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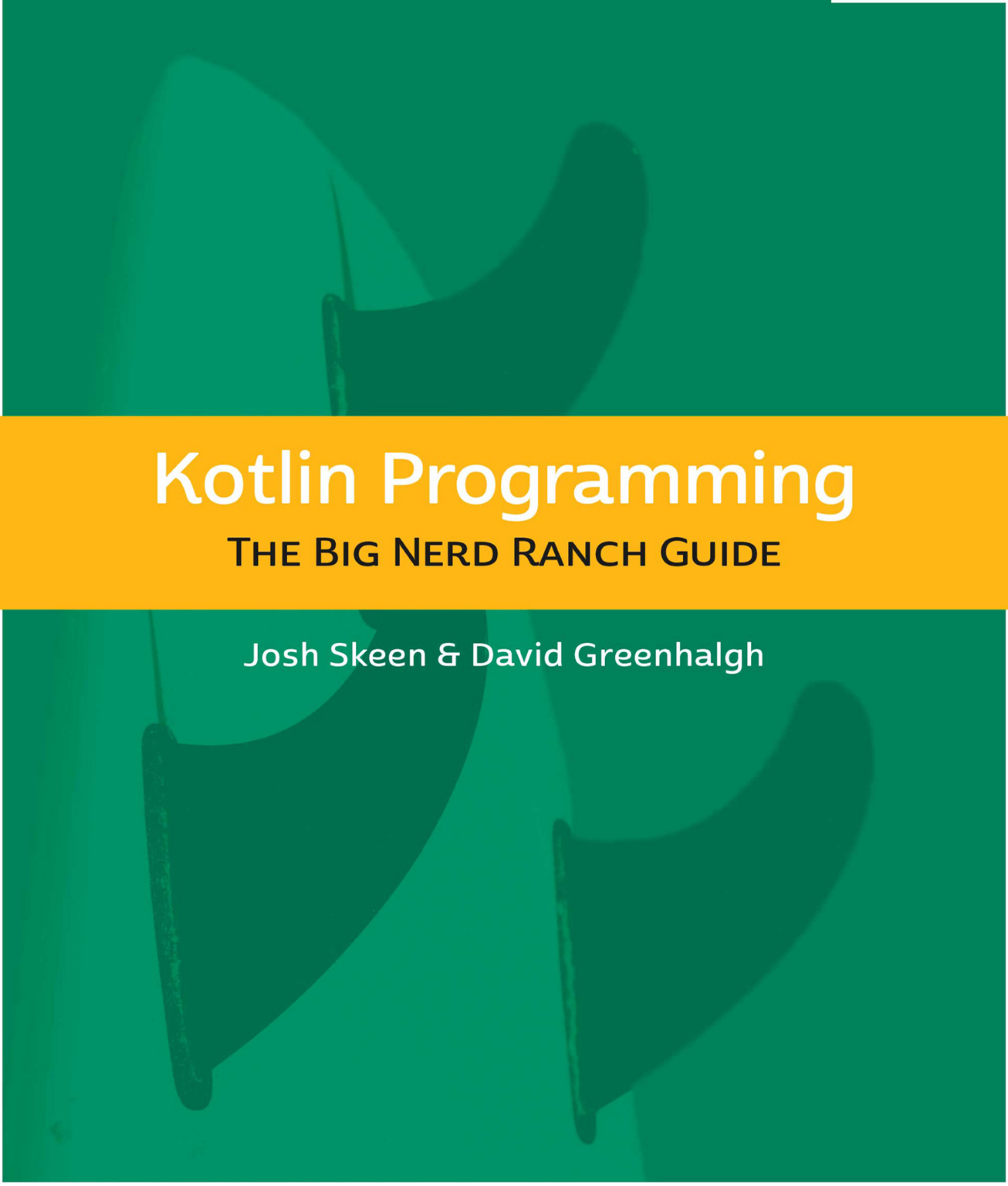

Kotlin Programming

THE BIG NERD RANCH GUIDE

Josh Skeen & David Greenhalgh

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Kotlin Programming: The Big Nerd Ranch Guide

by Josh Skeen and David Greenhalgh

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Dedication

For Baker, the best little bug.

— J.S.

To Rebecca, a driven, patient, beautiful woman, and the reason that this book came to be. To Mom and Dad, for valuing education above all else.

— D.G.

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Introducing Kotlin

In 2011, JetBrains announced the development of the Kotlin programming language, an alternative to writing code in languages like Java or Scala to run on the Java Virtual Machine. Six years later, Google announced that Kotlin would be an officially supported development path for the Android operating system.

Kotlin's scope quickly grew from a language with a bright future into the language powering applications on the world's foremost mobile operating system. Today, large companies like Google, Uber, Netflix, Capital One, Amazon, and more have embraced Kotlin for its many advantages, including its concise syntax, modern features, and seamless interoperability with legacy Java code.

Why Kotlin?

To understand the appeal of Kotlin, you first need to understand the role of Java in the modern software development landscape. The two languages are closely tied, because Kotlin code is most often written for the Java Virtual Machine.

Java is a robust and time-tested language and has been one of the most commonly written languages in production codebases for years. However, since Java was released in 1995, much has been learned about what makes for a good programming language. Java is missing the many advancements that developers working with more modern languages enjoy.

Kotlin benefits from the learning gained as some design decisions made in Java (and other languages, like Scala) have aged poorly. It has evolved beyond what was possible with older languages and has corrected what was painful about them. You will learn more in the coming chapters about how Kotlin improves on Java and offers a more reliable development experience.

And Kotlin is not just a better language to write code to run on the Java Virtual Machine. It is a multiplatform language that aims to be general purpose: Kotlin can be used to write native macOS and Windows applications, JavaScript applications, and, of course, Android applications. Platform independence means that Kotlin has a wide variety of uses.

Who Is This Book For?

We have written this book for developers of all kinds: experienced Android developers who want modern features beyond what Java offers, server-side developers interested in learning about Kotlin's features, and newer developers looking to venture into a high-performance compiled language.

