Kotlin

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Introduction

What is Kotlin?

Kotlin is a programming language developed by JetBrains, the creators of the IntelliJ Java IDE.

Why should I use Kotlin?

Kotlin is many things:

It is cross platform. Kotlin's current compilation targets are:

- JVM bytecode

- JavaScript

- Native binaries via LLVM:

  - iOS (arm32, arm64)

  - macOS (x86_64)

  - watchOS (x86_64, arm32, arm64)

  - tvOS (x86_64, arm64)

  - Android (x86, x86_64, arm32, arm64)

  - Windows (MinGW x86_64, x86)

  - Linux (x86_64, arm32, MIPS, RPi)

  - WebAssembly (wasm32)

It is multi-paradigm. Kotlin supports a mix of functional and object-oriented programming to achieve maximum productivity.

Its expansive standard library provides hundreds of utilities, ranging from basic helpers to entire suites of functions that, in order to work properly in other, less-flexible languages, would have had to be fully-fledged language features; the previous sentence may or may not be a not-so-subtle jab at C# and LINQ.

It is flexible. Kotlin is a great fit for domain-specific languages (DSLs) and has great support for being used as an embedded scripting language — in fact, the Gradle buildscript used to create this document was itself written in Kotlin.

How do I write Kotlin?

Language idioms

Kotlin was originally developed as a JVM language, and has thus been considerably influenced by the Java world. While this means that some fragments of may be translated line-by-line into Kotlin, this often does not result in optimal Kotlin code.

Take the following example:

```java
final var person = ...;

if (person != null) {
    final var addresses = person.getAddresses();
    if (addresses != null && !addresses.isEmpty()) {
        final var firstAddress = addresses.get(0);
        if (firstAddress != null) {
            final var street = firstAddress.getStreet();
            if (street != null) {
                final var streetName = street.getName();
                if (streetName != null) {
                    ...
                }
            }
        }
    }
}
```

One might argue that this Java antipattern is obsolete, due to the advent of Java 8 and its Optional utility class. Let us give this sample a more modern twist:

```java
final var person = ...;

Optional.ofNullable(person)
        .flatMap(Person::getAddresses)
        .flatMap(as -> as.stream().findFirst())
        .flatMap(Address::getStreet)
        .flatMap(Street::getName)
        .ifPresent(streetName -> {
            ...
        });
```

While this is much more concise, consider the overhead of wrapping every value that *may or may not* have a value with an extra object that:

- must be allocated on the stack (or heap)

- incurs a runtime performance penalty for each of the chained method calls

- results in code that is non-trivial to read

Not only is this be an unnecessarily complex approach to handling Tony Hoare's billion-dollar mistake, there exist *core language features* in Kotlin designed to avoid this problem entirely:

```kotlin
val person = ...

person?.addresses?.firstOrNull()?.street?.name?.let {
    ...
}
```

In short: to write proper, idiomatic Kotlin, you will *need* to ignore your instincts and find new approaches to solving problems. Pretending to write Kotlin when you are doing nothing more than translating the Java you *would've* written will not result in good code.

IntelliJ's built-in Java-to-Kotlin converter (*Ctrl+Alt+Shift+K*) is often a good start; its conversions are relatively decent due to the IDE's advanced static analysis capabilities. However, one should not rely solely on this tool — it will often produce suboptimal (or even invalid) code.

Kotlin ABCs

Kotlin fundamentals

Kotlin is fundamentally an object-oriented language. This, along with the constraints imposed by the JVM, means that classes and data will be structured in much the same way as in Java, C++, or any other object-oriented language.

Kotlin's primary advantage to developers is that it manages to be extremely expressive while remaining fairly short; for example, Kotlin code is completely semicolon-free!

Files

Unlike many other languages, the Kotlin compiler has the additional concept of a "file". Whereas all symbols in Java or C# must either be or be contained in *classes*, Kotlin allows properties and functions to be declared at the *top level*:

```kotlin
class Test {}

val foo = "This is a top-level property"
fun thisIsATopLevelFunction() {}
```

Top-level symbols are placed in the current package's scope, unless they are `private` — private top-level symbols are only visible within the same file. They can be imported with `[package-name].[symbol-name]`, similarly to classes:

```kotlin
// File A
package a

val foo = "This is a top-level property"

// File B
package b
import a.foo

fun main() = println(foo) // "This is a top-level property"
```

Kotlin files typically have the extension `.kt`.

The Kotlin compiler, `kotlinc`, supports dynamic execution of *Kotlin scripts*. Kotlin scripts have the extension `.kts` and do not require a `main` function; top-level statements are allowed and executed.

You can download `kotlinc`'s binaries here. If you prefer package managers, you can also install it with `pacman` (Arch Linux), Homebrew (macOS/Linux), Snappy (primarily Ubuntu), or Chocolatey (Windows).

`kotlinc` isn't necessary to compile or run Kotlin code, though. JetBrains' IntelliJ IDEA, unsurprisingly, has first-class Kotlin support built in to the IDE. An easy way to play around with Kotlin is to create a `.kts` *scratch file* (*Ctrl+Alt+Shift+Insert*). If you want to create a full Kotlin project, you can easily do so by using JetBrains' Kotlin Maven archetype or by selecting "Kotlin/JVM" in the Gradle project creation dialog.

