Creating Classes

We'll cover the following

Kotlin differs quite a bit from Java in how classes are defined. Writing classes in Java involves so much boilerplate code. To alleviate the pain of typing all that, programmers rely a lot on IDEs to generate code. Good news, you don't need to type as much. Bad news, you'll have to wade through all that code each day. Kotlin moves the code generation from the IDE to the compiler—kudos for that, especially for a language created by the company that makes the best IDEs in the world.

The syntax for creating a class in Kotlin is closer to the facilities in Scala than in Java. The number of options and flexibilities seem almost endless; let's start small and grow the code for creating a class incrementally.

The smallest class

Here's the minimum syntax for a `class`—the class keyword followed by the name of the class:

```
// empty.kts
```

```
class Car
```

We didn't provide any properties, state, or behavior for this class, so it's only fair that it does nothing useful.

Read-only properties

Let's define a property in the class:

```
// property.kts
class Car(val yearOfMake: Int)
```

We made a few design decisions right there in that highly concise syntax. We wrote a constructor to take an integer parameter and initialize a read-only property named `yearOfMake` of type `Int`—yep, all that in one line. The Kotlin compiler wrote a constructor, defined a field, and added a getter to retrieve the value of that field.

Let's take a closer look at the class definition. That line is a shortcut for this:

```
public class Car public constructor(public val yearOfMake: Int)
```

By default, the access to the class and its members is public and the constructor is public as well. In Kotlin, the line that defines the class is actually defining the primary constructor. The keyword `constructor` isn't needed unless we want to change the access modifier or place an annotation for the primary constructor.

Creating instances

Let's use the class to create an instance. New in Kotlin, related to creating objects, is there's no `new` keyword. To create an object use the class name like it's a function:

```
// property.kts
val car = Car(2019)
println(car.yearOfMake) //2019
```

The immutable variable `car` holds a reference to a `Car` instance created by calling the constructor with the value `2019`. The property `yearOfMake` is accessible directly on the instance `car`. Efforts to modify it will run into issues, like so:

```
car.yearOfMake = 2019 //ERROR: val cannot be reassigned
```

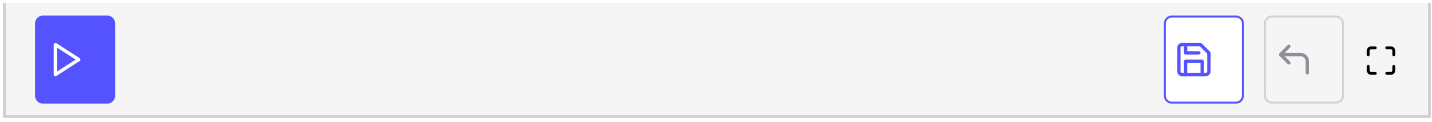
Much like `val` local variables, `val` properties are immutable too.

Read-write properties

You can design a property to be mutable if you like:

```
class Car(val yearOfMake: Int, var color: String)

val car = Car(2019, "Red")
car.color = "Green"
println(car.color) //GREEN
```



readwrite.kts

The newly added property `color` of type `String` is initialized with the constructor. But, unlike `yearOfMake`, we may change the value of `color` anytime on an instance of `Car`.

Use `val` to define read-only properties and `var` for properties that may change.

A peek under the hood—fields and properties

In the previous example, `yearOfMake` and `color` seem like fields rather than properties to my Java eyes. However, those are properties and not fields. Kotlin doesn't expose fields of classes.

When you call `car.yearOfMake`, you're actually calling `car.getYearOfMake()`—the good old JavaBean convention is honored by the compiler. To prove this, let's examine the bytecode generated by the Kotlin compiler.

First, write the class `Car` in a separate file named `Car.kt`:

```
// Car.kt
class Car(val yearOfMake: Int, var color: String)
```

Next, compile the code and take a look at the bytecode using the `javap` tool, by running these commands:

```
kotlinc-jvm Car.kt
```

```
javap -p Car.class
```

Here the excerpt of the bytecode generated by the Kotlin Compiler for the `Car` class is:

```
Compiled from "Car.kt"
public final class Car {
  private final int yearOfMake;
  private java.lang.String color;
  public final int getYearOfMake();
  public final java.lang.String getColor();
  public final void setColor(java.lang.String);
  public Car(int, java.lang.String);
}
```

That concise one line of Kotlin code for the `Car` class resulted in the creation of two fields—the backing fields for properties, a constructor, two getters, and a setter. Nice.

