

## Function signature

Kotlin as a language is Java sibling, and it's specially designed by JetBrains for Android development - to make this more pragmatic, especially in terms of the functional aspect of the language, treating functions as a first-class citizens.

Each language has "function" construct - as a block of code (instructions) that for a given inputs (if any) produces some result (if any), or alters the state of the program.  
The signature of the regular function is

```
fun <name> (param1: Param1 ..., paramN : ParamN) : <ReturnType> {  
    // block of the code  
}
```

For a simple function, we can even inline this, without using optional block of the code

```
fun createList(vararg args: Int): List<Int> = args.asList()
```

Well, this is yet another way to mimic in Kotlin already existing standard function - a factory method for List<T>: **listOf(...)**, which is here clumsy used to demonstrate the flexibility of the function declaration in Kotlin.

For the functions that don't return the value, we can just skip it from declaration - or explicitly emphasize it with *Unit* - which has the same meaning as Java/C++ *void*.

## Function templates

As with other similar languages (like Java, and especially the C++), we can also specify the function templates

```
fun <Key, Value> printMap(map: Map<Key, Value>) {  
    for ((key, value) in map) {  
        println("$key, $value")  
    }  
}
```

Do you know the meaning of the **higher-order** function?

This is language independent definition:

*The higher-order functions are the functions that either take other function(s) - callable(s) as argument(s), or return a function.*

This is especially useful for generic programming, where we want to implement *strategy design pattern* - to traversal through the collection - to iterate over the collection and apply the same functionality on each and every element, with one precondition: to satisfy the invocable concept (that has required signature).

In C++ std library, we have the entire <algorithm> written in this way - or to be precise, the entire std library is written following this concept: having the collections detached from the algorithms.

Let's define the custom filter function (like the one in range library), that is a simple wrapper around the **std::copy\_if** function

```
template <typename FwdIterator, typename UnaryPredicate>  
auto filter (FwdIterator first, FwdIterator last, UnaryPredicate p) {  
    using value_type = std::remove_cvref_t<decltype(*first)>;  
  
    std::vector<value_type> out;  
    out.reserve(std::distance(first, last));  
  
    std::copy_if(first, last, std::back_inserter(out), p);  
}
```

```
    return out;
}
```

In Kotlin, we can't have a functions as template parameter - we can't write

```
fun <Func, R> elapsed(f: Func): Pair<R, Long> {
    val start = System.currentTimeMillis()
    val result = f()
    return Pair(result, System.currentTimeMillis() - start)
}
```

We need to explicitly define the callback type

```
inline fun <R> elapsed(f: () -> R): Pair<R, Long> {
    val start = System.currentTimeMillis()
    val result = f()
    return Pair(result, System.currentTimeMillis() - start)
}
```

@note *inline* keyword here is hint to Compiler to inline the higher-order function along with invoking function having it like in-place substitution at the calling site, where the callable will be also inlined, avoiding the calling overhead by creating the anonymous function object on the stack (that is - the same as in C++)

We can pass the function arguments either by *reference*, or as *lambda*

```
fun someFunc() {}
val (result, time) = elapsed(::someFunc) // function reference

// or using the in-place callable - lambda
val (result, time) = elapsed { // lambda trailing syntax
    // block of code
}
```

Similar to Java/C++ the template parameter in Kotlin can be constrained - upper bounded to the base type

```
fun <T : Number> sumList(numbers: List<T>): Double {
    var sum = 0.0
    for(number in numbers) {
        sum += number.toDouble()
    }
    return sum
}
```

But also - it can be lower bound (*super* in Java), through something that is called use-site variance: using "in" keyword

```
fun <T> copy(from: Array<out T>, to: Array<in T>) {
    for (i in from.indices) {
        to[i] = from[i]
    }
}
```

In this example:

- Array<out T> means that the function can accept an array of T or any of its subtypes (covariance).
- Array<in T> means that the function can accept an array of T or any of its supertypes (contravariance).

Unlike C++, Kotlin don't have anything like *variadic template parameters* - parameter pack, which is required to specify the function of the arbitrary signature.

In Kotlin, we have *vararg* as the way to specify a function with arbitrary number of arguments - of the same type. The closest way to get to the parameter pack is to use *Any* type - as super type for all non-null types (like *Object* in Java).

@note The ? beside the Any indicated that the arbitrary type can be a null-type as well

```
fun <R> elapsedAny(f: KFunction<R>, vararg args: Any?): Pair<R, Long> {
    return elapsed { f.call(*args) }
}
```

where the KFunction<R> is the *function interface* that employs the **reflection** mechanism - to determine the function type - signature at the runtime.

