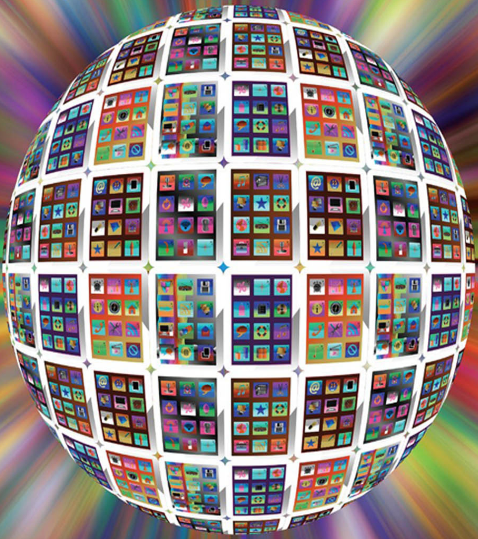
DEITEL® DEVELOPER SERIES

THIRD EDITION

Android™ 6 for Programmers

An App-Driven Approach

8 Fully Coded Android™ Apps



PAUL DEITEL • HARVEY DEITEL

ALEXANDER WALD

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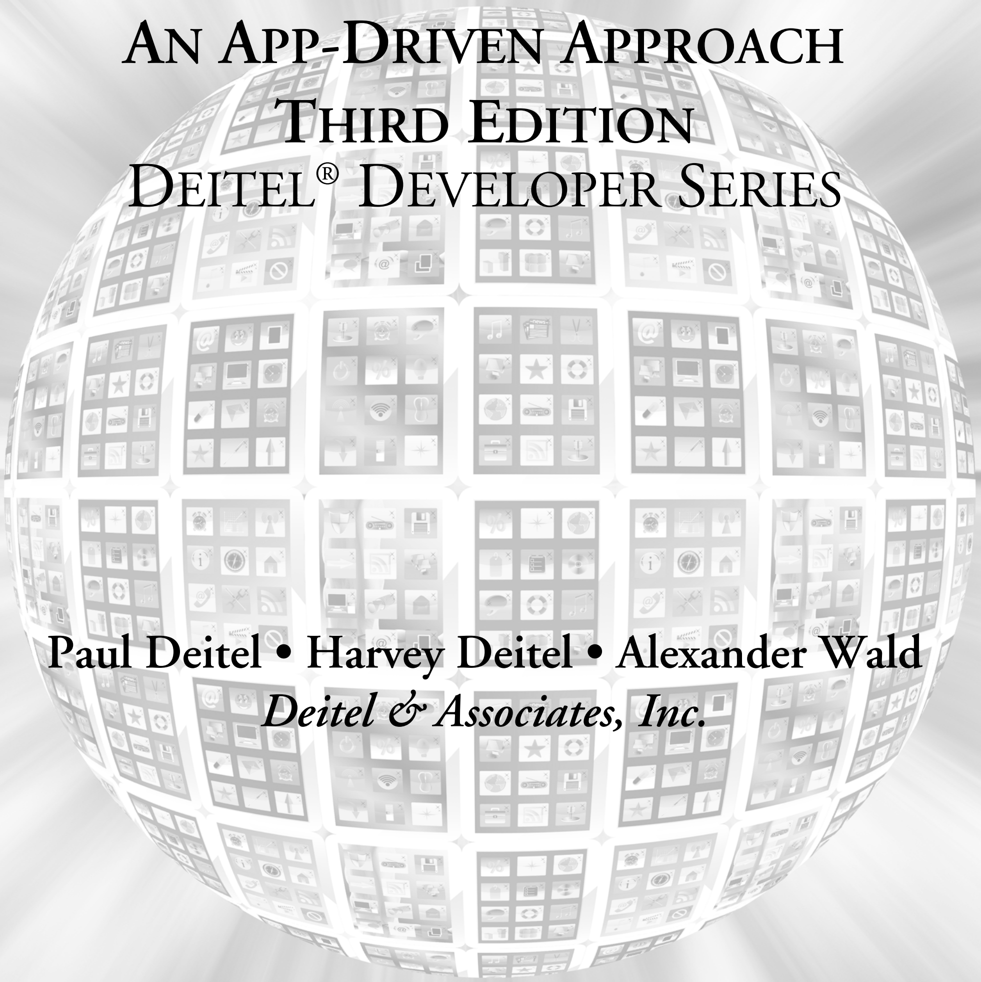

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To the Android software-engineering community:

For creating and evolving a platform that challenges app developers to test the limits of their imagination

Paul and Harvey Deitel

Contents

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Preface

Welcome to the dynamic world of Android *smartphone* and *tablet* app development with the Android Software Development Kit (SDK), the Java™ programming language and the rapidly evolving Android Studio Integrated Development Environment (IDE). Many of the Android techniques we present also apply to Android Wear and Android TV app development, so after reading this book, you'll be well prepared to investigate developing apps for these platforms.

Android 6 for Programmers: An App-Driven Approach presents leading-edge mobile computing technologies for professional software developers. In our *app-driven approach*, we present concepts in *complete working Android apps*, rather than using code snippets. Chapters 2–9 each present one app. Each chapter begins with an introduction to the app, an app test-drive showing one or more sample executions and an overview of the technologies we used to build the app. Then we present a detailed source-code walkthrough. All of the source code is available at

```
http://www.deitel.com/books/AndroidFP3
```

We recommend that you view each app's source code in the IDE as you read the chapter.

The opportunities for Android app developers are enormous. Sales of Android devices and app downloads have been growing exponentially. The first-generation Android phones were released in October 2008. According to IDC, after the first three months of 2015, Android had 78% of the global smartphone market share, compared to 18.3% for Apple, 2.7% for Microsoft and 0.3% for Blackberry.[1] Over one billion Android devices shipped in 2014 alone.[2] At the 2015 Google I/O conference, Google announced that in the prior 12 months there had been 50 billion app installs from Google Play™—Google's marketplace for Android apps.[3] Fierce competition among popular mobile platforms and carriers is leading to rapid innovation and falling prices. In addition, competition among the hundreds of Android device manufacturers is driving hardware and software innovation within the Android community.

