Kotlin Part 3: Functional Programming

CS 346 Application Development

What is functional programming?

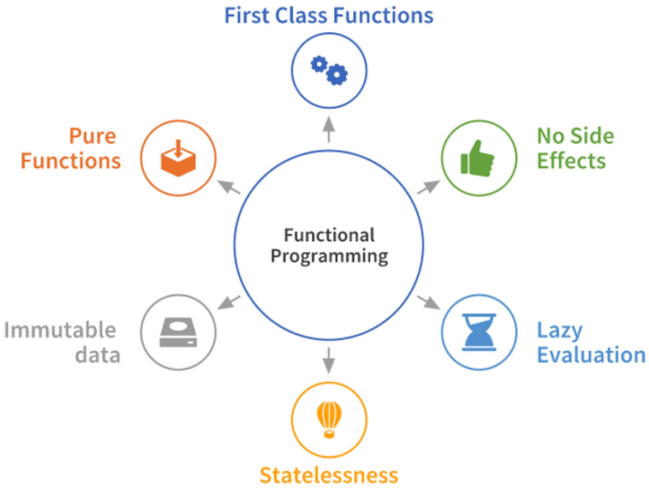
- Functional Programming (FP) is a declarative programming style where *computation is expressed as a series of functions that return values.*
- Complementary to other styles i.e., can co-exist alongside an object-oriented or imperative style.
- There are real benefits:
  - Robustness
  - Expressivity
  - Clarity

Don't worry, we're not bringing back Racket.

First-class functions means that *functions are treated as a type*. We can assign functions to variables, pass them parameters to another function, return functions etc.

- A **higher-order function** is a function that either takes a function as an argument or returns a function

Pure functions are functions that have no side effects. More formally, the return values of a pure function are identical for identical arguments (i.e. they don't depend on any external state for their return value).



The Functional Programming Paradigm.
https://towardsdatascience.com

Immutable data suggests that we do not modify data in-place.
We prefer immutable data that cannot be accidentally changed, especially as a side-effect.

Lazy evaluation means that we only evaluate as expression when we need to operate on it.

Functional Kotlin

Kotlin is a ***hybrid*** language that supports OO, FP and Imperative styles.

- Not a “pure” functional language (but those are rare/challenging).

How can we write Kotlin-style functional code? Simplest way.

- **Avoid unintended mutation and side effects**
  - Use `val` instead of `var`
  - Avoid global variables for carrying program state, as much as you can.
  - Favor pure functions that are free of side-effects i.e. avoid inline modification.
- **First-class functions & pure functions**
  - Explicitly functional expressions and constructs.
  - We’ll spent most of this lecture on this topic!

Function Types

Functions are types in Kotlin, and we can use them anywhere we would expect to use a regular type.

We can:

- assign functions to variables,
- pass functions as arguments to other functions, or
- return a function from a function.

Example is courtesy of Dave Leeds on Kotlin.

Function Types

Bert's Barber shop is creating a program to calculate the cost of a haircut, and they end up with 2 *almost-identical* functions.

```
fun calculateTotalWithFiveDollarDiscount(initialPrice: Double): Double {
  val priceAfterDiscount = initialPrice - 5.0
  val total = priceAfterDiscount * taxMultiplier
  return total
}

fun calculateTotalWithTenPercentDiscount(initialPrice: Double): Double {
  val priceAfterDiscount = initialPrice * 0.9
  val total = priceAfterDiscount * taxMultiplier
  return total
}
```

Identical except for this code.

If we could somehow pass in *that line of code as an argument*, then we could replace both with a single function that looks like this.

- What type do we use here to represent this function?

```
// applyDiscount = initialPrice * 0.9, or
// applyDiscount = initialPrice - 5.0


fun calculateTotal(initialPrice: Double, applyDiscount: ???): Double {
    val priceAfterDiscount = applyDiscount(initialPrice)
    val total = priceAfterDiscount * taxMultiplier
    return total
}
```

Function type?

What is the **type** of this function?

```
// this is the original function signature, for reference
fun discountFiveDollars(price: Double): Double = price - 5.0

// this function accepts a Double and returns a Double.
// we use this format when specifying the type
val discountFiveDollars: (Double) -> Double = { … }
```

Now that we know the type format, we can even assign a variable as a function reference and use it to invoke our function!

```
// get a function reference
fun discountFiveDollars(price: Double): Double = price - 5.0
val applyDiscount = ::discountFiveDollars


// invoke it
val discountedPrice: (Double) -> Double = applyDiscount(20.0) // 15.0

// type inference also works
val discountedPrice = applyDiscount(20.0) // 15.0
```

Our original problem? We can pass one of our functions as a parameter.

```
fun discountFiveDollars(price: Double): Double = price - 5.0 // signatures match
fun discountTenPercent(price: Double): Double = price * 0.9
fun noDiscount(price: Double): Double = price

fun calculateTotal(initialPrice: Double, applyDiscount: (Double) -> Double): Double {
    val priceAfterDiscount = applyDiscount(initialPrice)
    val total = priceAfterDiscount * taxMultiplier
    return total
}

val withFiveDollarsOff = calculateTotal(20.0, ::discountFiveDollars) // $16.35
val withTenPercentOff  = calculateTotal(20.0, ::discountTenPercent)  // $19.62
val fullPrice          = calculateTotal(20.0, ::noDiscount)          // $21.80
```

Return a function from a function

Instead of typing in the *name of the function* each time he calls `calculateTotal()`, Bert would like to just enter the *coupon code* from the bottom of the coupon that he receives from the customer.