Let's confirm that when using the object we're not directly accessing the fields. For this, create a file `UseCar.kt` with the following code:

```
fun useCarObject(): Pair<Int, String> {
  val car = Car(2019, "Red")

  val year = car.yearOfMake

  car.color = "Green"

  val color = car.color

  return year to color
}
```

UseCar.kt

Let's compile using the following commands and take a look at the bytecode generated:

```
kotlinc-jvm Car.kt UseCar.kt
javap -c UseCarKt.class
```

The formatted excerpt from the output that follows shows that we're not accessing the fields directly; the code follows the JavaBean convention and doesn't breach encapsulation.

```
//...

7: ldc           #12                 // String Red
       9: invokespecial #16                  // Method Car."<init>":(ILjava/lan
g/String;)V
      12: astore_0
      13: aload_0
      14: invokevirtual #20                  // Method Car.getYearOfMake:()I
      17: istore_1
      18: aload_0
      19: ldc           #22                 // String Green
      21: invokevirtual #26                  // Method Car.setColor:(Ljava/lan
g/String;)V
      24: aload_0
      25: invokevirtual #30                  // Method Car.getColor:()Ljava/lan
g/String;

//...
```

In Kotlin you access properties by providing the name of the property instead of the getter or setter.

Controlling changes to properties

In our `Car` class, `yearOfMake` is immutable but `color` is mutable. Immutability is safe, but uncontrolled change to a mutable property is unsettling. Kotlin will prevent someone changing or setting `color` to `null` since it's a `String` and not `String?` type—that is, it's not a nullable reference type. But what if someone sets it to an empty `string?` Let's fix the class to prevent that. Along the way we'll add another property to the class, but this one won't be given a value through the constructor.

```
class Car(val yearOfMake: Int, theColor: String) {
  var fuelLevel = 100

  var color = theColor
    set(value) {
      if (value.isBlank()) {
        throw RuntimeException("no empty, please")
      }

      field = value
    }
}
```

setter.kts

To reiterate, in Kotlin you never define fields—backing fields are synthesized automatically, but only when necessary. If you define a field with both a custom getter and custom setter and don't use the backing field using the `field` keyword, then no backing field is created. If you write only a getter or a setter for a property, then a backing field is synthesized.

In our constructor we defined one property, `yearOfMake`, and one parameter, not field, named `theColor`—we didn't place `val` or `var` for this parameter. If you really wanted to call this `color`, you could have done that as well.

Within the class, we created a property named `fuelLevel` and initialized it to a value of `100`. Its type is inferred to be `Int` by the compiler. This property isn't being set using any parameter of the constructor.

Then we created a property named `color` and assigned it to the value in the constructor parameter `theColor`. If we had called the constructor parameter `color` instead of `theColor`, then this line would have read like this:

```
var color = color
```

But named `thecolor`, it reads as follows:

```
var color = theColor
```

Using the same name for a property and a parameter is like the practice in Java where the `this.color = color` syntax is used for assignment, but if it's confusing, use different names for properties and parameters.

Kotlin will synthesize a getter and a setter for the `fuelLevel` property. For the `color` property it will only synthesize a getter, but use the setter provided in code. The setter throws an exception if the value given for the property is empty. You may call the parameter something other than `value` if you like. Also, you may specify the type for the parameter of `set` if you desire, but in this case the compiler knows the type, based on the type of the property initialization. If the given value is acceptable, then assign it to the field which is referenced by a special keyword `field`. Since Kotlin synthesizes fields internally, it doesn't give access to that name in code. You may refer to it using the keyword `field` only within getters and setters for that field.

and setters for that field.

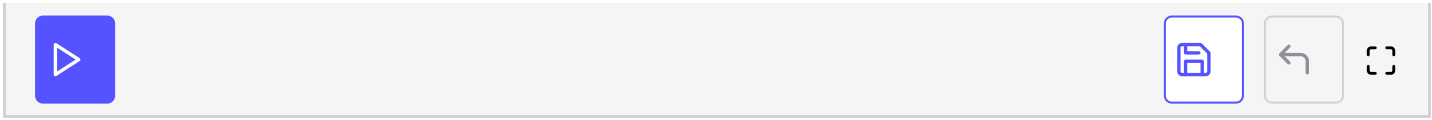
Let's use the modified class to access the fields.

```
val car = Car(2019, "Red")
car.color = "Green"
car.fuelLevel--

println(car.fuelLevel) //99

try {
    car.color = ""
} catch(ex: Exception) {
    println(ex.message) //no empty, please
}

println(car.color) //Green
```



setter.kts

No issue arose to change `fuelLevel` or to set `color` to "Green". But the attempt to change `color` to an empty string failed with a runtime exception. Following Kotlin convention, we got the details of the exception from the message property instead of using the `getMessage()` method of the Exception class. In the last line we verify that the `color` property is the same as what was set before the `try` expression.