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1. `http://www.idc.com/prodserv/smartphone-os-market-share.jsp`.
2. `http://www.businessinsider.com/android-1-billion-shipments-2014-strategy-analytics-2015-2`.
3. `http://bit.ly/2015GoogleIOKeynote`.

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Intended Audience

We assume that you're a Java programmer with object-oriented programming experience. We also assume that you're familiar with XML—as you'll see, Android projects contain many XML files, though you'll often interact with them through editors that hide much or all of the XML from you. We use only complete, working apps, so if you don't know Java but have object-oriented programming experience in a C-based language such as C++, C#, Swift or Objective-C you should be able to master the material quickly, learning a good amount of Java and Java-style object-oriented programming along the way.

This book is *not* a Java tutorial. If you're interested in learning Java, you may want to check out our publications:

- *Java for Programmers, 3/e* (`http://www.deitel.com/books/javafp3`)
- *Java Fundamentals, 2/e* LiveLessons videos. These videos are available to `SafariBooksOnline.com` subscribers and may be purchased from `Informit.com` and `Udemy.com`. Visit `http://www.deitel.com/LiveLessons` for subscription and purchase links.
- *Java How to Program, 10/e* (`http://www.deitel.com/books/jhtp10`; ISBN# 0-13-380780-0)

If you're not familiar with XML, many free online tutorials are available, including:

- `http://www.ibm.com/developerworks/xml/newto`
- `http://www.w3schools.com/xml/default.asp`
- `http://bit.ly/DeitelXMLBasics`
- `http://bit.ly/StructureXMLData`

Features

Here are some of this book's key features:

App-Driven Approach. Chapters 2–9 each present one completely coded app—we discuss what the app does, show screenshots of the app in action, test-drive it and overview the technologies and architecture we used to build it. Then we build the app's GUI and resource files, present the complete code and do a detailed code walkthrough. We discuss the programming concepts and demonstrate the functionality of the Android APIs used in the app.

Android 6 SDK. We cover various new Android 6 Software Development Kit (SDK) features.

Android Studio IDE. The free Android Studio (based on IntelliJ IDEA Community Edition) is now Google's preferred IDE for Android app development (the original Android development tools were based on the Eclipse IDE). Android Studio, combined with the free Android Software Development Kit (SDK) and the free Java Development Kit (JDK), provide all the software you'll need to create, run and debug Android apps, export them for distribution (e.g., upload them to Google Play™) and more. See the Before You Begin section after this Preface for download and installation instructions for all this software.

Material Design. With Android 5, Google introduced its new Android look-and-feel, based on their material design specification:

```
http://www.google.com/design/spec/material-design/introduction.html
```

In the specification, Google overviews the goals and principles of material design, then provides details on animation techniques, styling on-screen elements, positioning elements, uses of specific user-interface components, user-interaction patterns, accessibility, internationalization and more. Google now uses material-design principles in its mobile and browser-based apps.

Material design is a massive topic. In this book, we focus on the following aspects of material design:

- Using Android's built-in `Material` *themes*—these give Android's built-in user-interface components a look-and-feel that's consistent with material design principles.
- Using built-in Android Studio *app templates*—these are designed by Google to adhere to material design principles.
- Using *user-interface components*, as appropriate, that are recommended by the material design guidelines for specific purposes, such as `FloatingActionButton`s, `TextInputLayout`s and `RecyclerView`s.

In addition to Google's material design specification, you may want to read the book *Android User Interface Design: Implementing Material Design for Developers, 2nd Edition*:

```
http://bit.ly/IanCliftonMaterialDesign
```

by our professional colleague and past *Android for Programmers* reviewer Ian Clifton. From Ian: "Google announced the material design guidelines in 2014, creating a design system that suggested how an app should look as well as behave. The goal was to provide a design framework that would improve the visual appearance of all apps and create a behavioral consistency that did not exist previously across apps. *Android User Interface Design: Implementing Material Design for Developers, 2nd Edition* covers material design in detail, making user-centered design, color theory, typography, interaction patterns and other aspects of design accessible to all developers."

Support and App Compatibility Libraries. A big challenge developers face when using new Android features is backward compatibility with earlier Android platforms. Many new Android features are now introduced via support libraries. These enable you to use new features in apps targeting current and past Android platforms. One such library is the `AppCompat` library. Android Studio's app templates have been updated to use the `AppCompat` library and its themes, enabling the new apps you create to run on most Android devices. By creating apps with the `AppCompat` library from the start, you avoid having to reimplement your code if you decide to support older Android versions to target a wider audience.

In addition, at the 2015 Google I/O developer conference, Google introduced the Android Design Support Library

```
http://android-developers.blogspot.com/2015/05/android-design-
   support-library.html
```

for using material design in Android 2.1 and higher. Material design support also is built into most of Android Studio's app templates.

REST Web Services and JSON. Chapter 7 presents the **Weather Viewer** app, which demonstrates how to invoke Representational State Transfer (REST) web services—in this case, the 16-day weather-forecast service from `OpenWeatherMap.org`. This web service returns the weather forecast in JavaScript Object Notation (JSON)—a popular text-based data-interchange format used to represent objects as key–value pairs of data. The app also use classes from the `org.json` package to process the web service's JSON response.

Android 6.0 Permissions. Android 6.0 has a new permissions model that's designed for a better user experience. Before Android 6.0, a user was required at installation time to grant in advance all permissions that an app would ever need, which often discouraged users from installing apps. With the new model, the app is installed without asking for any permissions. Instead, the user is asked to grant a permission only the first time the corresponding feature is used. Chapter 5 introduces the new permissions model and uses it to request permission from the user to store an image on the device's external storage.