While there exists an equivalent plugin for Eclipse, it unfortunately tends to be updated quite infrequently, is prone to bugs, and is usually out of date.

new

Kotlin does not have a `new` operator. Constructors are called using standard function-call syntax:

```kotlin
val person = Person("Test", "Testerson")
```

> **NOTE** This is a nice time-saver, and is consistent with C++ syntax — `new` is used to allocate dynamic memory, call a constructor, and return a pointer; or to otherwise create the object on the stack and return an rvalue. As there is no real functional distinction between heap- and stack-allocated values on the JVM, since one generally does not have to deal with pointers, there is no reason to keep the keyword.

?

? is an integral part of Kotlin's type system; ? designates a type as *nullable*:

```
val foo1: String  = "bar"  // ok
val foo2: String? = "bar"  // ok
val foo1: String  = null   // ERROR
val foo2: String? = null   // ok
```

Non-nullable types cannot have the value null assigned to them! This is one of Kotlin's advantages — it is extremely difficult to write proper Kotlin code that throws a NullPointerException.

Nullable types come with their own useful utilities.

?., the *safe call* operator, can be used to perform operations on nullable values. If the value is null, it performs the operation; otherwise, it too returns null. This is useful for chaining methods on values that may be null:

```
val input: String? = readLine()
val enteredInt =
    input            // String?
    ?.trim()         // String? -> String?
    ?.toIntOrNull()  // String? -> Int?

if (enteredInt == null) println("You did not enter an integer")
```

The Elvis operator (?:, try turning it 90° clockwise) is frequently used as the last element in a ?. chain to return a fallback value. The result of an ?: expression returns the left operand if it is not null; otherwise, it returns the right operand.

This is equivalent to the ?? operator in C#.

```
val envvar: String? = System.getProperty("FOO")
val displayValue: String = envvar ?: "No value found" // Not nullable!

if (enteredInt == null) println("The value of FOO is: $displayValue")
```

If you *really* need to force the compiler to dereference a nullable value, the !! operator can be used for this purpose:

```
val maybeFoo: Foo? = retrieveMaybeFoo()
val foo = maybeFoo!!
```

	Note that this will throw an exception if the value is indeed `null`. Unless you are dealing with complex scenarios (e.g. reflection) where you can be *absolutely sure* that a value will not be null, **never** use this operator. There is always a better way to solve nullability issues.
CAUTION	

TODO nullableutil

Unit

Kotlin, like many functional languages, does not have the concept of "no return type"; every function must return a value. So how do we deal with `void` methods?

Kotlin represents the unit type as Unit. This is equivalent to `()` in Rust or Haskell, and `Unit` in Swift. `Unit` is a singleton value that holds no information, making it a perfect choice for methods that return nothing. It is automatically returned from blocks of code that do not contain a `return` expression:

```
val value = run {}
println(value) // kotlin.Unit
```

It also plays extremely well with generics! Previously, to create a `void` Callable in Java, one would have to specify the type parameter as `void`'s peculiar wrapper type, Void, and then manually return `null` from the implementation of the `call` method:

```
new Callable<Void>() {
    Void call() {
        foo();
        return null;
    }
}
```

This is redundant! Since there exist no valid instances of Void, there is no use in returning any sort of value. Furthermore, the client of this API would need to know to discard the returned value.

Fortunately, since `Unit` is implicitly returned, all we need to do in Kotlin is:

```
Callable<Unit> { foo() }
```

This also enables function chains returning `Unit` to compose nicely.

Nothing

While Nothing as a type is fundamentally similar to `Void`, they are extremely different in terms of usage.

A function returning `Nothing` will never return. This is primarily used for functions that will always throw exceptions (i.e. exception helpers), or that will loop forever. All statements following an expression that returns `Nothing` will never execute:

```
fun throwDataException(error: String): Nothing {
    throw DataException("SQL error: $error")
}

try {
    doDatabaseStuff()
} catch(e: SQLException) {
    throwDataException(e.message)
    foo() // Warning: unreachable code
}
```

This is used quite effectively in the standard library by the utility function TODO, often used during development to mark sections of code that are not implemented and should throw an error.

```
if (foo()) {
    handleFoo()
} else {
    // Not done with this yet
    TODO("handleNotFoo()")
    //^ NotImplementedError: "An operation is not implemented:
handleNotFoo()"
}
```

> **TIP**   Since `Nothing` cannot hold a value, and `T?` is a union between `T` and `null`, the type `Nothing?` can be used to hold a value that is always null.

Any

`Any` is Kotlin's equivalent to Object — it is the implicit base class for all types. It is functionally equivalent to `Object`, except that most of its methods have been removed:

- clone

  - Implement `Cloneable` instead, if you *really* need `clone`.

- finalize

- wait, notify, notifyAll

  - Use of these methods has been discouraged for years — Kotlin has simplified things by removing them outright.

- getClass

  - This method has been replaced by the `::class` operator.