Android support might be why you are reading this book, but the book is not limited to Kotlin programming for Android. In fact, except in one advanced chapter, Chapter 21, all the Kotlin code in this book is agnostic to the Android framework. That said, if you are interested in using Kotlin for Android application development, this book shows off some common patterns that make writing Android apps a breeze in Kotlin.

Although Kotlin has been influenced by a number of other languages, you do not need to know the ins and outs of any other language to learn Kotlin. From time to time, we will discuss the Java code equivalent for Kotlin code you have written. If you have Java experience, this will help you understand the relationship between the two languages. If you do not know Java, seeing how another language tackles the same problems can help you grasp the principles that have shaped Kotlin's development.

How to Use This Book

This book is not a reference guide. Our goal is to guide you through the most important parts of the Kotlin programming language. You will be working through example projects, building knowledge as you progress. To get the most out of this book, we recommend that you type out the examples in the book as you read along. Working through the projects will help build muscle memory and will give you something to carry on from one chapter to the next.

Also, each chapter builds on the topics presented in the last, so we recommend that you do not jump around. Even if you feel that you are familiar with a topic in other languages, we suggest that you read straight through – Kotlin handles many problems in unique ways. You will begin with introductory topics like variables and lists, work your way through object-oriented and functional programming techniques, and understand along the way what makes Kotlin such a powerful language. By the end of the book, you will have built your knowledge of Kotlin from that of a beginner to a more advanced developer.

Having said that, do take your time: Branch out, use the Kotlin reference at `kotlinlang.org/docs/reference` to follow up on anything that piqued your curiosity, and experiment.

For the More Curious

Most of the chapters in this book have a section or two titled "For the More Curious." Many of these sections illuminate the underlying mechanisms of the Kotlin language. The examples in the chapters do not depend on the information in these sections, but they provide additional information that you may find interesting or helpful.

Challenges

Most chapters end with one or more challenges. These are additional problems to solve that are designed to further your understanding of Kotlin. We encourage you to give them a try to enhance your Kotlin mastery.

Typographical conventions

As you build the projects in this book, we will guide you by introducing a topic and then showing how to apply your new-found knowledge. For clarity, we stick to the following typographical conventions.

Variables, values, and types are shown with fixed-width font. Class, function, and interface names are given bold font.

All code listings are shown in fixed-width font. If you are to type some code in a code listing, that code is denoted in bold. If you are to delete some code in a code listing, that code is struck through. In the following example, you are being instructed to delete the line defining variable `y` and to add a variable called `z`:

~~~
var x = "Python"
~~var y = "Java"~~
**var z = "Kotlin"**
~~~

Kotlin is a relatively young language, so many coding conventions are still being figured out. Over time, you will likely develop your own style, but we tend to adhere to JetBrains' and Google's Kotlin style guides:

- JetBrains' coding conventions: `kotlinlang.org/docs/reference/coding-conventions.html`
- Google's style guide, including conventions for Android code and interoperability: `android.github.io/kotlin-guides/style.html`

Looking Forward

Take your time with the examples in this book. Once you get the hang of Kotlin's syntax, we think that you will find the development process to be clear, pragmatic, and fluid. Until then, keep at it; learning a new language can be quite rewarding.

1

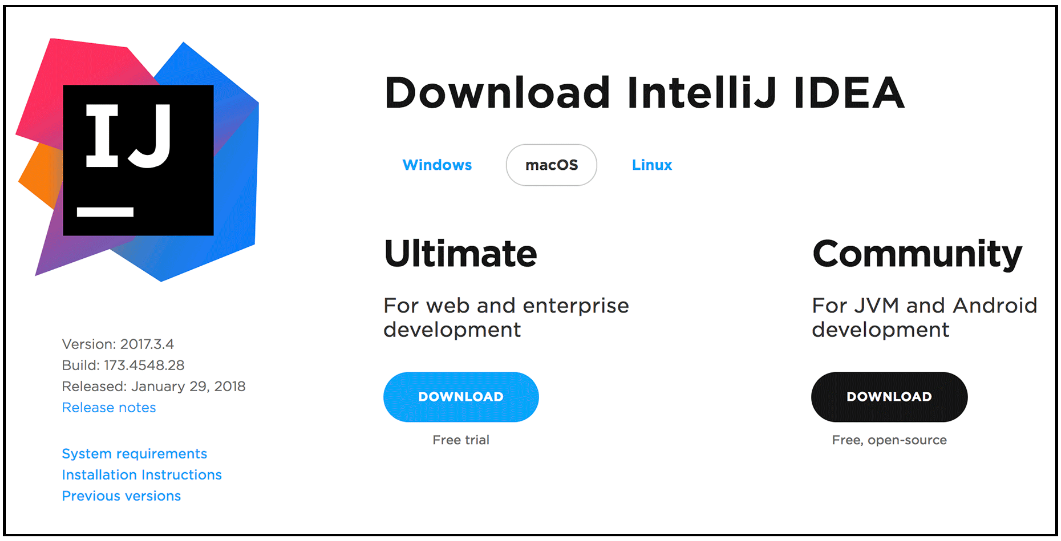
Your First Kotlin Application

In this chapter you will write your first Kotlin program, using IntelliJ IDEA. While completing this programming rite of passage, you will familiarize yourself with your development environment, create a new Kotlin project, write and run Kotlin code, and inspect the resulting output. The project you create in this chapter will serve as a sandbox to easily try out new concepts you will encounter throughout this book.

Installing IntelliJ IDEA

IntelliJ IDEA is an integrated development environment (IDE) for Kotlin created by JetBrains (which also created the Kotlin language). To get started, download the IntelliJ IDEA Community Edition from the JetBrains website at `jetbrains.com/idea/download` (Figure 1.1).

Figure 1.1 Downloading IntelliJ IDEA Community Edition



Once it has downloaded, follow the installation instructions for your platform as described on the JetBrains installation and setup page at `jetbrains.com/help/idea/install-and-set-up-product.html`.

