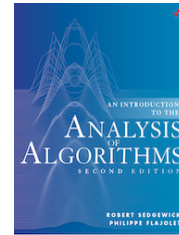




- [Algorithms, 4th edition](#)
  - [1. Fundamentals](#)
    - [1.1 Programming Model](#)
    - [1.2 Data Abstraction](#)
    - [1.3 Stacks and Queues](#)
    - [1.4 Analysis of Algorithms](#)
    - [1.5 Case Study: Union-Find](#)
  - [2. Sorting](#)
    - [2.1 Elementary Sorts](#)
    - [2.2 Mergesort](#)
    - [2.3 Quicksort](#)
    - [2.4 Priority Queues](#)
    - [2.5 Sorting Applications](#)
  - [3. Searching](#)
    - [3.1 Symbol Tables](#)
    - [3.2 Binary Search Trees](#)
    - [3.3 Balanced Search Trees](#)
    - [3.4 Hash Tables](#)
    - [3.5 Searching Applications](#)
  - [4. Graphs](#)
    - [4.1 Undirected Graphs](#)
    - [4.2 Directed Graphs](#)
    - [4.3 Minimum Spanning Trees](#)
    - [4.4 Shortest Paths](#)
  - [5. Strings](#)
    - [5.1 String Sorts](#)
    - [5.2 Tries](#)
    - [5.3 Substring Search](#)
    - [5.4 Regular Expressions](#)
    - [5.5 Data Compression](#)
  - [6. Context](#)
    - [6.1 Event-Driven Simulation](#)
    - [6.2 B-trees](#)
    - [6.3 Suffix Arrays](#)
    - [6.4 Maxflow](#)
    - [6.5 Reductions](#)

## ■ [6.6 Intractability](#)

- Related Booksites



- Web Resources

- [FAQ](#)
- [Data](#)
- [Code](#)
- [Errata](#)
- [Cheatsheet](#)
- [References](#)
- [Online Course](#)
- [Lecture Slides](#)
- [Programming Assignments](#)

# Hello World in Java on Mac OS X

This document instructs you on how to set up our Java programming environment for your Mac OS X computer. It also provides a step-by-step guide for creating, compiling, and executing a Java program using either DrJava or Terminal. All of the software used is freely available.

You will need a Mac running Mac OS X 10.8 (Mountain Lion) to Mac OS X 10.12 (Sierra). The autoinstaller has not been thoroughly tested with Mac OS X 10.13 (High Sierra), but we expect it to work.

## 0. Install the Programming Environment

Our installer downloads, installs, and configures the Java programming environment you will be using, including DrJava, the textbook libraries, and the Terminal.

- Log in to the user account in which you will be programming. Your account must have Administrator privileges (with a non-blank password) and you must be connected to the Internet.
- Install Oracle's implementation of the Java Platform, Standard Edition Development Kit (JDK 8).
  - Browse to [Java SE Development Kit 8u144](#). In the first table, check *Accept License*

*Agreement* and the click *jdk-8u144-macosx-x64.dmg*, which corresponds to the entry for Mac OS X. The exact version *8u144* is not essential.

**Java SE Development Kit 8u144**

You must accept the [Oracle Binary Code License Agreement for Java SE](#) to download this software.

☒ **Accept License Agreement** ☐ Decline License Agreement

| Product / File Description  | File Size | Download  |
|-----------------------------|-----------|---|
| Linux ARM 32 Hard Float ABI | 77.89 MB  | <a href="#">jdk-8u144-linux-arm32-vfp-hflt.tar.gz</a> |
| Linux ARM 64 Hard Float ABI | 74.83 MB  | <a href="#">jdk-8u144-linux-arm64-vfp-hflt.tar.gz</a> |
| Linux x86                   | 164.65 MB | <a href="#">jdk-8u144-linux-i586.rpm</a>              |
| Linux x86                   | 179.44 MB | <a href="#">jdk-8u144-linux-i586.tar.gz</a>           |
| Linux x64                   | 162.1 MB  | <a href="#">jdk-8u144-linux-x64.rpm</a>               |
| Linux x64                   | 176.92 MB | <a href="#">jdk-8u144-linux-x64.tar.gz</a>            |
| Mac OS X                    | 226.6 MB  | <a href="#">jdk-8u144-macosx-x64.dmg</a>              |
| Solaris SPARC 64-bit        | 139.87 MB | <a href="#">jdk-8u144-solaris-sparcv9.tar.Z</a>       |
| Solaris SPARC 64-bit        | 99.18 MB  | <a href="#">jdk-8u144-solaris-sparcv9.tar.gz</a>      |
| Solaris x64                 | 140.51 MB | <a href="#">jdk-8u144-solaris-x64.tar.Z</a>           |
| Solaris x64                 | 96.99 MB  | <a href="#">jdk-8u144-solaris-x64.tar.gz</a>          |
| Windows x86                 | 190.94 MB | <a href="#">jdk-8u144-windows-i586.exe</a>            |
| Windows x64                 | 197.78 MB | <a href="#">jdk-8u144-windows-x64.exe</a>             |