If you need to use any of `Object`'s methods, you can force the compiler to make them visible by casting an object to `Object`:

```
val foo = ...
(foo as java.lang.Object).notify()
```

Kotlin's type hierarchy
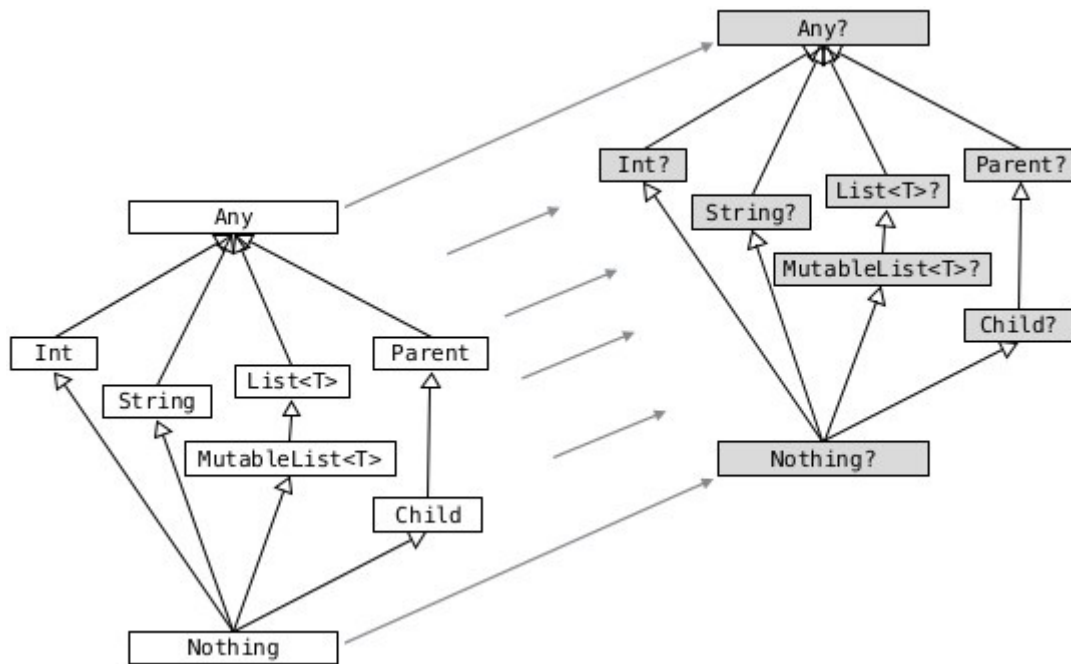
The base type for all other types in Kotlin is `Any`. All nullable types are subtypes of their respective non-nullable types. This is important since it allows nullable types to hold a regular, non-null value.

`Nothing`, the type discussed earlier, is at the bottom of the type hierarchy; it is considered a subtype of every other type, meaning that a variable of type `Nothing` cannot be implicitly assigned to.

The only expressions in Kotlin that return `Nothing` are:

- `return`

- `throw`

- `continue`

- `break`

Yes, `return` returns a value! This allows us to extremely easily handle precondition failures, and is a very common Kotlin idiom:

```kotlin
fun login(user: User): Boolean {
    val username = user.name ?: return false // User has no name, don't
try to log in
    val token = doLogin(user) ?: throw LoginException("Could not log
in")
    return true // Success
}
```

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In this case, `?:` will either return the preceding value or execute the right-hand expression, forcing the function to return prematurely without too much boilerplate code. This can also be used with `continue` or `return` to prematurely end the loop body.

Of course, this allows us to write meaningless code:

```
return return throw return throw throw return return throw return
```

While the compiler will warn that each of the expressions (except the last) is unreachable, this is valid code. It should be obvious that code like this is nevertheless meaningless and should never be written.

Statements and expressions

Generally, *expressions* are snippets of code that have a *value*. Statements, on the other hand, do not necessarily have any sort of resulting value.

Apart from declarations and assignments, everything in Kotlin is an expression:

```kotlin
val password = readLine()
val output = when (password) {
    "hunter2" -> "Authenticated!"
    else -> "Hacker detected!"
}
```

Even an `if` statement returns a value:

```kotlin
println(
    if (room.isSmoking) "This is a smoking room"
    else "This is a no-smoking room"
)
```

This is incredibly versatile, since it is possible to place multiple statements within the `if` statement's block — every *block* in Kotlin also returns a value! The result of the last statement in a block implicitly becomes the result of the block itself. If the last statement is not an expression, it returns `Unit` instead:

```
val value = run {
    val foo = 40
    foo + 2
}
print(value) // 42
```

Unlike in most other C-like languages, assignments are not expressions. This means many classic sources of programmer error can be eliminated:

```
_Bool ok = doSomething(...);
if (ok = true) { // = instead of ==, this will always get executed!
    printf("Success\n");
} else {
    // This will never get executed!
    printf("An error occured\n");
    abort();
}
```

Visibility modifiers

Kotlin has the following visibility modifiers:

- public

- internal

- protected

- private

public, protected and private members identically to how they work in Java and C++. private *top-level symbols* are visible everywhere in the same file.

> **TIP** Top-level symbols cannot be protected, as this would not make any sense — they do not have anything to do with inheritance.

Unlike Java, Kotlin does not have package-private (default) access. It replaces this with internal access, which makes a symbol visible to all other classes *in the same module.* Files outside a project (i.e. in other modules) will not be able to access an internal symbol.

Hello, world!