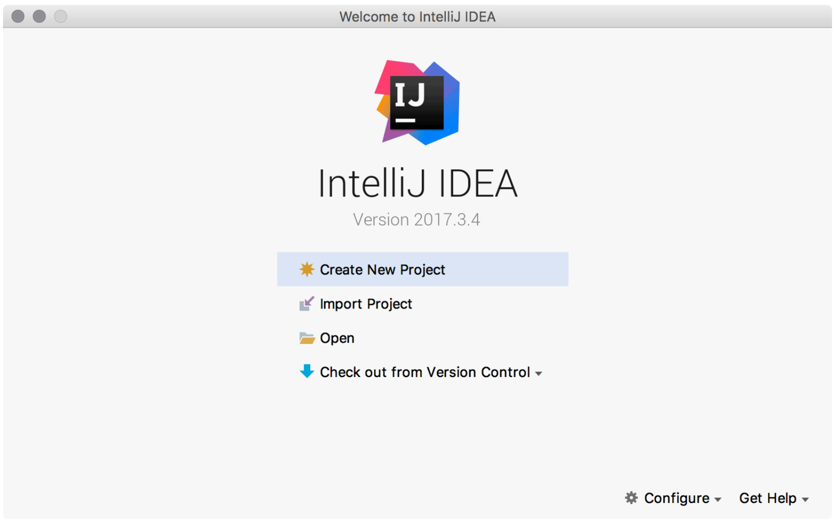
IntelliJ IDEA, called IntelliJ for short, helps you write well-formed Kotlin code. It also streamlines the development process with built-in tools for running, debugging, inspecting, and refactoring your code. You can read more about why we recommend IntelliJ for writing Kotlin code in the section called *For the More Curious: Why Use IntelliJ?* near the end of this chapter.

Your First Kotlin Project

Congratulations, you now have the Kotlin programming language and a powerful development environment to write it with. Now there is only one thing left to do: Learn to speak Kotlin fluently. First order of business – create a Kotlin project.

Open IntelliJ. You will be presented with the Welcome to IntelliJ IDEA dialog (Figure 1.2).

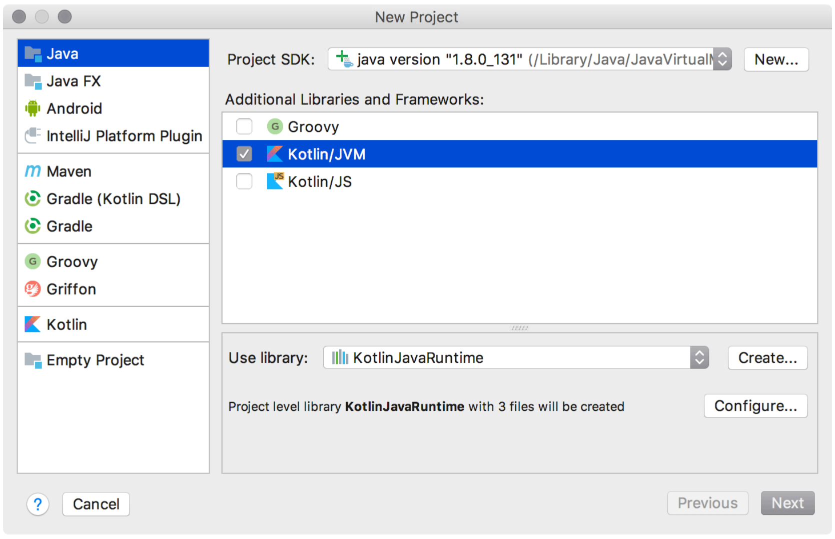
Figure 1.2 Welcome dialog



(If this is not the first time you have opened IntelliJ since installing it, you may be brought directly to the last project you had open. To get back to the welcome dialog, close the project using File → Close Project.)

Click Create New Project. IntelliJ will display the New Project dialog, as shown in Figure 1.3.

Figure 1.3 New Project dialog



Project SDK: java version "1.8.0_131" (/Library/Java/JavaVirtualM

Additional Libraries and Frameworks:

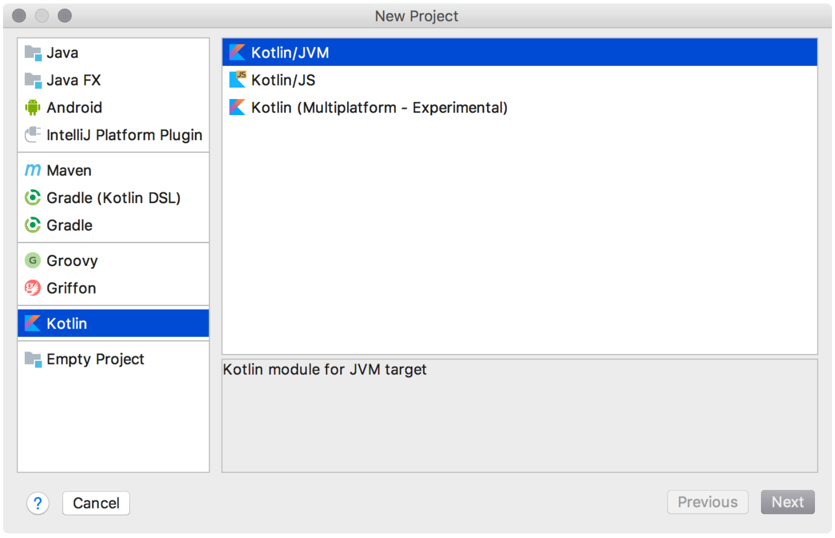
- [ ] Groovy
- [✓] Kotlin/JVM
- [ ] Kotlin/JS

Use library: KotlinJavaRuntime

Project level library **KotlinJavaRuntime** with 3 files will be created

In the New Project dialog, select Kotlin on the left and Kotlin/JVM on the right, as shown in Figure 1.4.