The `call` method - inspects whether the implementation of the function interface can be called with the given arguments

## Function membership

In C++ - since historically it is successor of C - we have free-functions, that are declared/defined outside of the class/structure scope.

In pure OOL like Java - the all functions are defined inside the custom type.

Interesting enough - Kotlin support free-functions (Top-Level Functions) as well.

Unlike C++ (before modules) - the ODR (One Definition Rule) issue is resolved in Kotlin (as well in Java) using the *packages* to avoid name conflicts and *import* mechanism at client side, to explicitly specify the package - a namespace from which the functionality will be imported.

## Function visibility

If not other access modifier is specified - the default visibility for functions, as well for custom types and properties, is *public*.

That would mean - the function can be addressed from anywhere in the code.

On the other hand, *private* access modifier denotes the function which is visible only within the file or class where it's defined.

Similar to other OO languages, *protected* would mean accessible only to base (*open*) class and its derived subclasses - it's not applicable to free-functions.

There is Kotlin-specific *internal* visibility that refers to the accessibility within the Android module (app module, or, usually encapsulated within the same library module - to prevent name collisions of APIs from different modules).

## Suspendable vs Non-suspendable Function

This is story about the **coroutines**.

It's - as you can imagine, quite complex topic - so I'll try to simplify it.

Similar to the C++, the Kotlin coroutines are stackless - in C++ it means that

there is a *promise\_type* interface that needs to be implemented by the coroutine return type - that will be allocated on the heap, to track the coroutine suspension/resume transitions - it's basically a state-machine.

(more on that: [https://github.com/damirlj/modern\\_cpp\\_tutorials/blob/main/docs/C%2B%2B20/Coroutines.pdf](https://github.com/damirlj/modern_cpp_tutorials/blob/main/docs/C%2B%2B20/Coroutines.pdf))

In Kotlin, the coroutines are fairly simpler to use - without so many boilerplate code to implement.

To mark the function as the one that **has suspension point**: that can be suspend and resumed - there is a reserved word *suspend* to be used

@note It's similar to *co\_await* and awaitable interface in C++

Let's rewrite our elapsed time measurement - to work for both - regular and suspend functions

```
private suspend fun <R> elapsed(f: suspend () ->R): Pair<R, Long> {
    val start = System.currentTimeMillis()
    val result = f() // suspension point
    return Pair(result, System.currentTimeMillis() - start)
}
```

@note In background - the compiler will create the Continuation object - to keep track about the state of the suspend function

The key components of the coroutines in Kotlin are:

- ❑ **CoroutineScope** class as a lifecycle manager of the coroutine
- ❑ **CoroutineContext** to define the *Dispatcher* - Scheduler (Default, IO, etc.), along some other thread attributes (name): as a thread context (actually, a thread pool) that will host the coroutine. There is a Job object as well - for handling the lifetime of the coroutine.

There are some predefined factory methods (builders) - for creating the coroutines on the fly

- **runBlocking** - factory method that creates coroutine that will block the calling thread, until the suspend function is not resumed. It's used to bridge the non-suspending (regular) function with the suspending one - providing the coroutine scope for its execution

- **lunch** - coroutine's factory method that returns the Job - a lifetime object of the coroutine on which one can join - wait on coroutine completion, cancel it (all pending jobs) - or even query the state of the coroutine (similar to *std::jthread* in C++).  
It can be used also in non-blocking way, without joining on completion - but rather detached from the calling thread - as fire-and-forget coroutine
- **async** - factory method that creates deferred coroutine: returns *Deferred<T>* object - that can be lazily invoked: awaited on the result of the coroutine (similar to the *std::async* in C++)

```
/**
 * For measuring the elapsed time of a synchronous function.
 * It will be turned into blocking call - waiting on the function to be
 * executed within the coroutine context
 */
fun <R> func_elapsed(f: () ->R): Pair<R, Long> {
    val result : Pair<R, Long>
    runBlocking { // CoroutineScope
        result = elapsed(f) // elapsed() itself as suspension point
    }
    return result
}
```

Source code:

[https://github.com/damirli/modern\\_cpp\\_tutorials/tree/main/src/Kotlin/src/main/java/com/example/practice\\_kotlin](https://github.com/damirli/modern_cpp_tutorials/tree/main/src/Kotlin/src/main/java/com/example/practice_kotlin)

Unit test:

[https://github.com/damirli/modern\\_cpp\\_tutorials/blob/main/src/Kotlin/src/test/java/com/example/practice\\_kotlin/coroutines/TestCoroutines.kt](https://github.com/damirli/modern_cpp_tutorials/blob/main/src/Kotlin/src/test/java/com/example/practice_kotlin/coroutines/TestCoroutines.kt)

## Links

#Scope functions: <https://kotlinlang.org/docs/scope-functions.html>