even
// if it's never explicitly marked `final`.
class EffectivelyFinalExample {
    public static void main(String[] args) {
        String prefix = "Order #"; // never reassigned -> effectively final, capturable

        Supplier<String> label = () -> prefix + "42";
        System.out.println(label.get());

        // The line below would NOT compile if uncommented -- reassigning "prefix"
        // anywhere after the lambda captures it makes it no longer effectively final:
        // prefix = "Ticket #";

        // A mutable object (not a local variable) sidesteps the restriction entirely
        // -- this is the usual escape hatch when a lambda genuinely needs to
        // accumulate state across multiple calls.
        List<String> collected = new ArrayList<>(); // the REFERENCE never changes
        Runnable addOne = () -> collected.add("item"); // mutating the LIST is fine
        addOne.run();
        addOne.run();
        System.out.println(collected);
    }
}
```

Expected Output

```
Order #42
[item, item]
```

`prefix` is never reassigned, so the lambda can capture it without any trouble; if there were a line `prefix = "..."` anywhere after `label` is defined, you'd get a compile error -- and that error happens even if you write that reassignment **after** the lambda, because the rule isn't "not reassigned after being captured," it's "never reassigned across the variable's entire lifetime." The usual way around this, as the example shows, is to change the **contents** an object points to rather than the reference itself -- `collected` itself is never reassigned (still effectively final), but the list it points to can change via `add(...)`.

> The reason for the effectively-final rule isn't thread safety (a lambda doesn't necessarily have to run on another thread) -- the real reason is that a lambda captures a variable by **copying** it. If the variable could be reassigned, the lambda's own copy and the real value in the enclosing scope would silently drift apart; the compiler prevents that up front, at compile time.

Anonymous Inner Classes vs. Lambdas

Beyond the syntax difference we saw in "Why Does It Exist?", there's a real behavioral difference between the two as well -- what `this` actually refers to:

```
interface ClickHandler {
    void onClick(String source);
}

// Same functional interface, two ways to provide an implementation -- side by side,
// to make both the syntax reduction and the "this" difference concrete.
class AnonymousClassVsLambdaExample {

    private final String owner = "AnonymousClassVsLambdaExample";

    void demoThis() {
        // Anonymous inner class: creates a REAL, separate class -- "this" inside its
        // body refers to the anonymous class instance itself.
        ClickHandler anonymous = new ClickHandler() {
            @Override
            public void onClick(String source) {
                System.out.println("anonymous this: " + this.getClass().getName());
            }
        };

        // Lambda: does NOT create a new class in that same sense -- "this" inside a
        // lambda body is inherited from the ENCLOSING scope, exactly as if the
        // lambda's body were pasted directly into the surrounding method.
        ClickHandler lambda = source -> System.out.println("lambda this: " + this.owner);

        anonymous.onClick("button");
        lambda.onClick("button");
    }

    public static void main(String[] args) {
        new AnonymousClassVsLambdaExample().demoThis();
    }
}
```

An anonymous inner class produces a real, **separate** class (in its compiled form you'll see a name like `AnonymousClassVsLambdaExample$1`) -- `this` inside it refers to that anonymous class's own instance. A lambda, on the other hand, behaves as if it **doesn't** produce a new class at all -- `this` inside it refers to the **enclosing object**, exactly as if the lambda's body had been pasted directly into the surrounding method. That difference is small-looking but it's the entire reason writing `this.owner` inside a lambda reaches the enclosing class's field directly (inside an anonymous class you'd have had to write `OuterClass.this.owner` to do the same thing).

Best Practices

- **Keep a lambda's body short** -- a block body running more than a few lines is usually a sign it should be extracted into a named method (or its own class); a lambda's power comes from its brevity.
- **Don't write parameter types, let the compiler infer them** -- as we saw in "Parameters: Zero, One, or Multiple", an explicit type is almost never necessary and just adds noise.
- **Treat the effectively-final restriction as a design signal, not an obstacle** -- as we saw in "Capturing Variables: Effectively Final", a lambda needing to reassign an outer variable is usually a sign that logic should actually be a named method, not a lambda.
- **Prefer a lambda for a single line of logic, and an anonymous class (or a named class) when you need several related methods** -- as we saw in "Anonymous Inner Classes vs. Lambdas," functional interfaces are single-method by definition.
- **Check the `java.util.function` package before writing your own functional interface** (a principle we also touched on in "Interface"'s "Functional Interfaces and Lambdas" section) -- this category's next topic is dedicated entirely to that package.

Common Mistakes

1. Forgetting `return` inside a block body. Writing something like `{ "Hi, " + name }` out of expression-body habit doesn't compile -- as we saw in "The Body: Expression Body vs. Block Body," the moment you open braces, `return` becomes mandatory.

2. Being inconsistent about parentheses on single-parameter lambdas across a codebase. Both compile (see "Parameters: Zero, One, or Multiple"), but picking one convention and sticking to it within a file/team improves readability.

3. Not understanding a compile error caused by capturing a variable that isn't effectively final. As we saw in "Capturing Variables: Effectively Final", the error usually points at the line where the variable is "captured," but the real cause is that the variable is reassigned **somewhere else** -- fixing it means checking every place that variable is used.

4. Assuming `this` inside a lambda behaves the way it does inside an anonymous class. As we saw in "Anonymous Inner Classes vs. Lambdas", `this` inside a lambda refers to the enclosing object -- unlike an anonymous class, a lambda has no "`this`" of its own.

5. Continuing to write a new named class every time you need a `Comparator`/`Runnable`/etc. As we saw in "Why Does It Exist?", a lambda exists precisely to remove that repetition -- when you need a one-off implementation of a single-method interface, reach for a lambda first.

Summary, Cheat Sheet, and Glossary

In this lesson we covered lambda syntax end to end: the parameter-writing rules, the expression-body/block-body split and when `return` is mandatory, the compiler assigning a lambda a type from context (target typing), the effectively-final restriction and why it exists, and how a lambda differs from an anonymous inner class in terms of `this`. Key points:

- A lambda is, on the spot, an instance of a functional interface (exactly one abstract method) -- it has no type of its own
- Parentheses are mandatory for zero parameters, optional for exactly one, and mandatory again for more than one
- An expression body has no `return` (it's implicit); a block body requires an explicit `return`
- A lambda can only capture local variables that are effectively final (never reassigned)
- `this` inside a lambda refers to the enclosing object -- unlike an anonymous class, a lambda has no `this` of its own

Quick reference:

```
() -> ...                   // no parameters
x -> ...                    // one parameter, no parentheses
(x) -> ...                  // one parameter, with parentheses
(x, y) -> ...               // multiple parameters, parentheses mandatory
x -> x * 2                  // expression body, implicit return
x -> { return x * 2; }      // block body, explicit return mandatory
```

Glossary

Lambda expression — A nameless, short function definition that implements a functional interface's single abstract method.

Functional interface — An interface with exactly one abstract method ("Interface" lesson).

Expression body — A lambda body consisting of a single expression, requiring no `return`.

Block body — A lambda body wrapped in `{ }` that can contain multiple statements, and requires an explicit `return` on every path that produces a value.

Target type — The functional interface type the compiler infers for a lambda from its context (a variable's type, a parameter's type, a return type).

Effectively final — The state of a local variable never having been reassigned after its first assignment; lambdas can only capture variables in this state.