Figure 1.4 Creating a Kotlin/JVM project



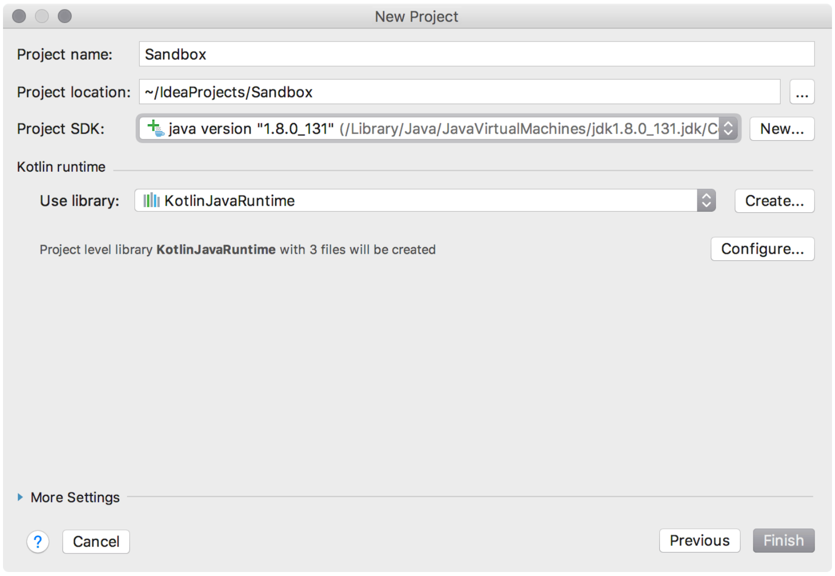
Kotlin module for JVM target

You can use IntelliJ to write code in languages other than Kotlin, including Java, Python, Scala, and Groovy. Selecting Kotlin/JVM tells IntelliJ you intend to use Kotlin. More specifically, Kotlin/JVM tells IntelliJ you intend to write Kotlin code that *targets*, or runs on, the Java Virtual Machine. One of the benefits of Kotlin is that it features a toolchain that allows you to write Kotlin code that can run on different operating systems and platforms.

(From here on, we will refer to the Java Virtual Machine as just “JVM,” as it is commonly called in the Java developer community. You can learn more about targeting the JVM in the section called *For the More Curious: Targeting the JVM* near the end of this chapter.)

Click Next in the New Project dialog. IntelliJ will display a dialog where you can choose settings for your new project (Figure 1.5). For the Project name, enter “Sandbox.” The Project location field will auto-populate. You can leave the location as is or select a new location by pressing the ... button to the right of the field. Select a Java 1.8 version from the Project SDK dropdown to link your project to Java Development Kit (JDK) version 8.

Figure 1.5 Naming the project



Project name: Sandbox
Project location: ~/IdeaProjects/Sandbox
Project SDK: java version "1.8.0_131" (/Library/Java/JavaVirtualMachines/jdk1.8.0_131.jdk/C
Kotlin runtime
Use library: KotlinJavaRuntime
Project level library **KotlinJavaRuntime** with 3 files will be created

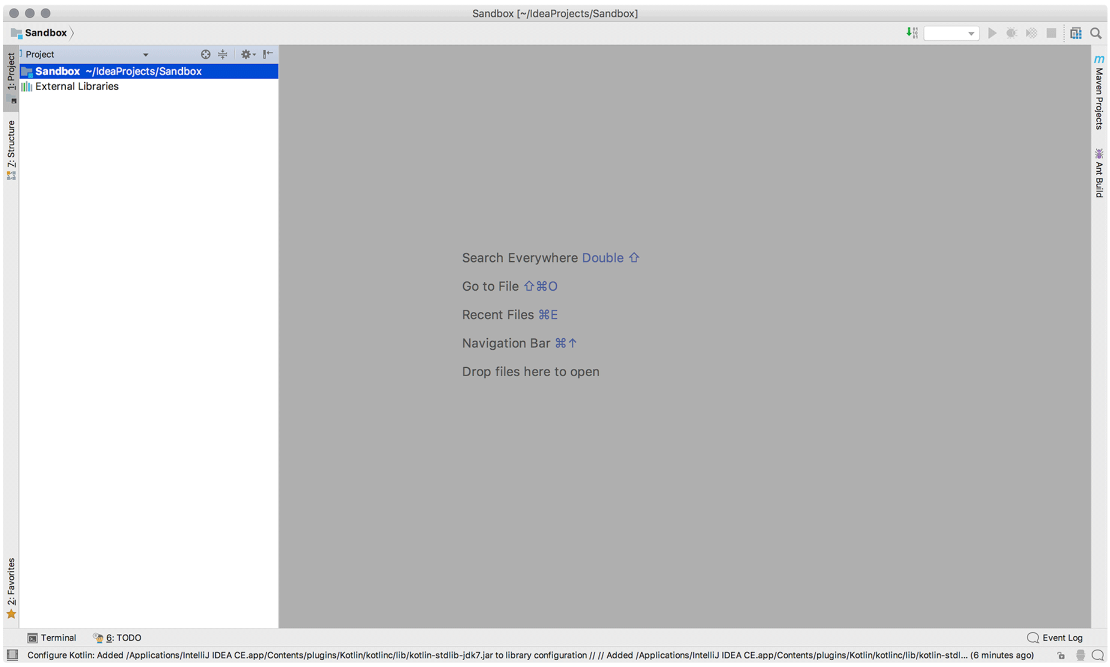
Why do you need the JDK to write a Kotlin program? The JDK gives IntelliJ access to the JVM and to Java tools that are necessary for converting your Kotlin code to bytecode (more on that in a moment). Technically, any version 6 or greater will work. But our experience, as of this writing, is that JDK 8 works most seamlessly.

If you do not see some version of Java 1.8 listed in the Project SDK dropdown, this means you have not yet installed JDK 8. Do so now before proceeding: Download JDK 8 for your specific platform from `oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html`. Install the JDK, then restart IntelliJ. Work back through the steps outlined to this point to create a new project.

When your settings dialog looks like Figure 1.5, click Finish.

IntelliJ will generate a project named Sandbox and display the new project in a default two-pane view (Figure 1.6). On disk, IntelliJ creates a folder and a set of subfolders and project files in the location specified in the Project location field.