Access modifiers

The properties and methods of a class are public by default in Kotlin. The possible access modifiers are: `public`, `private`, `protected`, and `internal`. The first two have the same meaning as in Java. The protected modifier gives permission to the methods of the derived class to access that property. The `internal` modifier gives permission for any code in the same module to access the property or method, where a module is defined as all source code files that are compiled together. The `internal` modifier doesn't have a direct bytecode representation. It's handled by the Kotlin compiler using some naming conventions without posing any runtime overhead.

The access permission for the getter is the same as that for the property. You may provide a different access permission for the setter if you like. Let's change the access modifier for `fuelLevel` so that it can be accessed from only within the class.

```
// privatesetter.kts
var fuelLevel = 100
```

```
  private set
```

To make the setter private, simply place the keyword `private` before the keyword `set`. If you don't have an implementation to provide for the setter, then leave out the parameter `value` and the body. If you don't write a setter, or if you don't specify the access modifier for the setter, then its permission is the same as that of the property.

Initialization code

The primary constructor declaration is part of the first line. Parameters and properties are defined in the parameter list for the constructor. Properties not passed through the constructor parameters may also be defined within the class. If the code to initialize the object is more complex than merely setting values, then we may need to write the body for the constructor. Kotlin provides a special space for that.

A class may have zero or more `init` blocks. These blocks are executed as part of the primary constructor execution. The order of execution of the `init` blocks is top-down. Within an `init` block you may access only properties that are already defined above the block. Since the properties and parameters declared in the primary constructor are visible throughout the class, any `init` block within the class can use them. But to use a property defined within the class, you'll have to write the `init` block after the said property's definition.

Just because we can define multiple `init` blocks doesn't mean we should. Within your class, first declare your properties at the top, then write one `init` block, but only if needed, and then implement the secondary constructors (again only if needed), and finally create any methods you may need.

If you're curious to see an `init` block, here's one to set the value of the `fuelLevel` based on the `yearOfMake` property.

```
class Car(val yearOfMake: Int, theColor: String) {
  var fuelLevel = 100
    private set

  var color = theColor
    set(value) {
      if (value.isBlank()) {
        throw RuntimeException("no empty, please")
      }
```

```
      field = value
    }

  init {
    if (yearOfMake < 2020) { fuelLevel = 90 }
  }
}
```

initialization.kts

Within the `init` block we change the value of `fuelLevel` based on the value of `yearOfMake`. Since this requires access to `fuelLevel`, it can't be earlier than the declaration of `fuelLevel`.

You may wonder if, instead of the `init` block, could we have accomplished the task at the location of `fuelLevel` definition? Sure thing—you may remove the above init block entirely and write the following:

```
var fuelLevel = if (yearOfMake < 2020) 90 else 100
  private set
```

Don't write more than one `init` block, and avoid it if you can. The less work we do in constructors, the better from the program safety and also performance point of view.

Secondary constructors

If you don't write a primary constructor, then Kotlin creates a no-argument default constructor. If your primary constructor has default arguments for all parameters, then Kotlin creates a no-argument constructor in addition to the primary constructor. In any case, you may create more constructors, called secondary constructors.

Your secondary constructors are required to either call the primary constructor or call one of the other secondary constructors. Also, secondary constructors' parameters can't be decorated with `val` or `var`; they don't define any properties. Only the primary constructor and declarations within the class may define properties.

Let's define a few constructors for a Person class.

```
class Person(val first: String, val last: String) {
  var fulltime = true
  var location: String = "-"
```

```
  constructor(first: String, last: String, fte: Boolean): this(first, last) {
    fulltime = fte
  }

  constructor(
    first: String, last: String, loc: String): this(first, last, false) {
    location = loc
  }

  override fun toString() = "$first $last $fulltime $location"
}
```

secondary.kts

The primary constructor for `Person` defines two properties, `first` and `last`, through the two parameters annotated as `val`. The keyword `constructor` is optional here. The two secondary constructors are declared using the keyword `constructor`. The first secondary constructor calls the primary constructor, referring to it using `this`. Within the body, this secondary constructor initializes one of the fields. The second secondary constructor calls the first secondary constructor. It could have instead called the primary constructor.