As with any other programming language, to write an executable program we need an entry point. A Kotlin program's entry point is a top-level function called `main`. As many programs do not make use of command-line arguments, the `args` parameter is optional. This means a "hello world" program could look something like:

```kotlin
fun main(args: Array<String>) {
    println("Hello, world!")
}
```

or

```kotlin
fun main() {
    println("Hello, world!")
}
```

Our golfing opportunities don't end here, though. In the interest of enabling terse, functional programming, there exists a shorter syntax for functions that consist of and return a single expression:

```kotlin
fun main() = println("Hello, world!")
```

Basic types

"Primitives"

Kotlin provides Java's eight primitive types as built-in classes:

- `kotlin.Byte` — 8-bit signed integer
- `kotlin.Short` — 16-bit signed integer
- `kotlin.Int` — 32-bit signed integer

- `kotlin.Long` — 64-bit signed integer

- `kotlin.Float` — 32-bit IEEE 754 floating-point

- `kotlin.Double` — 64-bit IEEE 754 floating-point

- `kotlin.Boolean` — true/false

- `kotlin.Char` — 16-bit Unicode character (**not** a numeric type!)

In addition to these types, Kotlin also provides four *unsigned integer* types:

- `kotlin.UByte` — 8-bit unsigned integer

- `kotlin.UShort` — 16-bit unsigned integer

- `kotlin.UInt` — 32-bit unsigned integer

- `kotlin.ULong` — 64-bit unsigned integer

The format of numeric literals in Kotlin is almost identical to that of Java; octal literals have been removed.

```
val one = 1 // Int
val threeBillion = 3000000000 // Long
val oneLong = 1L // Long
val oneByte: Byte = 1
val creditCardNumber = 1234_5678_9012_3456L
val hexBytes = 0xFF_EC_DE_5E
val bytes = 0b11010010_01101001_10010100_10010010
val bool = true
val char = 'A'
val uint = 20U // UInt
val ulong = 9082348590UL // ULong
val pi = 3.14 // Double
val e = 2.7182818284 // Double
val eFloat = 2.7182818284f // Float
```

[1]

	Everything in Kotlin is a class! There are no primitive types; the
TIP	compiler will automatically deal with boxing/unboxing for you, making
	working with generics a breeze.

Values of the built-in types cannot be converted between each other implicitly, since in other languages this is a common cause of error or loss of precision. To do so one

must use the built-in `toXXX` functions:

```kotlin
val char = 'A'
val double: Double = char * 2 // ERROR
val double: Double = char.toDouble() * 2 // ok
```

> **TIP**
> Often, this is not necessary because the standard arithmetic operators have overloads for most appropriate conversions [2]. For example, adding a `Long` and an `Int` will compile without any conversions, and will result in a `Long` value.

The conversion functions are compiler intrinsics and thus do not introduce any function call overhead.

Arrays

Arrays in Kotlin are represented by the generic `kotlin.Array<T>` class. For performance reasons, primitive arrays have their own specialized types. These map directly to the respective primitive array type (i.e. `IntArray = int[]`).

Kotlin does not have array literals (they exist, but are only allowed in annotations); to create an array you can use the built-in `arrayOf` function:

```kotlin
val strings: Array<String> = arrayOf("Hello", "world")
val ints: IntArray = intArrayOf(1, 2, 3)
```

Strings

Strings are defined using double quotes.

String templates (also known as string interpolation) are the recommended way to concatenate values with a string:

```kotlin
val foo = 3
println("The value of foo is $foo") // "The value of foo is 3"
println("Half of foo is ${foo / 2}") // "Half of foo is 1"
```

[3]

Multi-line (raw) strings, which unfortunately didn't make it into JDK 13, can be defined using triple quotes:

```kotlin
val text = """
foo
bar
"""
```

> **NOTE** Multi-line strings do not support escape characters. If you need to escape a $ in a raw string, you can replace it with ${'$'}.

To achieve nicer indentation, you can add a margin and trim it:

```kotlin
val text = """
    foo
    bar
""".trimIndent()
```

> **NOTE** Don't worry about performance when using trimIndent — this function is actually a compiler intrinsic.

Collections

The base class of all collections in Kotlin is Collection<T>. Unlike Java, Kotlin's collections provide no mutating operations:

```kotlin
val list: List<Int> = ArrayList<Int>()
list.add(3) // ERROR: List has no add method
```

Only Collection's subtype, MutableCollection, allows the object to be mutated. The same applies to all of the built-in collection types.

Similarly to arrays, you can create collections using the builder functions xxxOf:

```kotlin
val unmodifiableList = listOf(1, 2, 3)
val modifiableList = mutableListOf(1, 2, 3)
val arrayList = arrayListOf(1, 2, 3)
val hashMap = hashMapOf("key" to "value", "hello" to "world") // Takes
a list of Pair<,>s
val set = setOf(1, 2, 3, 2) // {1, 2, 3}
```

The syntax `"key" to "value"` makes use of the infix function `to`, which takes two values and constructs a `Pair` from them. You could also have written `hashMapOf(Pair("key", "value"), Pair("hello", "world"))`, but it wouldn't have been as readable.

Classes and objects: Data handling

The basic types in Kotlin are identical to those found in Java and C#.

We have:

- (`abstract`) `class`es

- `interface`s

- `enum class`es

  - Analogous to `enum`s in Java; this construct is rare in other languages.