- Double click the downloaded file *jdk-8u144-macosx-x64.dmg* to begin the installation. Enter your OS X password when prompted. We recommend all of the default options.
- Delete *jdk-8u144-macosx-x64.dmg*.
- To install,
  - Download [algs4.zip](#) to the Desktop; double-click it to unzip (if necessary). This creates *algs4.app*.
  - Double-click *algs4.app* to perform the installation. If you receive a warning that *algs4.app* is an application downloaded from the Internet, click *Open*.
  - Enter your OS X password when prompted.
- If the installation succeeds, you will see the following:
  - A terminal window containing approximately this [execution log](#).
  - A *Standard Drawing* window containing a red bullseye and a textbook graphic.
- Delete *algs4.zip* and *algs4.app*.

## 1. Create the Program in DrJava

Now you are ready to write your first Java program. You will develop your Java programs in an application called *DrJava*. DrJava features many specialized programming tools including syntax highlighting, bracket matching, auto indenting, and line numbering.

- The installer creates a shortcut to DrJava on the desktop. Double-click it to launch DrJava. If you receive a warning about incoming network connections, click *Allow*.
- In the main DrJava window, type the Java program [HelloWorld.java](#) exactly as it appears below. If you omit even a semicolon, the program won't work.

```
public class HelloWorld {  
    public static void main(String[] args) {  
        System.out.println("Hello, World");  
    }  
}
```

As you type, DrJava does the indenting for you.

- Finally, click the *Save* button to save the file, using the name `HelloWorld.java`. The filename is case sensitive and must exactly match the name of the class in the Java program.

## 2. Compile the Program from DrJava

It is now time to convert your Java program into a form more amenable for execution on a computer. To do this, click the *Compile* button. If all goes well, you should see the following message in the *Compiler Output* pane at the bottom:

```
Compilation completed.
```

If DrJava complains in some way, you mistyped something. Check your program carefully, using the error messages in the Compiler Output pane as a guide.

## 3. Execute the Program from DrJava

Now it is time to run your program. This is the fun part.

- Type the following in the *Interactions* pane at the bottom. By convention, we highlight the text you type in boldface.

```
> java HelloWorld
```

If all goes well, you should see the following message:

```
Welcome to DrJava. Working directory is /Users/<username>/Desktop
```

```
> java HelloWorld  
Hello, World
```

- You may need to repeat this *edit–compile–execute* cycle a few times before it works.

## 4. Command-Line Interface

The command-line provides capabilities beyond those available in DrJava, including redirection and piping. You will type commands in an application called the *Terminal*.

- The installer creates a shortcut on the desktop to the Terminal. Double-click it to launch the Terminal. You should see something like:

```
machine:~ <username>$
```

The ~ is shorthand for your home directory /Users/username; the name machine will be replaced by the name of your machine; the name username will be replaced by your username.

- To confirm that the Java compiler is installed, type the command in boldface below and check that the results match:

```
machine:~ <username>$ javac -version  
javac 1.8.0_144
```

It's important that you see the number 1.8 for the Java version number, but the rest is not critical.

- To confirm that the Java interpreter is installed, type the command in boldface below and check that the results match:

```
machine:~ <username>$ java -version  
java version "1.8.0_144"  
Java(TM) SE Runtime Environment (build 1.8.0_144-b16)  
Java HotSpot(TM) 64-Bit Server VM (build 1.8.0_144-b16, mixed mode)
```

Again, it's important that you see the number 1.8 for the Java version number, but the rest is not critical.

## 5. Compile the Program from the Terminal

You will use the `javac` command to convert your Java program into a form more amenable for execution on a computer.

- From the Terminal, navigate to the directory containing `HelloWorld.java`, say `/Users/<username>/intros/hello`, by typing the `cd` (*change directory*) commands below:

```
machine:~/Desktop <username>$ cd hello
machine:~/Desktop/hello <username>$
```

- Compile it by typing the `javac` command below:

```
machine:~/Desktop/hello <username>$ javac HelloWorld.java
machine:~/Desktop/hello <username>$
```

Assuming the file `HelloWorld.java` is in the current working directory, you should see no error messages.