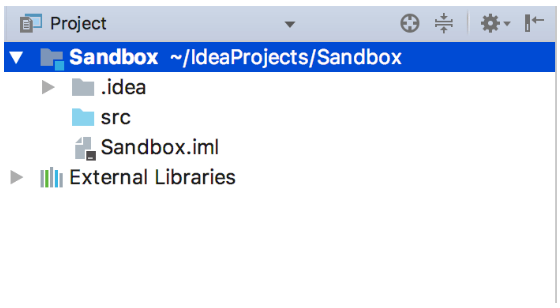
Figure 1.6 Default two-pane view



Configure Kotlin: Added /Applications/IntelliJ IDEA CE.app/Contents/plugins/Kotlin/kotlinc/lib/kotlin-stdlib-jdk7.jar to library configuration // // Added /Applications/IntelliJ IDEA CE.app/Contents/plugins/Kotlin/kotlinc/lib/kotlin-stdl... (6 minutes ago)

The pane on the left shows the *project tool window*. The pane on the right is currently empty. This is where you will view and edit the contents of your Kotlin files in the *editor*. Turn your attention to the project tool window on the left. Click the disclosure arrow to the left of the project name, Sandbox. It will expand to display the files contained in the project, as shown in Figure 1.7.

Figure 1.7 Project view



A *project* includes all of the source code for your program, along with information about dependencies and configurations. A project can be broken down into one or more *modules*, which are like subprojects. By default, a new project has one module, which is all you need for your simple first project.

The `Sandbox.iml` file contains configuration information specific to your single module. The `.idea` folder contains settings files for the entire project as well as those specific to your interaction with the project in the IDE (for example, which files you have open in the editor). Leave these auto-generated files as they are.

The External Libraries entry contains information about libraries the project depends on. If you expand this entry you will see that IntelliJ automatically added Java 1.8 and KotlinJavaRuntime as dependencies for your project.

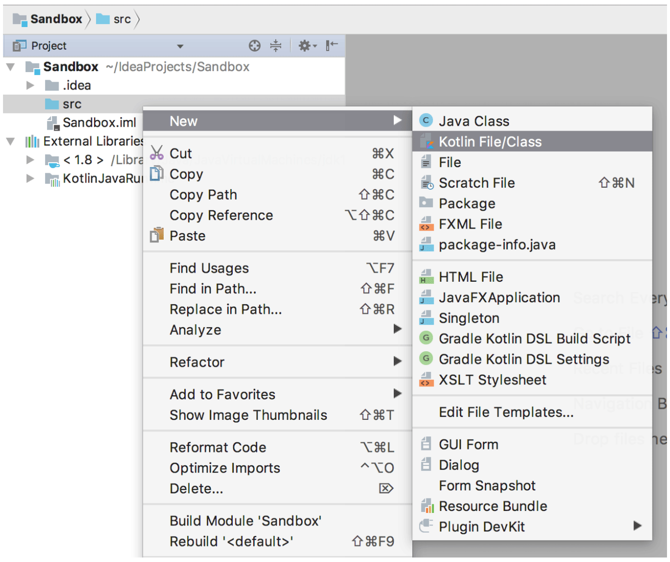
(You can learn more about IntelliJ project structure on the JetBrains documentation website at `jetbrains.org/intellij/sdk/docs/basics/project_structure.html`.)

The `src` folder is where you will place all the Kotlin files you create for your Sandbox project. And with that, it is time to create and edit your first Kotlin file.

Creating your first Kotlin file

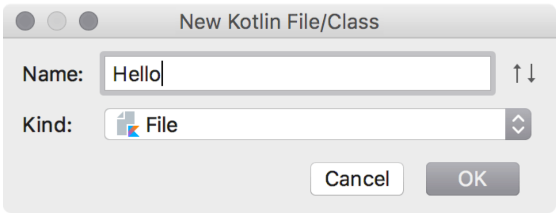
Right-click on the `src` folder in the project tool window. Select New and then Kotlin File/Class from the menu that appears (Figure 1.8).

Figure 1.8 Creating a new Kotlin file



In the New Kotlin File/Class dialog, type “Hello” in the Name field and leave the Kind field set to File (Figure 1.9).

Figure 1.9 Naming the file

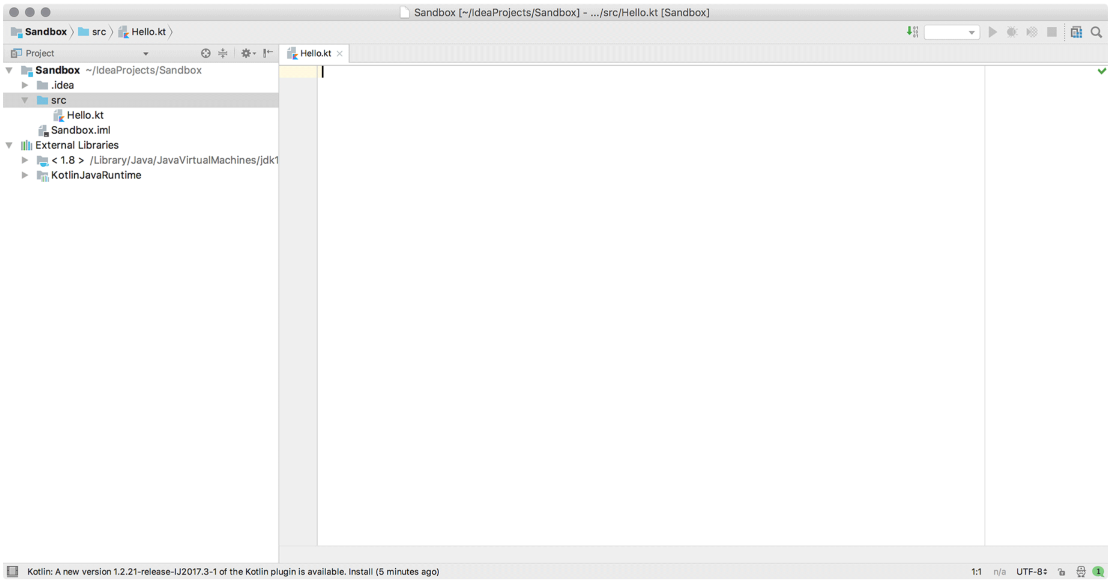


Name: Hello

Kind: File

Click OK. IntelliJ will create a new file in your project, `src/Hello.kt`, and display the contents of the file in the editor on the righthand side of the IntelliJ window (Figure 1.10). The `.kt` extension indicates that the file contains Kotlin, just like the `.java` extension is used for Java files and `.py` for Python files.