- `annotation class`es

  - Analogous to `@interface`s in Java and `Attribute`s in C#.

Unlike Java, where interfaces have only recently gained support for default implementations, Kotlin permits this for any JVM target level using bytecode magic.

Primary and secondary constructors

Before discussing classes in Kotlin, it is important to understand how constructors work. There are two types of constructors in Kotlin: *primary* and *secondary* constructors.

This is the basic structure of a class in Kotlin:

```kotlin
class Foo constructor(bar: String) {
    constructor(baz: Int) { ... }
    ...
}
```

A constructor in Kotlin is declared with the keyword `constructor`, followed by the list of parameters.

The constructor immediately following the type name, *if present*, is called the *primary constructor*. Unlike a secondary constructor, a primary constructor **does not** have a body. Any initialization logic must be wrapped in an `init` block. The parameters of this constructor are visible for all property initializers:

```
class Person constructor(birthYear: Int) {
    val age: Int
    val birthYearMinusOne = birthYear - 1 // birthYear is in scope
here!

    init {
        // Do some extra work here
        age = 2019 - birthYear
    }

    fun foo() {
        println(birthYear) // ERROR: construction has finished,
parameters are no longer available
    }
}
```

Additionally, the `constructor` keyword may be omitted *for the primary constructor only*. It is only required if you wish to apply an access modifier or annotation to the primary constructor:

```
@Component
class MyService @Autowired internal constructor(...)
```

What makes the primary constructor so powerful is that **it can have properties as parameters**. It is no longer necessary to repeat `this.field = field;` for every single constructor parameter!

```
class Person(var name: String, private var ssn: String)
```

This is all the code necessary to create a class with two properties, their respective getters/setters, and the proper constructor!

> **TIP** Notice that the class or constructor body (`{}`) can be omitted when it is empty; this is another useful quality-of-life feature.

If a primary constructor is present, all secondary constructors are required to *chain*

to it, either directly or through another secondary constructor. This is useful if you wish to have a convenience constructor with different parameters that can be easily converted to the desired type:

```kotlin
class Timestamp(val instant: Instant) {
    constructor(ldt: LocalDateTime)
        : this(ldt.toInstant(ZoneOffset.UTC))
    constructor() {
        // ERROR: not chained to primary constructor!
        doSomethingElse()
    }
}
```

objects

In addition to these types, Kotlin introduces a new type of class called the `object`. More commonly known as *singletons*, `object`s only can have one global instance for the whole lifetime of a program — this behavior is identical to that of standard singletons and of `static` globals in C/C++. What makes `object`s really stand out, however, is that they require no boilerplate code to implement and are thus free from programmer error. Since they are normal classes, they can implement interfaces, and their instance can be passed around like a normal value.

This means that something like

```java
public interface Bar {
    String baz();
}

// Typical Java singleton
public enum Foo implements Bar {
    INSTANCE {
        @Override String baz() {
            return "Hello, world!";
        }
    }
}

public class Program {
    public static void doSomething(Bar bar) {
        System.out.println(bar.baz());
    }
    public static void main(String[] args) {
        doSomething(Foo.INSTANCE); // Unnecessary qualification :(
    }
}
```

would become

```kotlin
interface Bar {
    fun baz(): String
}

object Foo : Bar {
    override fun baz() = "Hello, world!"
}

fun doSomething(bar: Bar) {
    println(bar.baz())
}

fun main() = doSomething(Foo) // The type name itself refers to the instance!
```

Kotlin and `static`

This leads us to another important point: *Kotlin does not have the concept of* `static`. The optimal replacement for static utility classes is either a set of top-level functions or an `object`. This is mostly up to your own taste, but typically depends on whether the utility conceptually belongs *at the package level*, or if they should be further grouped according to a certain criterion.

This means that something like

```java
public class LzmaUtils {
    private LzmaUtils() {}
    public static void decompressStream(InputStream input) { ... }
}
```

would become

```kotlin
package myapp // These utilities may not belong at the top level

object LzmaUtils {
    fun decompressStream(input: InputStream) { ... }
}
```

or, alternatively, simply:

```kotlin
package myapp.lzma // This is an appropriate package for these
utilities

fun decompressStream(input: InputStream) { ... }
```

While it is ultimately up to the user to decide, creating top-level symbols is usually considered more idiomatic.

companion objects

What if one wants to mix static functions and instance methods within a single class? This is often not an indicator of good design choices — if you can, think about making these into (private) top-level functions instead.

This is possible, however, using companion objects:

```kotlin
class Person {
    var name = "Gagagegg" // Instance property

    companion object {
        fun createPerson(): Person = Person()
    }
}

...

Person.createPerson() // Person(name="Gagagegg")
```

A companion object is essentially an embedded `object` with the same name as a class: it is accessed using the enclosing class's name, can implement interfaces or abstract classes, and is treated as a value. This effectively removes the "non-object-orientedness" of static methods from the language, making it truly object-oriented.

Companion objects can be used to remove the need for boilerplate code. The most common application of this is in logging frameworks:

```kotlin
abstract class LoggerCompanion {
    val LOGGER = ...
}

class MyApplication {
    private companion object : LoggerCompanion()

    fun foo() {
        LOGGER.log("Hello, world!")
    }
}
```

All properties and functions of the companion object are pulled into the enclosing class's scope.

data classes

Data classes are one of Kotlin's most loved features. If you need to store complex objects in memory and have all of the boilerplate abstracted away, they are the feature for you.