Fragments. Starting with Chapter 4, we use `Fragments` to create and manage portions of each app's GUI. You can combine several fragments to create user interfaces that take advantage of tablet screen sizes. You also can easily interchange fragments to make your GUIs more dynamic, as you'll do in Chapter 9.

View-Holder Pattern, `ListView` and `RecyclerView`. The apps in Chapters 7–9 each display scrollable lists of data. Chapter 7 presents the data in a `ListView` and introduces the view-holder pattern, which improves scrolling performance by reusing GUI components that scroll off-screen. With `ListViews`, using the view-holder pattern is recommended. Chapters 8 and 9 each present a list of data in the more flexible and more efficient `RecyclerView` for which the view-holder pattern is required.

Printing. We demonstrate class `PrintHelper` (Chapter 5) from Android's printing framework for printing from an app. Class `PrintHelper` provides a user interface for selecting a printer, has a method for determining whether a given device supports printing and provides a method for printing a `Bitmap`. `PrintHelper` is part of the Android Support Library.

Immersive Mode. The status bar at the top of the screen and the menu buttons at the bottom can be hidden, allowing your apps to fill more of the screen. Users can access the status bar by swiping down from the top of the screen, and the system bar (with the back button, home button and recent apps button) by swiping up from the bottom.

Testing on Android Smartphones, Tablets and the Android Emulator. For the best app-development experience and results, you should test your apps on actual Android smartphones and tablets. You can still have a meaningful experience using just the Android emulator (see the Before You Begin section); however, it's processor intensive and can be slow, particularly with games that have a lot of moving parts. In Chapter 1, we mention some Android features that are not supported on the emulator.

Cloud Test Lab. Google is working on a new *Cloud Test Lab*—an online site for testing your apps across a wide range of devices, device orientations, locales, spoken languages and network conditions. You'll be able to run automated tests and receive detailed reports containing screenshots and videos of your app in action, as well as error logs to help you find problems and improve your apps. For more information and to sign up to be notified when Cloud Test Lab becomes available, visit:

```
http://developers.google.com/cloud-test-lab/
```

Android Wear and Android TV. Android Wear runs on smart watches. Android TV runs directly on some smart TVs and media players that you can connect to your TV (typically via HDMI cables). Many Android techniques we present also apply to Android Wear and Android TV app development. The Android SDK provides Android Wear and Android TV emulators, so you can test your apps for these platforms, even if you don't have devices. To learn more about these technologies from the developer perspective, visit:

```
http://developer.android.com/wear/index.html
```

for Android Wear and

```
http://developer.android.com/tv/index.html
```

for Android TV.

Multimedia. The apps use a range of Android multimedia capabilities, including graphics, images, frame-by-frame animation and audio.

Uploading Apps to Google Play. Chapter 10, Google Play and App Business Issues, discusses Google Play and setting up a merchant account so you can sell your apps. You'll learn how to prepare apps for submission to Google Play, find tips for pricing your apps, and find resources for monetizing them with in-app advertising and in-app sales of virtual goods. You'll also find resources for marketing your apps. Chapter 10 can be read after Chapter 1.

Pedagogic Features

Syntax Coloring. For readability, we syntax color the code, similar to Android Studio's use of syntax coloring. Our syntax-coloring conventions are as follows:

```
comments appear like this
keywords appear like this
constants and literal values appear like this
all other code appears like this
```

Code Highlighting. We emphasize the key code segments in each program by enclosing them in yellow rectangles.

Using Fonts for Emphasis. We use various font conventions:

- The defining occurrences of key terms appear **bold maroon** for easy reference.
- On-screen IDE components appear in **bold Helvetica** (e.g., the **File** menu).
- Program source code appears in `Lucida` (e.g., `int x = 5;`).

In this book you'll create GUIs using a combination of visual programming (point-and-click, drag-and-drop) and writing code. We use different fonts when we refer to GUI elements in program code versus GUI elements displayed in the IDE:

- When we refer to a GUI component that we create in a program, we place its class name and object name in a `Lucida` font—e.g., `Button saveContactButton`.
- When we refer to a GUI component that's part of the IDE, we place the component's text in a **bold Helvetica** font and use a plain text font for the component's type—e.g., "the **File** menu" or "the **Run** button."

Using the > Character. We use the **>** character to indicate selecting a menu item from a menu. For example, we use the notation **File > New** to indicate that you should select the **New** menu item from the **File** menu.

Source Code. All of the book's source code is available for download from

```
http://www.deitel.com/books/AndroidFP3
```

Documentation. All the Android documentation you'll need to develop Android apps is available at

```
http://developer.android.com
```

An overview of Android Studio is available at

```
http://developer.android.com/tools/studio/index.html
```

Chapter Objectives. Each chapter begins with a list of learning objectives.

Figures. Numerous tables, source-code listings and screenshots are included.

Software Engineering. We stress program clarity and performance, and we concentrate on building well-engineered, object-oriented software.

Index. We include an extensive index for reference. The page number of the defining occurrence of each key term is highlighted in **bold maroon**.

Working with Open-Source Apps

The numerous free, open-source Android apps available online are excellent resources for learning Android app development. We encourage you to download open-source apps and read their source code to understand how they work.