Figure 1.10 Empty `Hello.kt` file displays in editor


Sandbox [~/IdeaProjects/Sandbox] - .../src/Hello.kt [Sandbox]
Sandbox
src
Hello.kt
Project
Hello.kt
Sandbox ~/IdeaProjects/Sandbox
.idea
src
Hello.kt
Sandbox.iml
External Libraries
< 1.8 > /Library/Java/JavaVirtualMachines/jdk1
KotlinJavaRuntime
1:1
n/a
UTF-8

Kotlin: A new version 1.2.21-release-IJ2017.3-1 of the Kotlin plugin is available. Install (5 minutes ago)

At last, you are ready to write Kotlin code. Give your fingers a little stretch and go for it. Type the following code into the `Hello.kt` editor. (Remember that throughout this book, code you are to enter is shown in bold.)

Listing 1.1 “Hello, world!” in Kotlin (`Hello.kt`)

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

The code you just wrote might look unfamiliar. Do not fear – by the end of this book, reading and writing Kotlin will feel like second nature. For now, it is enough to understand the code at a high level.

The code in Listing 1.1 defines a new *function*. A function is a group of instructions that can be run later. You will learn in great detail how to define and work with functions in Chapter 4.

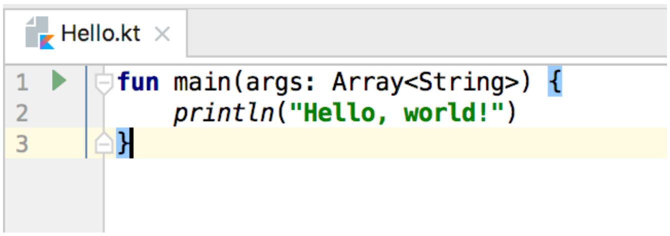
This particular function – the **`main`** function – has a special meaning in Kotlin. The **`main`** function indicates the starting place for your program. This is called the *application entry point*, and one such entry point must be defined for Sandbox (or any program) to be runnable. Every project you write in this book will start with a **`main`** function.

Your **`main`** function contains one instruction (also known as a *statement*): `println("Hello, world!")`. **`println()`** is also a function that is built into the *Kotlin standard library*. When the program runs and `println("Hello, world!")` is executed, IntelliJ will print the contents of the parentheses (without the quotation marks, so in this case `Hello, world!`) to the screen.

Running your Kotlin file

Shortly after you finish typing the code in Listing 1.1, IntelliJ will display a green ▶, known as the "run button," to the left of the first line (Figure 1.11). (If the icon does not appear, or if you see a red line underneath the filename in the tab or under any of the code you entered, this means you have an error in your code. Double-check that you typed the code exactly as shown in Listing 1.1. On the other hand, if you see a red and blue Kotlin K, this flag is the same as the run button.)

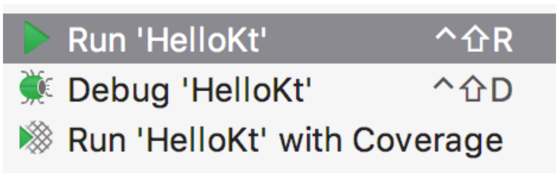
Figure 1.11 Run button



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

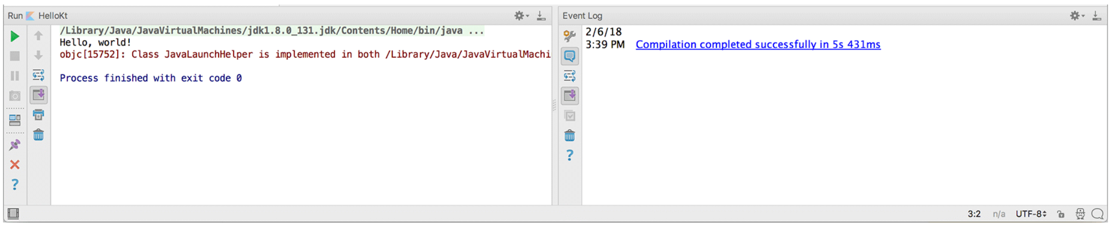
It is time for your program to come to life and greet the world. Click the run button. Select Run 'HelloKt' from the menu that appears (Figure 1.12). This tells IntelliJ you want to see your program in action.

Figure 1.12 Running `Hello.kt`



When you run your program, IntelliJ executes the code inside of the curly braces (`{}`), one line at a time, and then terminates execution. It also displays two new tool windows at the bottom of the IntelliJ window (Figure 1.13).

Figure 1.13 Run and event log tool windows



```
/Library/Java/JavaVirtualMachines/jdk1.8.0_131.jdk/Contents/Home/bin/java ...
Hello, world!
objc[15752]: Class JavaLaunchHelper is implemented in both /Library/Java/JavaVirtualMachi

Process finished with exit code 0
```

```
2/6/18
3:39 PM   Compilation completed successfully in 5s 431ms
```

On the left is the *run tool window*, also known as the *console* (which is what we will call it from now on). It displays information about what happened as IntelliJ executed your program, as well as any output your program prints. You should see `Hello, world!` printed in your console. You should also see `Process finished with exit code 0`, indicating successful completion. This line appears at the end of all console output when there is no error; we will not show it in console results from now on.

(macOS users, you may see red error text stating that there is an issue with `JavaLauncherHelper`, as shown in Figure 1.13. Do not worry about this. It is an unfortunate side effect of how the Java Runtime Environment is installed on macOS. To remove it would require a lot of effort, but the issue does no harm – so you may ignore it and carry on.)