Data classes:

- must have a primary constructor with one or more parameters

- must have a primary constructor with no non-property parameters

- **should** generally be immutable

- cannot be inherited from

In most ways they behave identically to regular classes, except that `equals`, `toString` and `hashCode` *are automatically generated*!

```kotlin
data class Student(val name: String, val id: String, val graduation:
Year)
```

This single line of code will generate a `Student` class with a proper implementation of all of the following:

- constructors

- `getName`, `getId`, `getGraduation`

- `equals`, `hashCode`, `toString`

- `copy`

`copy` is automatically generated for all data classes and allows the user to construct an exact copy of the specified object, with the specified changes:

```kotlin
val john = Student("John", "1234", Year.of(2020))
val jane = john.copy(name = "Jane", id = "5678")
```

Thanks to `copy`, there is often no to make data classes mutable — new, modified instances can be created easily. Immutability comes with a large amount of benefits, including the elimination of defensive copying; data classes should generally be made immutable.

> **NOTE** It may be worth mentioning that Java is adopting this syntax in JDK 14, for its proposed records feature! While this is a preview feature and may not necessarily make it into the full release, this is impressive progress.

Nesting

Classes can be nested in Kotlin.

CAUTION	Unlike in Java, to comply with scope rules, outer classes cannot access private members of inner classes!

Nested classes

This is equivalent to `static` classes in Java; the class is placed in the scope of the enclosing class and can access its private members, but is otherwise unrelated to it.

Inner classes

This is equivalent to normal nested classes in Java. Inner classes hold a reference to an instance of the outer class. In Kotlin, an inner class is denoted by the `inner` keyword:

```kotlin
class Outer {
    inner class Inner
}
```

Labels

To access the outer class instance, use `this@Outer`. Whereas in Java you would use `Outer.this`, Kotlin uses *labels* to accomplish this.

```kotlin
class Outer {
    fun foo() {
        println("Outer")
    }

    inner class Inner {
        fun foo() {
            println("Inner")
        }

        fun bar() {
            this@Outer.foo() // "Outer"
            this.foo() // "Inner"
        }
    }

    class Nested {
        fun bar() {
            this@Outer.foo() // ERROR: this is not an inner class,
                             // so it has no Outer instance!
        }
    }
}
```

Type aliases

Type aliases are often used to shorten long generic type names, or to alias function types.

```kotlin
typealias EventHandler = (EventData, String, Any) -> Boolean
typealias HandlerList = List<EventHandler>

val handlers: HandlerList // Instead of List<(EventData, String, Any)
-> Boolean>
```

Like C's `typedef` and C++'s `using`, typealiases are equivalent to and interchangeable with their aliased types.

```kotlin
typealias Id = String
fun retrieveId(): Id

val id: String = retrieveId() // ok
```

This is a good alternative to defining functional interfaces. Since Kotlin already has built-in function types, one can simply write

```
typealias Predicate<T> = (T) -> Boolean
```

instead of

```
@FunctionalInterface
interface Predicate<T> {
    boolean test(T t);
}
```

Functions and properties

Functions

Kotlin functions are declared using `fun`:

```
fun functionName(params): Type {...}
```

Parameters, along with all other values in Kotlin, are defined using *Pascal notation*. Parameters can also have *default arguments*, which helps to reduce the need for overloads.

```
fun makePurchase(amount: Int = 1) {
    ...
}
```

If no return type is specified, it is inferred to be `Unit`. Similarly, if a `return` statement is made with no value, it will implicitly return `Unit`:

```
fun foo() { // Equivalent to fun foo(): Unit
    return // return Unit
}
```

If no return statement is present in the body of a function, and the function is specified to return `Unit`, it is implicitly returned.

If a function's body consists of a single expression, you can make use of a special, shorter syntax:

```
override fun toString() = "..."
```

Single-expression functions can have their return types omitted; they will be inferred from the expression.

Variadic arguments

A parameter can accept an arbitrary number of arguments if it is annotated by `varargs`:

```
fun takeLotsOfStrings(vararg strings: String) {
    for (string in strings) println(string)
}
```

Within the function, `varargs` parameters are treated as arrays and can be used as such.

To pass the contents of an array to a `varargs` parameter, you can use the *spread operator* *:

```
val strings = arrayOf("Hello", "world")
// The spread operator can even interleave varargs parameters!
takeLotsOfStrings("Something", *strings, "else")
```

> **CAUTION** No more than one parameter per function can be `varargs`.

Named arguments

When invoking a function, parameters can be referred to by name. This is helpful when invoking a function with multiple default parameter values:

```kotlin
fun joinToString(
    strings: Iterable<String>,
    separator: CharSequence = ", ",
    prefix: CharSequence = "",
    postfix: CharSequence = "",
    limit: Int = -1,
    truncated: CharSequence = "...",
    transform: ((T) -> CharSequence)? = null
): String { ... }

...

joinToString(listOf("Hello", "world"), separator = "; ", truncated = "
(more)")
```

If named arguments had not been used, redundant values for all intermediate parameters would have had to have been specified.