- To make our textbook libraries accessible to Java, use the command `javac-algs4` instead. For example, to compile [TestAlgs4.java](#), which uses our *standard drawing library*, the auto-installer issues the following command:

```
machine:~/Desktop <username>$ javac-algs4 TestAlgs4.java
```

At this time, `javac-cos226` and `javac-coursera` are equivalent to `javac-algs4`.

## 6. Execute the Program from the Terminal

You will use the `java` command to execute your program.

- From the Terminal, type the `java` command below.

```
machine:~/Desktop <username>$ java HelloWorld
Hello, World
```

You should see the output of the program.

- To make our textbook libraries accessible to Java, use the command `java-algs4` instead. For example, to test standard drawing and standard audio, type the following two commands:

```
machine:~/Desktop <username>$ java-algs4 edu.princeton.cs.algs4.StdDraw
[ displays a graphics window with some geometric shapes and text ]

machine:~/Desktop <username>$ java-algs4 edu.princeton.cs.algs4.StdAudio
```

```
[ plays an A major scale ]
```

At this time, `java-cos226` and `java-coursera` are equivalent to `java-algs4`.

## 7. Static Code Analysis Tools

You can use [Findbugs](#), [PMD](#), and [Checkstyle](#) and to check the style of your programs and identify common bug patterns.

- To run Findbugs 3.0.1, type the following command in the Terminal:

```
machine:~/Desktop/hello <username>$ findbugs-algs4 *.class
Running findbugs on HelloWorld.class:
```

The argument must be a list of `.class` files. Here is a list of [bug descriptions](#).

- To run PMD 5.8.1, type the following command in the Terminal:

```
machine:~/Desktop/hello <username>$ pmd-algs4 .
```

The argument must be a directory containing `.java` files. Here is a list of [bug patterns](#).

- To run Checkstyle 8.2, type the following command in the Terminal:

```
machine:~/Desktop/hello <username>$ checkstyle-algs4 *.java
Running checkstyle on HelloWorld.java:
Starting audit...
Audit done.
```

The argument must be a list of `.java` files. Here is a list of [available checks](#).

- COS 226 students should use the following versions of these commands, to match the corresponding versions in the autograder:

```
machine:~/Desktop/hello <username>$ findbugs-cos226 HelloWorld.class
Running findbugs on HelloWorld.class:
```

```
machine:~/Desktop/hello <username>$ pmd-cos226 .
```

```
machine:~/Desktop/hello <username>$ checkstyle-cos226 HelloWorld.java
Running checkstyle on HelloWorld.java:
Starting audit...
Audit done.
```

- Coursera students should use the following versions of these commands, to match the corresponding versions in the autograder:

```
machine:~/Desktop/hello <username>$ findbugs-coursera HelloWorld.class
Running findbugs on HelloWorld.class:
```

```
machine:~/Desktop/hello <username>$ pmd-coursera .
```

```
machine:~/Desktop/hello <username>$ checkstyle-coursera HelloWorld.java
Running checkstyle on HelloWorld.java:
Starting audit...
Audit done.
```

## Troubleshooting

**I previously used the *introcs.app* installer from the textbook *Computer Science: An Interdisciplinary Approach*. Should I use the *algs4.app* installer?** Yes, we recommend using the *algs4.app* installer because it will install `algs4.jar`, as well as the corresponding commands `javac-algs4` and `java-algs4`.

**How long should the installer take?** Once downloaded, the Oracle Java installer should take about 10 seconds and the *algs4.app* installer should take about 20 seconds. If you have virus detection software running (such as McAfee Endpoint), each could take 5–10 minutes (or more).

**The installer didn't work on my machine. What should I do?** Please read the next few Q+As. If these don't resolve the issue, please contact a staff member to identify what went wrong.

**When I run the installer, I get the error message “bash: /Volumes/Macintosh: No such file or directory.”** Your user account and OS must be on the same volume.

**When I run the installer, the Terminal windows just waits after asking for a password. But, I don't even have a password-enabled account.** You must have a non-blank password. Here are instructions for [resetting a user's password](#).

**When I run the installer, I get an error like “bash: /private/var/folders/70/n8stth1d1x33hrw8n07kf1280000gn/T/AppTranslocation/45FC25B7-17E3-46DF-AC27-9A7EF56DDFD3/d/algs4.app/Contents/Resources/launcher.sh: No such file or directory.”** What should I do? This is likely due to OS X Sierra path randomization. Use the Finder to move `algs4.app` to some other folder and try again.