On the right is the *event log tool window*, which displays information about work IntelliJ did to get your program ready to run. We will not mention the event log again, because you get much more interesting output in the console. (For the same reason, do not be concerned if the event log never opened to begin with.) You can close it with the hide button at its top right, which looks like this: ⤓.

Compilation and execution of Kotlin/JVM code

A lot goes on in the short time between when you select the run button's Run 'HelloKt' option and when you see `Hello, World!` print to the console.

First, IntelliJ *compiles* the Kotlin code using the `kotlinc-jvm` compiler. This means IntelliJ translates the Kotlin code you wrote into *bytecode*, the language the JVM "speaks." If `kotlinc-jvm` has any problems translating your Kotlin code, it will display an error message (or messages) giving you a hint about how to fix the issues. Otherwise, if the compilation process goes smoothly, IntelliJ moves on to the execution phase.

In the execution phase, the bytecode that was generated by `kotlinc-jvm` is executed on the JVM. The console displays any output from your program, such as printing the text you specified in your call to the **`println()`** function, as the JVM executes the instructions.

When there are no more bytecode instructions to execute, the JVM terminates. IntelliJ shows the termination status in the console, letting you know whether execution finished successfully or with an error code.

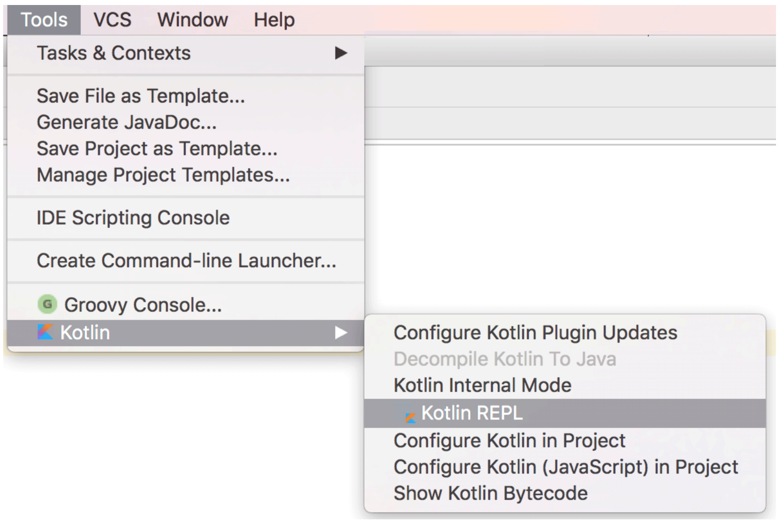
You will not need a comprehensive understanding of the Kotlin compilation process to work through this book. We will, however, discuss bytecode in more detail in Chapter 2.

The Kotlin REPL

Sometimes you might want to test out a small bit of Kotlin code to see what happens when you run it, similar to how you might use a piece of scratch paper to jot down steps for a small calculation. This is especially helpful as you are learning the Kotlin language. Luckily for you, IntelliJ provides a tool for quickly testing code without having to create a file. This tool is called the *Kotlin REPL*. We will explain the name in a moment – for now, open it up and see what it can do.

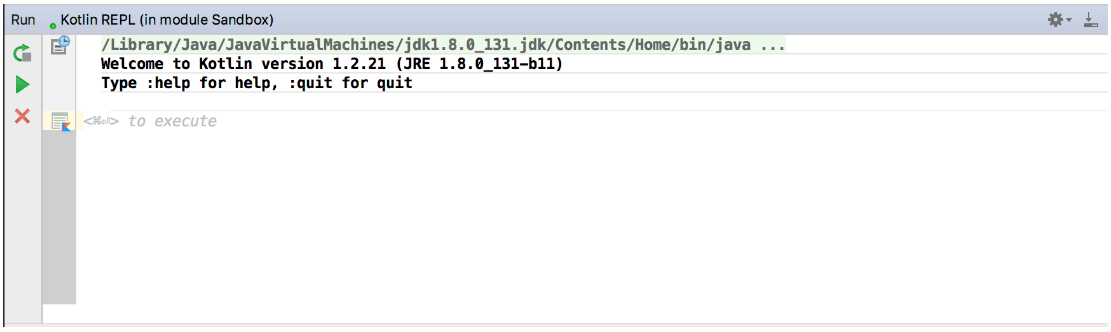
In IntelliJ, open the Kotlin REPL tool window by selecting Tools → Kotlin → Kotlin REPL (Figure 1.14).

Figure 1.14 Opening the Kotlin REPL tool window



IntelliJ will display the REPL at the bottom of the window (Figure 1.15).

Figure 1.15 The Kotlin REPL tool window



```
/Library/Java/JavaVirtualMachines/jdk1.8.0_131.jdk/Contents/Home/bin/java ...
Welcome to Kotlin version 1.2.21 (JRE 1.8.0_131-b11)
Type :help for help, :quit for quit
```

You can type code into the REPL, just like in the editor. The difference is that you can have it evaluated quickly, without compiling an entire project.

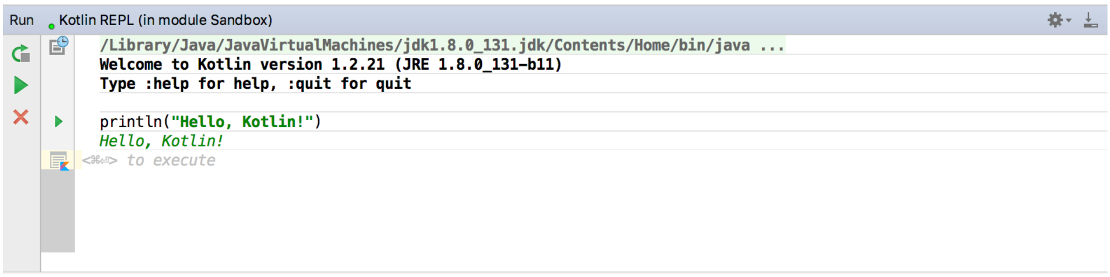
Enter the following code in the REPL:

Listing 1.2 “Hello, Kotlin!” (REPL)

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

Once you have entered the text, press Command-Return (Ctrl-Return) to evaluate the code in the REPL. After a moment, you will see the resulting output underneath, which should read `Hello, Kotlin!` (Figure 1.16).