Properties

Kotlin, like Swift, has no concept of *fields*. All instance attributes are automatically encapsulated in properties.

Properties may be backed by fields internally; this is the default. They may also have custom accessors.

The syntax for defining a property is:

```kotlin
[var/val] name: Type = [initialValue]
    get
    set
```

This notation, where the type follows the name, is called *Pascal notation*.

var properties are *mutable*; they have getters and setters, whereas val properties only have getters. By default, the getter and setter can be omitted, unless you wish to apply an access modifier or annotation to it.

```kotlin
var property: Any? = null
    @Inject internal set
```

Getters and setters may also have bodies, as in C#:

```
var fullName: String
    get() {
        return "$first $last"
    }
    set(value) {
        val split = value.split(" ")
        first = split[0]
        last = split.skip(1).joinToString(" ")
    }
```

If the body of a getter or setter contains a single expression, the braces may be omitted similarly to functions:

```
val fullName: String
    get() = "$first $last"
```

The type of the property may usually be omitted; it will be automatically inferred from its getter or initial value.

```
// These are equivalent:
val foo: Int = 3
val foo = 3
```

Backing fields

Within the body of a field-backed property's getter or setter, a **magic variable** called `field` is accessible. This is a mutable reference to the property's backing field, and can be used to easily add additional logic to a property setter.

Without `lateinit`, the property would have to be declared as nullable because its initial value is `null`; every operation on it would either have to make use of the `!!` operator or use unnecessary `?.` chaining.

```
var positiveInt: Int = 1
    get
    set(value) {
        if (value > 0) field = value
    }
```

`lateinit` properties

The `lateinit` modifier allows a property or local variable of a non-nullable type to initially have no value. This is especially useful for classes that do not have their fields initialized at construction time; Android activities, test fixtures, or Spring services are common examples.

```
@Test
class FooServiceTest {
    lateinit var fooService: FooService

    @BeforeClass
    fun init() {
        this.fooService = ...
    }
}
```

Nesting

Local functions and classes

Classes and functions can be declared *locally*, that is, within other functions:

```
fun foo() {
    fun bar() {
        ...
    }
    class Quux

    bar()
}

fun baz() {
    bar() // ERROR
    Quux::class // ERROR
}
```

This is an invaluable tool — the scope of symbols should be restricted as much as possible, and if a certain subroutine or data class is only needed within a function, it is a great idea to make them local to that function.

Classes, functions, properties, and inheritance

Kotlin classes, functions and properties are `final` by default. They can be made virtual by adding the `open` modifier:

```
open class Foo // This class can be extended!
```

Abstract classes and functions do not need to be declared as `open`, as this would defeat their purpose.

Inheritance

To extend a class, add it after the type name using the C++-style extension syntax:

```
class Derived : Base
```

The base class must be initialized in the class header:

```
abstract class Base

class Derived : Base() // Primary constructor is called
```

Alternatively, if the base class has no primary constructor, its secondary

constructors can chain to `super`:

```
class Derived : Base {
    constructor() : super()
}
```

This ensures that the superclass constructor has finished by the time the subclass's initializers run.

abstract **and** override

Functions and properties can also be `abstract` members of abstract classes and interfaces. Interface functions are implicitly `abstract`. Default implementations for interface functions are easy to specify — just give the function a body:

```
interface Comparer<T1, T2> {
    fun compare(a: T1, b: T2): Boolean {
        return true // Default implementation always returns true
    }
}
```

To override a function or property, declare it in the subtype using the `override` modifier.

To override a member and prevent further overriding, declare it as `final`, like in C++:

```kotlin
interface A {
    // `abstract` is implied, since this is an interface
    fun foo()
    val bar: String
}

open class B : A {
    final override fun foo()
    override val bar get() = "Baz"
}

class C : B {
    override fun foo() // ERROR
    override val bar get() = "Quux" // ok
}
```

TIP | `override` can even be used on primary constructor property parameters! This is especially useful for use with data classes.

Explicit `super`

If a class inherits the same member from multiple supertypes, it must provide its own implementation to avoid the diamond problem: [4]

```kotlin
open class Rectangle {
    open fun draw() { ... }
}

interface Polygon {
    fun draw() { ... } // Default implementation
}

class Square : Rectangle(), Polygon {
    // The compiler requires draw to be overridden:
    override fun draw() {
        super<Rectangle>.draw() // call to Rectangle.draw
        super<Polygon>.draw() // call to Polygon.draw
    }
}
```

Function objects

Kotlin treats functions as first-class language citizens; they can be stored in variables and passed around. To accomplish this, Kotlin uses *function types*:

```kotlin
val intConsumer: (Int) -> Unit = fun(int: Int) {
    println(int)
}
```

There is a shorter, more concise syntax for creating an anonymous function — the *lambda expression.*

```kotlin
val intConsumer: (Int) -> Unit = { int ->
    println(int)
}
```

Kotlin lambdas are entirely contained within {}; like in Swift, the parameters are declared within the body itself:

```
{
    arg1, ... ->
    [lambda body]
    [last statement]
}
```

[5]

The value of the last expression of a lambda is implicitly returned.

NOTE	If a lambda has only one parameter, the parameter list can be left out; the parameter receives the special name it.

CAUTION	Avoid using implicit parameter names with nested lambdas — it quickly becomes unclear just *which* it is being referred to.