**When I run the installer, I receive the following error after I enter my password: “bash: /???/Users/<username>/Desktop/algs4.app/Contents/Resources/launcher.sh: No such file or directory.”** We're not sure what causes this (but we think it is related to users with dual-boot systems / USB drives). Try opening a Terminal windows and typing

```
sudo /Users/<username>/Desktop/algs4.app/Contents/Resources/launcher.sh
```



**What does the installer do?** In short, it downloads, installs, and configures Checkstyle, Findbugs, DrJava, and our textbook libraries. Here is a more detailed list:

1. Checks that Java is installed.
2. Downloads the textbook library from [algs4.jar](#).
3. Downloads the Java wrapper scripts [javac-algs4](#) and [java-algs4](#).
4. Downloads and installs [Findbugs 3.0.1](#) from [findbugs.zip](#). Downloads our findbugs configuration file [findbugs.xml](#) and wrapper script [findbugs-algs4](#).
5. Downloads and installs [PMD 5.8.1](#) from [pmd.zip](#). Downloads our PMD configuration file [pmd.xml](#) and wrapper script [pmd-algs4](#).
6. Downloads and installs [Checkstyle 8.2](#) from [checkstyle.zip](#). Downloads our checkstyle configuration file [checkstyle-algs4.xml](#) and wrapper script [checkstyle-algs4](#).
7. Downloads and installs the latest stable version of [DrJava](#), from [DrJava.zip](#). Creates a shortcut to DrJava on the Desktop. Downloads the DrJava configuration file from [drjava](#) to `/Users/<username>/.drjava`. Note that this will overwrite any existing `.drjava` configuration file.
8. Tests that the installation succeeded by compiling and executing [TestAlgs4.java](#).

**Why does the installer need my password?** The installer copies files into `/usr/local/bin` and `/usr/local/algs4`, which require elevated privileges.

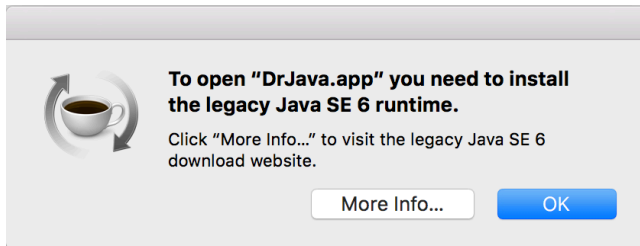
### How do I completely uninstall algs4.app?

- Delete the directory `/usr/local/algs4`.
- To uninstall DrJava, delete the following two files:
  - `/Applications/DrJava.app`.
  - `/Users/<username>/.drjava`.
- To uninstall the Java, Findbugs, PMD, and Checkstyle, wrapper scripts, delete the following files:
  - `/usr/local/bin/javac-{algs4,cos226,coursera}`
  - `/usr/local/bin/java-{algs4,cos226,coursera}`
  - `/usr/local/bin/findbugs-{algs4,cos226,coursera}`
  - `/usr/local/bin/pmd-{algs4,cos226,coursera}`
  - `/usr/local/bin/checkstyle-{algs4,cos226,coursera}`
- Delete the shortcut to DrJava and Terminal on the Desktop.

**What happens if I rerun the installer?** It will re-download, install, and configure Findbugs, PMD, Checkstyle, DrJava, and our textbook libraries.

**Can I use a different version of Java?** Yes. Any version of Java 8 (either Oracle or OpenJDK) or later should work fine.

**Why I try to run DrJava, I get the following error message. How should I proceed?**



Are you sure that you are using the version of DrJava that was installed by our auto-installer (and not downloaded from the DrJava website)? We suggest deleting any older versions of DrJava and using the one that the auto-installer copied to the `/Applications` directory.

**Can I use a different IDE?** Yes you can use another IDE (such as Eclipse) but you will have to configure the IDE properties yourself (such as the classpath).

**When I compile or execute a program in Terminal that uses one of the textbook libraries, I get an error that it cannot find the library. How can I fix this?** Be sure that you are using the wrapper scripts `/usr/local/bin/javac-algs4` and `/usr/local/bin/java-algs4`.

**Which shell should I use in the Terminal?** The default shell in Mac OS X is bash, but feel free to use a different one if you prefer.

**What's the sha256sum of algs4.zip?** `483786a1197b7282b92c846667e847cd31a97a4e42bca71f95e21a2ce668fc33`

*Last modified on October 20, 2017.*

Copyright © 2000–2016 [Robert Sedgewick](#) and [Kevin Wayne](#). All rights reserved.