Figure 1.16 Evaluating the code



```
/Library/Java/JavaVirtualMachines/jdk1.8.0_131.jdk/Contents/Home/bin/java ...
Welcome to Kotlin version 1.2.21 (JRE 1.8.0_131-b11)
Type :help for help, :quit for quit

println("Hello, Kotlin!")
Hello, Kotlin!
<⌘⏎> to execute
```

REPL is short for “read, evaluate, print, loop.” You type in a piece of code at the prompt and submit it by clicking the green run button on the REPL’s left side or by pressing Command-Return (Ctrl-Return). The REPL then *reads* the code, *evaluates* (runs) the code, and *prints* out the resulting value or side effect. Once the REPL finishes executing, it returns control back to you and the process *loop* starts all over.

Your Kotlin journey has begun! You accomplished a great deal in this chapter, laying the foundation for your growing knowledge of Kotlin programming. In the next chapter, you will begin to dig into the language’s details by learning about how you can use variables, constants, and types to represent data.

For the More Curious: Why Use IntelliJ?

Kotlin can be written using any plain text editor. However, we recommend using IntelliJ, especially as you are learning. Just as text editing software that offers spell check and grammar check makes writing a well-formed prose essay easier, IntelliJ makes writing well-formed Kotlin easier. IntelliJ helps you:

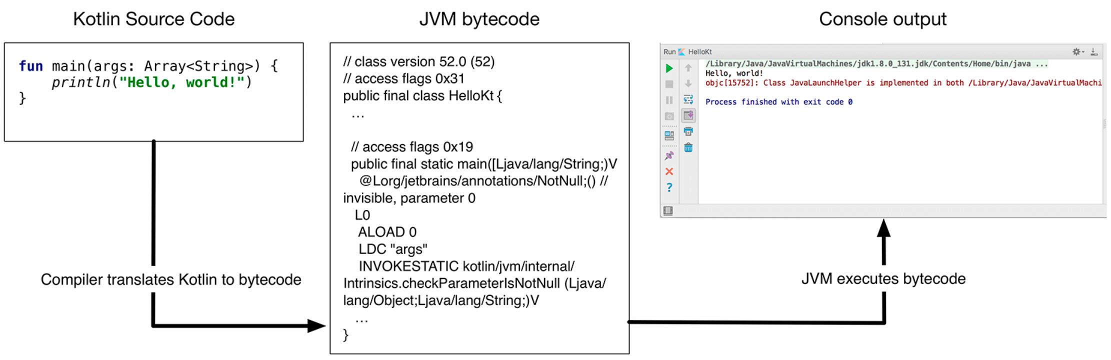
- write syntactically and semantically correct code with features like syntax highlighting, context-sensitive suggestions, and automatic code completion
- run and debug your code with features like debug breakpoints and real-time code stepping when your application is running
- restructure existing code with refactoring shortcuts (like rename and extract constant) and code formatting to clean up indentation and spacing

Also, since Kotlin was created by JetBrains, the integration between IntelliJ and Kotlin is carefully designed – often leading to a delightful editing experience. As an added bonus, IntelliJ is the basis of Android Studio, so shortcuts and tools you learn here will translate to using Android Studio, if that is your thing.

For the More Curious: Targeting the JVM

The JVM is a piece of software that knows how to execute a set of instructions, called bytecode. “Targeting the JVM” means compiling, or translating, your Kotlin source code into Java bytecode, with the intention of running that bytecode on the JVM (Figure 1.17).

Figure 1.17 Compilation and execution flow



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

```
// class version 52.0 (52)
// access flags 0x31
public final class HelloKt {
  ...

  // access flags 0x19
  public final static main([Ljava/lang/String;)V
    @Lorg/jetbrains/annotations/NotNull;() //
invisible, parameter 0
   L0
    ALOAD 0
    LDC "args"
    INVOKESTATIC kotlin/jvm/internal/
Intrinsics.checkParameterIsNotNull (Ljava/
lang/Object;Ljava/lang/String;)V
   ...
}
```

```
/Library/Java/JavaVirtualMachines/jdk1.8.0_131.jdk/Contents/Home/bin/java ...
Hello, world!
objc[15752]: Class JavaLaunchHelper is implemented in both /Library/Java/JavaVirtualMachi

Process finished with exit code 0
```

Each platform, such as Windows or macOS, has its own instruction set. The JVM acts as a bridge between the bytecode and the different hardware and software environments the JVM runs on, reading a piece of bytecode and calling the corresponding platform-specific instruction(s) that map to that bytecode. Therefore, there are different versions of the JVM for different platforms. This is what allows Kotlin developers to write platform-independent code that can be written one time and then compiled into bytecode and executed on different devices regardless of their operating systems.

Since Kotlin can be converted to bytecode that the JVM can execute, it is considered a JVM language. Java is perhaps the most well-known JVM language, because it was the first. However, other JVM languages, such as Scala and Kotlin, have emerged to address some shortcomings of Java from the developer perspective.

Kotlin is not limited to the JVM, however. At the time of this writing, Kotlin can also be compiled into JavaScript or even into native binaries that run directly on a given platform – such as Windows, Linux, and macOS – negating the need for a virtual machine layer.

Challenge: REPL Arithmetic

Many of the chapters in this book end with one or more challenges. The challenges are for you to work through on your own to deepen your understanding of Kotlin and get a little extra experience.

Use the REPL to explore how arithmetic operators in Kotlin work: `+`, `-`, `*`, `/`, and `%`. For example, type `(9+12)*2` into the REPL. Does the output match what you expected?

If you wish to dive deeper, look over the mathematical functions available in the Kotlin standard library at `kotlinlang.org/api/latest/jvm/stdlib/kotlin.math/index.html` and try them out in the REPL. For example, try `min(94, -99)`, which will tell you the minimum of the two numbers provided in parentheses.

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