To do this, he creates a function that accepts the coupon code and returns the correct discount function.

```
// accepts a String argument, and return a function
fun discountForCouponCode(couponCode: String): (Double) -> Double =
when (couponCode) {
    "FIVE_BUCKS" -> ::discountFiveDollars
    "TAKE_10"    -> ::discountTenPercent
    else         -> ::noDiscount
}
```

Function Literals (Lambdas)

We can use this same notation to express the idea of a **function literal**, or a function as a value.

```
val applyDiscount: (Double) -> Double = { price: Double -> price - 5.0 }
val applyDiscount = { price: Double -> price - 5.0 } // type inferred
```

The code on the RHS of this expression is a **function literal**, which captures the body of this function. We also call this a **lambda**. A lambda is just an anonymous function, written in this form:

- the function is enclosed in curly braces { }
- the parameters are listed, followed by an arrow
- the body comes after the arrow

```
{ price: Double -> price - 5.0 }
```

A lambda expression

The implicit ‘it’

In cases where there’s only a *single parameter* for a lambda, you can *omit the parameter name and the arrow*. When you do this, Kotlin will automatically make the name of the parameter `it`.

Original forms:

- `val applyDiscount: (Double) -> Double = { price: Double -> price - 5.0 }`
- `val applyDiscount = { price: Double -> price - 5.0 } // type inferred`

Shortened forms:

- `val applyDiscount: (Double) -> Double = { it - 5.0 }`

Lambdas as Arguments

We can rewrite our earlier example to use lambdas instead of function references:

```
fun calculateTotal(initialPrice: Double, applyDiscount: (Double) -> Double): Double {
    val priceAfterDiscount = applyDiscount(initialPrice)
    val total = priceAfterDiscount * taxMultiplier
    return total
}
val withFiveDollarsOff = calculateTotal(20.0, { it - 5.0 }) // $16.35
val withTenPercentOff  = calculateTotal(20.0, { it * 0.9 }) // $19.62
val fullPrice          = calculateTotal(20.0, { it })       // $21.80
```

Trailing lambda

In cases where function's *last parameter* is a function type, you can move the lambda argument *outside* of the parentheses to the right, like this:

```
val withFiveDollarsOff = calculateTotal(20.0) { it - 5.0 } // $16.35
val withTenPercentOff  = calculateTotal(20.0) { it * 0.9 } // $19.62
val fullPrice          = calculateTotal(20.0) { it }       // $21.80
```

This is meant to be read as **two arguments**: one parameter inside the brackets, and the lambda as the second parameter, outside the brackets.

This syntax, where the lambda function is placed outside of the brackets, is called a trailing lambda.

Returning lambdas

We can easily modify our earlier function to return a lambda as well.

```
fun discountForCouponCode(couponCode: String): (Double) -> Double =
    when (couponCode) {
        "FIVE_BUCKS" -> { price -> price - 5.0 }
        "TAKE_10"    -> { price -> price * 0.9 }
        else         -> { price -> price }
    }
```

Lambdas & Collections

filter produces a new list of those elements that return true from a predicate function.

```
val list = (1..100).toList()
val filtered = list.filter { it % 5 == 0 } // 5 10 15 20 ... 100
```

map produces a new list that is the results of applying a function to every element.

```
val list = (1..100).toList()
val doubled = list.map { it * 2 } // 2 4 6 8 ... 200
```

reduce accumulates values starting with the first element and applying an operation to each element from left to right.

```
val strings = listOf("a", "b", "c", "d")
val str = strings.reduce { acc, string -> acc + string }) // abcd
```

forEach calls a function for every element in the collection.

```
val fruits = listOf("advocado", "banana", "cantaloupe" )
fruits.forEach { print("$it ") }  // advocado banana cantaloupe
```

take returns a collection containing just the first *n* elements. **drop** returns a new collection with the first *n* elements removed.

```
val list = (1..50)
val first10 = list.take(10) // 1 2 3 ... 10
val last40 = list.drop(10)  // 11 12 13 ... 50
```

first and **last** return those respective elements. **slice** allows us to extract a range of elements into a new collection.

```
val list = (1..50)
val even = list.filter { it % 2 == 0 } // 2 4 6 8 10 ... 50
even.first()     // 2
even.last()      // 50
even.slice(1..3) // 4 6 8
```

Reference

- Leeds. 2025. Dave Leeds on Kotlin. Online.
- Leeds. 2025. **Kotlin: An Illustrated Guide**. TypeAlias Studios LLC. ISBN 979-8992796605.
- JetBrains. 2025. Kotlin Documentation. Online.
- Elizarov, et al. 2024. **Kotlin in Action**. 2nd edition. Manning Publications. ISBN 9781617299605.
- Vermeulen et al. 2021. **Functional Programming with Kotlin**. Manning. ISBN 978-1617297168.