Caution: The terms of open-source licenses vary considerably. Some allow you to use the app's source code freely for any purpose, while others stipulate that the code is available for personal use only—not for creating for-sale or publicly available apps. **Be sure to read the licensing agreements carefully. If you wish to create a commercial app based on an open-source app, you should consider having an intellectual-property attorney read the license; be aware that these attorneys charge significant fees.**

Android 6 App-Development Fundamentals LiveLessons Video Training Products

Our *Android 6 App-Development Fundamentals* LiveLessons videos show you what you need to know to start building robust, powerful Android apps with Android 6, the Java™ programming language and Android Studio. Included are approximately 16–20 hours of expert training synchronized with *Android 6 for Programmers: An App-Driven Approach*. For additional information about Deitel LiveLessons video products, visit

```
http://www.deitel.com/livelessons
```

or contact us at `deitel@deitel.com`. You also can access our LiveLessons videos if you have a subscription to `SafariBooksOnline.com`. For a free 10-day trial, register at

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http://www.safaribooksonline.com/register
```

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```
http://www.deitel.com/newsletter/subscribe.html
```

Contacting the Authors

We'd sincerely appreciate your comments, criticisms, corrections and suggestions for improvement. Please address all questions and other correspondence to

```
deitel@deitel.com
```

We'll respond promptly and post corrections and clarifications as Android evolves at:

```
http://www.deitel.com/books/AndroidFP3
```

and on Facebook, LinkedIn, Twitter, Google+ and the *Deitel® Buzz Online*.

Visit `http://www.deitel.com` to

- download code examples
- check out the growing list of online programming Resource Centers
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- receive information on our *Dive Into® Series* instructor-led programming-language training courses offered at customer sites worldwide.

Acknowledgments

Thanks to Barbara Deitel for long hours devoted to this project—she created all of our Android Resource Centers and patiently researched hundreds of technical details.

We appreciate the efforts and 20-year mentorship of our friend and professional colleague Mark L. Taub, Editor-in-Chief of the Pearson Technology Group. Mark and his team publish all of our professional books and LiveLessons video products. Michelle Housley recruited distinguished members of the Android community to review the manuscript. We selected the cover art and Chuti Prasertsith designed the cover. John Fuller manages the production of all of our Deitel Developer Series books.

We thank Michael Morgano, a former colleague of ours at Deitel & Associates, Inc., now an Android developer at PHHHOTO, who co-authored the first editions of this book and our book, *iPhone for Programmers: An App-Driven Approach*. Michael is an extraordinarily talented software developer.

Finally, we thank Abbey Deitel, former President of Deitel & Associates, Inc., and a graduate of Carnegie Mellon University's Tepper School of Management where she received a B.S. in Industrial Management. Abbey managed the business operations of Deitel & Associates, Inc. for 17 years, along the way co-authoring a number of our publications, including the previous editions' versions of Chapters 1 and 10.

Reviewers of the Content from* Android 6 for Programmers: An App-Driven Approach *and* Android How to Program *Recent Editions

We'd like to thank the following professionals and academics who reviewed this book and/or its previous editions. They scrutinized the text and the code and provided countless suggestions for improving the presentation: Paul Beusterien (Principal, Mobile Developer Solutions), Eric J. Bowden, COO (Safe Driving Systems, LLC), Tony Cantrell (Georgia Northwestern Technical College), Ian G. Clifton (Independent Contractor, Android App Developer and author of *Android User Interface Design: Implementing Material Design for Developers, 2nd Edition*), Daniel Galpin (Android Advocate and author of *Intro to Android Application Development*), Jim Hathaway (Application Developer, Kellogg Company), Douglas Jones (Senior Software Engineer, Fullpower Technologies), Charles Lasky (Nagautuck Community College), Enrique Lopez-Manas (Lead Android Architect, Sixt, and Computer Science Teacher at the University of Alcalá in Madrid), Sebastian Nykopp (Chief Architect, Reaktor), Michael Pardo (Android Developer, Mobiata), Luis Ramirez (Lead Android Engineer at Reverb), Ronan "Zero" Schwarz (CIO, OpenIntents), Arijit Sengupta (Wright State University), Donald Smith (Columbia College), Jesus Ubaldo Quevedo-Torrero (University of Wisconsin, Parkside), Dawn Wick (Southwestern Community College) and Frank Xu (Gannon University).

Well, there you have it! *Android 6 for Programmers: An App-Driven Approach* will quickly get you started developing Android apps with Android 6 and Android Studio. We hope you enjoy reading the book as much as we enjoyed writing it!

Paul Deitel
Harvey Deitel

About the Authors

Paul Deitel, CEO and Chief Technical Officer of Deitel & Associates, Inc., is a graduate of MIT, where he studied Information Technology. He holds the Java Certified Programmer and Java Certified Developer designations and is an Oracle Java Champion. Paul was also named as a Microsoft® Most Valuable Professional (MVP) for C# in 2012–2014.

Through Deitel & Associates, Inc., he has delivered hundreds of programming courses worldwide to clients, including Cisco, IBM, Siemens, Sun Microsystems, Dell, Fidelity, NASA at the Kennedy Space Center, the National Severe Storm Laboratory, White Sands Missile Range, Rogue Wave Software, Boeing, SunGard, Nortel Networks, Puma, iRobot, Invensys and many more. He and his co-author, Dr. Harvey Deitel, are the world's best-selling programming-language textbook/professional book/video authors.

Dr. Harvey Deitel, Chairman and Chief Strategy Officer of Deitel & Associates, Inc., has over 50 years of experience in the computer field. Dr. Deitel earned B.S. and M.S. degrees in Electrical Engineering from MIT and a Ph.D. in Mathematics from Boston University—he studied computing in each of these programs before they spun off Computer Science departments. He has extensive college teaching experience, including earning tenure and serving as the Chairman of the Computer Science Department at Boston College before founding Deitel & Associates, Inc., in 1991 with his son, Paul. The Deitels' publications have earned international recognition, with translations published in Japanese, German, Russian, Spanish, French, Polish, Italian, Simplified Chinese, Traditional Chinese, Korean, Portuguese, Greek, Urdu and Turkish. Dr. Deitel has delivered hundreds of programming courses to corporate, academic, government and military clients.