Lambdas as function parameters

Lambdas can be passed to functions as parameters. There are many functions in the standard library which accept lambda expressions; most of their charm comes from the fact that *the last argument, if it is a lambda expression, can be placed outside of the function call.*

This might not sound like much at first, but this:

```kotlin
val list = listOf(1, 2, 3)
list.forEach({
    println(it)
})
```

becomes

```kotlin
val list = listOf(1, 2, 3)
list.forEach {
    println(it)
}
```

This is what helps many of Kotlin's standard library functions fit into the language so well—they *look* like they could be built-in language features, but they are really just normal, convenient functions.

A great example of this is repeat:

```kotlin
// For loop
for (i in 0 until 7) {
    foo()
}

// `repeat`
repeat(7) {
    foo()
}
```

repeat is much more readable, and the intent of the code becomes much clearer at no additional cost.

Inlining lambdas

Functions can be declared as inline—this means that they will not be compiled to an actual function; their code will simply be pasted into the call site wherever it is used. The usefulness of this feature becomes apparent when it is combined with lambdas. Literal lambdas passed to inline methods will also become inlined:

```
inline fun run(block: () -> Unit) {
    block()
}

run { println("Hello, world!") }
```

is compiled to simply

```
println("Hello, world!")
```

This removes the entire object overhead of lambda expressions, and allows useful functional utilities to be built.

NOTE	Most standard-library functions that affect control flow (i.e. `repeat`, `forEach`, `map`, etc.) are inlined and thus incur no performance penalties!

NOTE	If you need a lambda to remain in "object form" and not be inlined into an inline function (e.g. if you need to store it in a list), you can annotate the parameter as `noinline`.

NOTE	If an inlined lambda needs to be cross-inlined into *another* inline function (e.g. this inline function calls another one), you must annotate the parameter as `crossinline`.

CAUTION	Because inline lambdas are inserted directly into the call site, `return`ing from them may have unexpected behavior!

```
fun loopList() {
    list.forEach { item ->
        if (item == 3) return // This will return from the ENTIRE function,
                              // not just from the lambda!
    }
}
```

This is called a non-local return, which is often seen in standard loops. It is important to mean that `return` has no meaning within a lambda and always affects

the enclosing function scope. It is advisable to avoid using `return` within a lambda unless necessary.

`reified` **generics**

Inline functions can be used to provide compile-time reified generics.

Since the functions are inlined, they have access to generic type data:

```kotlin
inline fun <reified T> checkType(any: Any): Boolean {
    return any is T // This would not work in Java,
                    // or in a non-inline function!
}
```

This allows `is`, `as`, and `::class` to be safely used on generic type parameters.

Anonymous objects

Objects of an anonymous type can be created using `object` literals.

```kotlin
val runnable = object : Runnable {
    override fun run() {
        foo()
    }
}
```

However, when using SAM (single-abstract-method) interfaces that are defined in Java code, this is unnecessary, because Kotlin will automatically create helper constructors for these interfaces to allow for a nicer syntax. This is called *SAM conversion*:

```kotlin
val runnable = Runnable {
    foo()
}
```

Additionally, anonymous objects that do not extend any class can be created. This is similar to C#'s `new {}`.

```kotlin
val list = listOf(3)
val mapped = list.map { int ->
    object {
        val value = int
    }
}

for (item in mapped) {
    println(item.value)
}
```

While the type cannot be referred to by name, it is available to the compiler and can thus be used within the same scope. Since anonymous objects have no proper type, they cannot be returned from methods.

> **TIP** It is often better to use local data classes instead of untyped anonymous objects, as they are named and they more clearly express the intent of the code.

```kotlin
fun foo() {
    data class TempData(...) // Local data class!
}
```

[1] https://kotlinlang.org/docs/reference/basic-types.html

[2] https://kotlinlang.org/docs/reference/basic-types.html#explicit-conversions

[3] This is somehow the context for my second-most popular StackOverflow answer: https://stackoverflow.com/a/48800990

[4] https://kotlinlang.org/docs/reference/classes.html#overriding-rules

[5] This is largely paraphrased from my StackOverflow answer here.

Advanced topics

As this paper is primarily an introduction to the Kotlin language itself, it does not include certain advanced use-cases.

The following is a list of incredibly useful language features and links to their references.

- The standard library

  - Kotlin has an immense standard library, which is best learned through experience. Often, searching for an implementation of a complex utility function will reveal that it already exists in the `stdlib`.

- Reflection

  - Kotlin has its own advanced reflection system — however, its complexities and gotchas are too great to discuss in an introductory paper.

- Coroutines (`suspend` functions)

  - Enables safe, structured, asynchronous programming without much need for synchronization

- Kotlin/Native

  - Compiles Kotlin to native binaries — this is *very* experimental.

- Multiplatform projects (Gradle only)

  - Builds projects for multiple platforms (JVM, JS, Native) using a single common project

Additional resources

In addition to the contents of this paper, a set of official Kotlin koans can be found online at play.kotlinlang.org. These are a set of small Kotlin examples to get you used to the language and assist the learning process.

Additionally, Kotlin's extensive reference is an extremely helpful resource, even for veteran Kotlin developers. It goes into great detail about most, if not all, important parts of the language itself.