Any secondary constructor may call either the primary constructor or any of the other secondary constructors, as long as the call doesn't fall into a cyclic chain that leads up to the constructor being defined.

Let's verify this class works by creating a few instances to use the different constructors:

```
println(Person("Jane", "Doe"))         //Jane Doe true -
println(Person("John", "Doe", false))  //John Doe false -
println(Person("Baby", "Doe", "home")) //Baby Doe false home
```

secondary.kts

From the caller point of view, whether they're using the primary constructor or one of the secondary constructors makes no difference—they keep their focus on creating an object with the desired parameters.

Defining instance methods

Define methods in classes using the `fun` keyword. By default methods are `public`, but you may mark them as `private`, `protected`, or `internal` before the `fun`

but you may mark them as `private`, `protected`, or `internal` before the `fun` keyword if you want to change the access permission.

Here's a `fullName()` method, marked `internal`, and a `private` method `yearsOfService()` in the `Person` class:

```
class Person(val first: String, val last: String) {
  //...

  internal fun fullName() = "$last, $first"

  private fun yearsOfService(): Int =
    throw RuntimeException("Not implemented yet")
}
```

methods.kts

The methods within a class are defined much like top-level functions, except they appear within the class body `{}`. The methods have access to the properties and other methods of the class, just like in Java. You may also use `this` to refer to the instance or the receiver on which the instance method is being executed.

Any effort to access a method that's not accessible—`private` for example—will result in an error. For instance, in the previous code, the `yearsOfService()` method isn't visible outside the class, and any effort to access it will result in a compilation error:

```
val jane = Person("Jane", "Doe")
println(jane.fullName()) //Doe, Jane
//jane.yearsOfService() //ERROR: cannot access...private in 'Person'
```

methods.kts

Kotlin classes have the same semantics as classes written in Java, but the language has a special feature to erase classes at compile time—let's explore that next.

Inline classes

Classes represent abstractions, and so do primitive types. During design, sometimes we debate between using a class or using a primitive type. For example, should Social Security Number, or any other form of government issued identification, be represented using an `SSN` class or merely a `String`. Creating a class gives the distinctive advantage of clarity. We wouldn't be able to accidentally

pass an arbitrary string, like “John Doe”, where `SSN` is expected. But if all that it

represents is a `String` in reality, that overhead of wrapping a string inside of an object of `SSN` may be overkill and may result in poor performance—more overhead of object creating and memory usage. `inline` classes, which are experimental in Kotlin at the time of this writing, strike a great balance. You get the benefit of classes at compile time but you get the benefits of using a primitive at runtime—the class is transformed into a primitive in the bytecode.

Calls to `inline` functions—which we discuss in Inlining Functions with Lambdas—are replaced with their body, and thus they don’t incur the overhead of a function call. Likewise, `inline` classes are expanded or replaced by their underlying member where they are used.

For example, in the following code we mark the class `SSN` as `inline`:

```
inline class SSN(val id: String)

fun receiveSSN(ssn: SSN) {
  println("Received $ssn")
}
```

ssn.kts

If the code is compiled with the `-XXLanguage:+InlineClasses` command-line option, to indicate that we’re using an experimental feature, then the function `receiveSSN()` will be compiled to receive a `String` instead of an instance of `SSN`. When invoking, however, the Kotlin compiler will verify that the `receiveSSN()` function is invoked with an instance of `SSN` and not a raw string, like so:

```
receiveSSN(SSN("111-11-1111"))
```

Once the compiler verifies that an instance of `SSN` is passed to `receiveSSN()`, it will unwrap the embedded instance of `String` and pass that directly to `receiveSSN()`, thus removing the wrapper and any potential overhead both in terms of memory and object creation.

`inline` classes may have properties and methods and may implement interfaces as well. Under the hood, methods will be rewritten as `static` methods that receive the primitive types that are being wrapped by the `inline` class. inline classes are required to be `final` and aren’t allowed to extend from other classes.

QUIZ

1

What type of constructor is shown in the following code snippet?

```
constructor(
    first: String, second: String, third: String): this(first, se
cond, true) {
    // code...
  }
```

2

Which class gets transformed into a primitive type at runtime?

3

Which variable exhibits the read-write property in the following initialization

Which variable exhibits the read-write property in the following initialization of a class?

```
class Person(val var1: Int, var var2: String)
```

Retake Quiz

Creating classes with properties and instance methods is straightforward. In Java we're used to `static` methods too, but you can't simply place the `static` keyword before the keyword `fun` in Kotlin. Kotlin provides companion objects for creating class members, as explained in the next lesson.