Alexander Wald, a Deitel summer intern, helped us convert the book and our Android apps from Android 4.3 and 4.4 using Eclipse to Android 6 using Android Studio. Alexander is currently pursuing a B.S. in Computer Science at Worcester Polytechnic Institute with a minor in Electrical Engineering. He became interested in mathematics and the sciences at an early age and has been writing code for approximately 9 years. He's motivated by his passion to be creative and innovative and his interest in sharing his knowledge with others.

About Deitel & Associates, Inc.

Deitel & Associates, Inc., founded by Paul Deitel and Harvey Deitel, is an internationally recognized authoring and corporate training organization, specializing in Android and iOS app development, computer programming languages, object technology and Internet and web software technology. The company's clients include many of the world's largest corporations, government agencies, branches of the military, and academic institutions. The company offers instructor-led training courses delivered at client sites worldwide on major programming languages and platforms, including Android app development, iOS app development, Swift™, Java™, C++, C, Visual C#®, Visual Basic®, Internet and web programming and a growing list of additional programming and software-development courses.

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```
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```

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```
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```

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```
      http://www.informit.com/store/sales.aspx
```

Before You Begin

In this section, you'll set up your computer for use with this book. Google frequently updates the Android™ development tools, so before reading this section, check the book's website

```
http://www.deitel.com/books/AndroidFP3
```

to see if we've posted an updated version of this Before You Begin section.

Software and Hardware System Requirements

To develop Android apps, you need a Windows®, Linux® or Mac® OS X® system. To view the latest operating-system requirements visit

```
http://developer.android.com/sdk/index.html#Requirements
```

and scroll down to the **System Requirements** heading. We developed the apps in this book using the following software:

- Java SE 7 Software Development Kit
- Android Studio 1.4 Integrated Development Environment (IDE)
- Android 6 SDK (API 23)

You'll see how to obtain each of these in the following sections.

Installing the Java Development Kit (JDK)

Android requires the Java Development Kit version 7 (JDK 7). All Java language features in JDK 7 are supported in Android Studio, but the `try`-with-resources statement is supported only for Android platform versions with API levels 19 and higher. To download JDK 7 for Windows, OS X or Linux, go to

```
http://www.oracle.com/technetwork/java/javase/downloads/java-
   archive-downloads-javase7-521261.html
```

Choose the appropriate 32-bit or 64-bit version for your computer hardware and operating system. Be sure to follow the installation instructions at

```
http://docs.oracle.com/javase/7/docs/webnotes/install/index.html
```

Android does not yet support Java 8 language features, such as lambda expressions, new interface features and the stream APIs. You can use JDK 8 (as we did when developing this book's apps), provided that you use no Java 8 language features in your code.

Installing Android Studio

Google's Android Studio comes with the latest Android Software Development Kit (SDK) and is based on the popular Java IDE from JetBrains called IntelliJ® IDEA. To download Android Studio, go to

```
http://developer.android.com/sdk/index.html
```

and click the **Download Android Studio** button. When the download completes, run the installer and follow the on-screen instructions to complete the installation. If you previously installed an earlier Android Studio version, a **Complete Installation** window will appear at the end of the install process and give you the option to import your previous settings. At the time of this writing, Android Studio 1.4 is the current released version and Android Studio 1.5 is available as an early access release.

Using Early Access Releases

When building apps for release to Google Play or other app stores, it's best to use the currently released version of Android Studio. If you'd like to work with new features in Android Studio early access and beta releases, Google releases these versions in the so-called **Canary Channel** and **Beta Channel**. You can configure Android Studio to obtain updates from these channels. To update Android Studio to the latest early access or beta release:

1. Open Android Studio.
2. In the **Welcome to Android Studio** window, click **Configure**.
3. Click **Check for Update**.
4. In the **Platform and Plugin Updates** dialog, click the **Updates** link.
5. In the **Updates** dialog, select **Canary Channel** or **Beta Channel** from the drop-down to the right of the **Automatically check updates for** checkbox.
6. Click **OK**, then click **Close**.
7. Click **Check for Update** again.
8. The IDE will check for updates and tell you whether there are updates to apply.
9. Click **Update and Restart** to install the latest Android Studio version.

If you've previously opened a project in Android Studio and did not close the project, the IDE skips the **Welcome to Android Studio** window and opens the last project. In this case, you can access the **Updates** dialog on a Mac via **Android Studio > Check for Updates...** or on Windows/Linux via **Help > Check for Update...**. Then continue from *Step 4* above. For a Google's list of Android Studio Tips and Tricks, visit:

```
http://developer.android.com/sdk/installing/studio-tips.html
```

Configure Android Studio to Show Line Numbers

By default, Android Studio does not show line numbers next to the code that you write. To turn on line numbers to make it easier to follow our line-numbered code examples:

1. Open Android Studio ( ).

2. When the **Welcome to Android Studio** window appears, click **Configure**, then click **Settings** to open the **Default Settings** window. If the **Welcome to Android Studio** window does not appear, use the menus on Mac to select **Android Studio > Preferences...** or on Windows/Linux to select **File > Other Settings > Default Settings...**.
3. Expand the **Editor > General** node and select **Appearance**, then ensure that **Show line numbers** is selected and click **OK**.

Configure Android Studio to Disallow Code Folding

By default, Android Studio's code-folding feature is enabled. This feature collapses multiple lines of code into a single line so you can focus on other aspects of the code. For example, all the `import` statements in a Java source-code file can be collapsed into a single line to hide them, or an entire method can be collapsed into a single line. You can expand these lines if you need to look at the code in detail. We disabled this feature in our IDE. If you wish to do so, follow the steps in the preceding section, then under **Editor > General > Code Folding** uncheck **Show code folding outline**.

Android 6 SDK

This book's code examples were written using Android 6. At the time of this writing, the Android 6 SDK was bundled with Android Studio. As new Android versions are released, the latest version will be bundled, which may prevent our apps from compiling properly. When you work with this book, we recommend using Android 6. You can install prior Android platform versions as follows:

1. Open Android Studio ( ).
2. When the **Welcome to Android Studio** window appears, click **Configure**, then click **SDK Manager** to display the **Android SDK** manager. If a project window appears rather than the **Welcome to Android Studio** window, you can access the **Android SDK** manager via **Tools > Android > SDK Manager**.
3. In the SDK Platforms tab, check the versions of Android you wish to install, then click **Apply** and **OK**. The IDE then downloads and installs the additional platform versions. The IDE also will help you keep your installed versions up-to-date.

Creating Android Virtual Devices (AVDs)

The Android SDK's **Android emulator** allows you to test apps on your computer rather than on an Android device—this is essential, of course, if you do not have Android devices. To do so, you create Android Virtual Devices (AVDs) that run in the emulator. The emulator can be slow, so most Android developers prefer testing on actual devices. Also, the emulator does not support various features, including phone calls, USB connections, headphones and Bluetooth. For the latest emulator capabilities and limitations, visit

```
    http://developer.android.com/tools/devices/emulator.html
```

That page's **Using Hardware Acceleration** section discusses features that can improve emulator performance, such as using the computer's graphics processing unit (GPU) to increase graphics performance, and using the Intel HAXM (hardware accelerated execution manager) emulator to increase overall AVD performance. There are also faster third-party emulators, such as Genymotion.

After you've installed the Android Studio and before you run an app in the emulator, you must create at least one **Android Virtual Device** (**AVD**) for Android 6. Each AVD defines the characteristics of the device you wish to emulate, including

- its screen size in pixels
- its pixel density
- its screen's physical size
- the size of the SD card for data storage
- and more.

To test your apps for multiple Android devices, you can create AVDs that emulate each unique device. You also can use Google's new Cloud Test Lab

```
https://developers.google.com/cloud-test-lab/
```

a website that will enable you to upload your app and test it on many of today's popular Android devices. By default, Android Studio creates for you one AVD that's configured to use the version of Android bundled with the IDE. For this book, we use AVDs for two of Google's Android reference devices—the Nexus 6 phone and the Nexus 9 tablet—which run standard Android without the modifications made by many device manufacturers. It's easiest to create AVDs in Android Studio once you already have a project open in the IDE. For this reason, we'll show how to create the Android 6 AVDs in Section 1.9.

Setting Up an Android Device for Testing Apps

Testing apps on Android devices tends to be quicker than using AVDs. In addition, recall that there are some features you can test only on actual devices. To execute your apps on Android devices, follow the instructions at

```
http://developer.android.com/tools/device.html
```

If you're developing on Microsoft Windows, you'll also need the Windows USB driver for Android devices that you installed earlier in this Before You Begin section. In some cases on Windows, you may also need the manufacturer's device-specific USB drivers. For a list of USB driver sites for various device brands, visit

```
http://developer.android.com/tools/extras/oem-usb.html
```

Downloading the Book's Code Examples

The source code for *Android 6 for Programmers: An App-Driven Approach* is available for download at

```
http://www.deitel.com/books/AndroidFP3/
```

Click the **Download Code Examples** link to download a ZIP archive file containing the examples to your computer. Depending on your operating system, double click the ZIP file to unzip the archive or right click and select the option to extract the archive's contents. Remember where the extracted files are located on your system so you can access them later.

A Note Regarding Android Studio and the Android SDK

If you import one of our apps into Android Studio and it does not compile, this could be the result of updates to Android Studio or the Android platform tools. For such issues, please check Android questions and answers on StackOverflow at:

```
http://stackoverflow.com/questions/tagged/android
```

and the Google+ Android Development community at:

```
http://bit.ly/GoogleAndroidDevelopment
```

or write to us at

```
deitel@deitel.com
```

You've now installed all the software and downloaded the code examples you'll need to study Android app development with *Android 6 for Programmers: An App-Driven Approach* and to begin developing your own apps. Enjoy!

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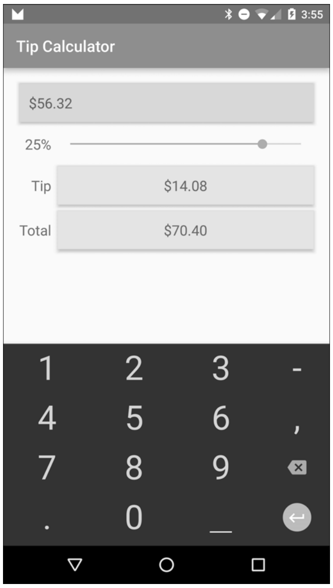
3

Tip Calculator App

Introducing GridLayout, EditText, SeekBar, Event Handling, NumberFormat, Customizing the App's Theme and Defining App Functionality with Java



Objectives

In this chapter you'll:

- Change the default GUI theme.
- Customize the GUI theme's colors.
- Design a GUI using a GridLayout.
- Use the IDE's **Component Tree** window to add views to a GridLayout.
- Use TextViews, an EditText and a SeekBar.
- Use Java object-oriented programming capabilities, including classes, objects, interfaces, anonymous inner classes and inheritance to add functionality to an app.
- Programmatically change the text in a TextView.
- Use event handling to respond to user interactions with an EditText and a SeekBar.
- Specify that the keypad should display by default when the app executes.
- Specify that the app supports only portrait orientation.

Outline

3.1 Introduction

The **Tip Calculator** app (Fig. 3.1(a)) calculates and displays the tip and total for a restaurant bill amount. As you touch the numeric keypad to enter the bill amount's digits, the app calculates and displays the tip and total bill amounts for the current tip percentage (15% by default). You specify a tip percentage from 0% to 30% by moving the `SeekBar` *thumb*—this updates the displayed tip percentage and recalculates the tip and total. All numeric values are displayed using *locale-specific* formatting. Figure 3.1(b) shows the app after the user enters the amount 56.32 and changes the tip percentage to 25%.

You'll begin by test-driving the app. Then we'll overview the technologies you'll use to create the app. You'll build the app's GUI using Android Studio's layout editor and the **Component Tree** window. Finally, we'll present the complete Java code for the app and do a detailed code walkthrough.

Note Regarding the Keyboard in Our Screen Captures

The keypad in Fig. 3.1 may differ, based on your AVD's or device's Android version or whether you've installed and selected a custom keyboard on your device. We configured our AVD to display the *dark keyboard* for better contrast in our screen captures. To do so:

1. Touch the home (●) icon on your AVD or device.

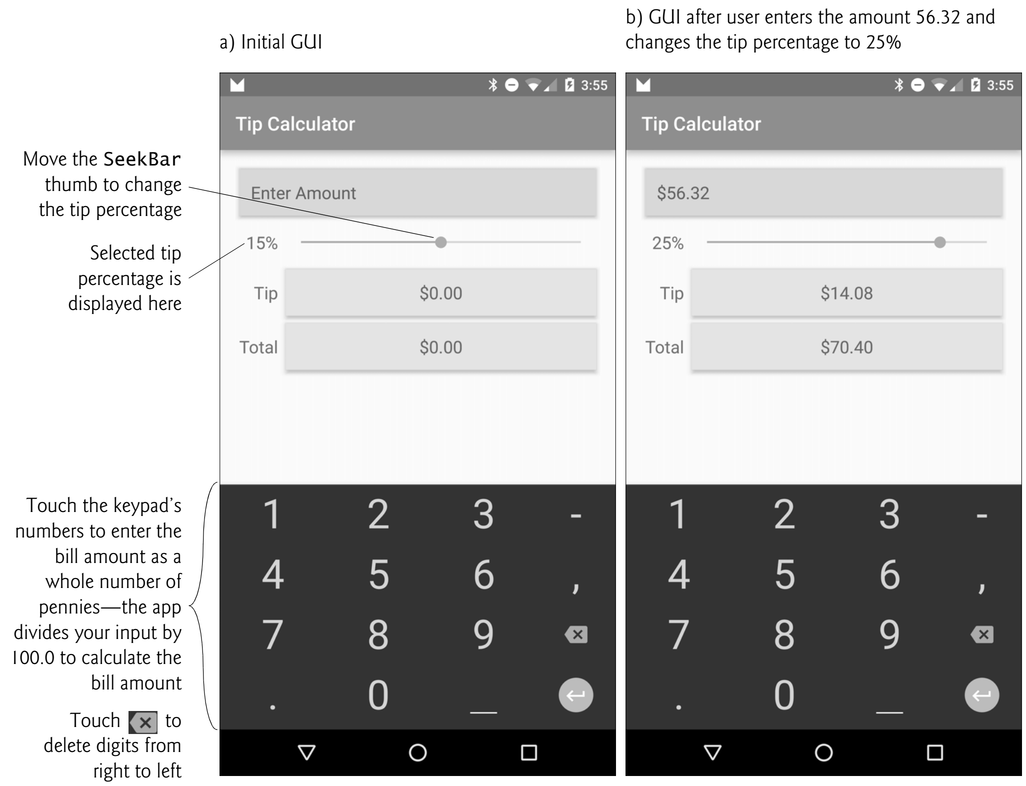

a) Initial GUI
b) GUI after user enters the amount 56.32 and changes the tip percentage to 25%
Move the SeekBar thumb to change the tip percentage
Selected tip percentage is displayed here
Touch the keypad's numbers to enter the bill amount as a whole number of pennies—the app divides your input by 100.0 to calculate the bill amount
Touch ☒ to delete digits from right to left
3:55
Tip Calculator
Enter Amount
15%
Tip
$0.00
Total
$0.00
$56.32
25%
$14.08
$70.40
1 2 3 -
4 5 6 ,
7 8 9
. 0 _

Fig. 3.1 | Entering the bill total and calculating the tip.

2. On the home screen, touch the launcher (⋮⋮⋮) icon, then open the **Settings** app.
3. In the **Personal** section, touch **Language and Input.**
4. On an AVD, touch **Android Keyboard (AOSP).** On a device touch **Google Keyboard**—we assume you're using the standard Android keyboard.
5. Touch **Appearance & layouts**, then touch **Theme.**
6. Touch **Material Dark** to change to the keyboard with the dark background.

3.2 Test-Driving the Tip Calculator App

Opening and Running the App

Perform the steps in Sections 1.9.1 and 1.9.3 to open the **Tip Calculator** app project in Android Studio and run the app on the Nexus 6 AVD. If you prefer, perform the steps in Section 1.9.4 to run the app on an Android phone.

Entering a Bill Total

Enter the bill total `56.32` by touching numbers on the numeric keypad. If you make a mistake, press the keypad's delete button (☒) to erase the last digit you entered. Even though the keypad contains a decimal point, the app is configured so that you may enter only the digits 0 through 9—other input buttons on the keypad are ignored and an Android device will vibrate to indicate when you touch an invalid input button. Each time you touch a digit or delete a digit, the app reads what you've entered so far, and

- converts it to a number
- divides the number by 100.0 and displays the new bill amount
- recalculates the tip and total amounts, based on the current tip percentage (**15%** by default) and
- displays in the **Tip** and **Total** `TextViews` the new tip and total amounts.

If you delete all the digits, the app redisplays **Enter Amount** in the blue `TextView` and displays 0.00 in the orange `TextViews`. The app divides the value by 100.0 and displays the result in the blue `TextView`. The app then calculates and updates the tip and total amounts in the orange `TextViews`.

All monetary amounts are displayed in locale-specific currency formats and the tip percentage is displayed in a locale-specific percentage format. For the U.S. locale, as you enter the four digits `5`, `6`, `3` and `2`, the bill total is displayed successively as **$0.05**, **$0.56**, **$5.63** and **$56.32**, respectively.

Selecting a Tip Percentage
Use the `Seekbar`—often called a *slider* in other GUI technologies—to specify the tip percentage. Drag the `Seekbar`'s *thumb* until the percentage reads **25%** (Fig. 3.1(b)). As you drag the thumb, the tip and total update continuously. By default, the `Seekbar` allows you to select values from 0 to 100, but we specified a maximum value of 30 for this app.

3.3 Technologies Overview

This section introduces the IDE and Android features you'll use to build the **Tip Calculator** app. We assume that you're already familiar with Java object-oriented programming—we present Java in our book *Java SE 8 for Programmers* (`http://bit.ly/JavaSE8FP`). You'll

- use various Android classes to create objects
- call methods on classes and objects
- define and call your own methods
- use inheritance to create a class that defines the **Tip Calculator**'s functionality and
- use event handling, anonymous inner classes and interfaces to process the user's GUI interactions.

3.3.1 Class `Activity`

Android apps have four types of executable components—*activities*, *services*, *content providers* and *broadcast receivers*. In this chapter, we'll discuss activities, which are defined as subclasses of **`Activity`** (package **`android.app`**). An app can have many activities, one of which is the first you see after launching the app. You interact with an `Activity` through views—GUI components that inherit from class **`View`** (package `android.view`).

Before Android 3.0, a separate `Activity` was typically associated with each screen of an app. As you'll see, starting in Chapter 4, an `Activity` can manage multiple `Fragments`.

On a phone, each `Fragment` typically occupies the entire screen and the `Activity` switches between the `Fragments`, based on user interactions. On a tablet, activities typically display multiple `Fragments` per screen to take advantage of the larger screen size.

3.3.2 `Activity` Lifecycle Methods

Throughout its life, an `Activity` can be in one of several *states*—*active* (i.e., *running*), *paused* or *stopped*. The `Activity` transitions between these states in response to various *events*:

- An *active* `Activity` is *visible* on the screen and "has the focus"—that is, it's in the *foreground*. You can interact with the `Activity` currently in the foreground.
- A *paused* `Activity` is *visible* on the screen but *does not* have the focus—such as when an alert dialog is displayed. You cannot interact with the *paused* activity until it becomes active—for example, after the user dismisses an alert dialog.
- A *stopped* activity is *not visible* on the screen—it's in the *background* and is likely to be killed by the system when its memory is needed. An `Activity` is *stopped* when another `Activity` enters the *foreground* and becomes *active*. For example, when you answer a phone call, the phone app becomes *active* and the app you previously were using is *stopped*.

As an `Activity` transitions among these states, the Android runtime calls various `Activity` *lifecycle methods*—all of which are defined by the `Activity` class in package `android.app`. You'll override the **`onCreate`** method in *every* activity. This method is called by the Android runtime when an `Activity` is *starting*—that is, when its GUI is about to be displayed so you can interact with the `Activity`. Other lifecycle methods include `onStart`, `onPause`, `onRestart`, `onResume`, `onStop` and `onDestroy`. We'll discuss most of these in later chapters. Each activity lifecycle method you override *must* call the superclass's version; otherwise, an *exception* will occur. This is required because each lifecycle method in superclass `Activity` contains code that must execute in addition to the code you define in your overridden lifecycle methods. For more on the `Activity` lifecycle see

```
http://developer.android.com/reference/android/app/Activity.html
```

3.3.3 AppCompat Library and Class `AppCompatActivity`

A big challenge developers face when using new Android features is backward compatibility with earlier Android platforms. Google now introduces many new Android features via the *Android Support Library*—a set of libraries that enable you to use newer Android features in apps targeting current and past Android platforms.

One such library is the `AppCompat` library, which enables apps to provide an app bar (formerly called an action bar) and more on devices running Android 2.1 (API 7) and higher—app bars were originally introduced in Android 3.0 (API 11). Android Studio's app templates have been updated to use the `AppCompat` library, enabling the new apps you create to run on almost all Android devices.

Android Studio's **Empty Activity** app template defines the app's `MainActivity` class as a subclass of **`AppCompatActivity`** (package **`android.support.v7.app`**)—an indirect subclass of `Activity` that supports using newer Android features in apps running on current and older Android platforms.

Software Engineering Observation 3.1

By creating apps with the `AppCompat` library from the start, you avoid having to reimplement your code if you decide to support older Android versions to target a wider potential audience for your app.

Software Engineering Observation 3.2

Some Android features are not available in earlier Android versions, even if you use the `AppCompat` libraries. For example, Android's printing capabilities are available only in Android 4.4 and higher. If you use such features in your app, you must either restrict the app to the supported platforms or disable those features on Android versions that do not support them.

For more details on Android Support Libraries, including when to use them and how to set them up, visit:

```
http://developer.android.com/tools/support-library
```

3.3.4 Arranging Views with a `GridLayout`

Recall that you arrange a GUI's views in layouts. We'll use a **`GridLayout`** (package **`android.widget`**) to arrange views into cells in a rectangular grid. Cells can occupy *multiple* rows and columns, allowing for complex layouts. Normally, `GridLayout` requires API level 14 or higher. However, the *Android Support Library* provides alternate versions of `GridLayout` and many other views and layouts so that you can use them in older Android versions. For more information on this library and how to use it in your apps, visit

```
http://developer.android.com/tools/support-library/index.html
```

We'll cover more layouts and views in later chapters—for a complete list, visit

```
http://developer.android.com/reference/android/widget/package-
   summary.html
```

3.3.5 Creating and Customizing the GUI with the Layout Editor and the Component Tree and Properties Windows

You'll create `TextView`s, an `EditText` and a `SeekBar` using the layout editor (that you used in Chapter 2) and **Component Tree** window, then customize them with the IDE's **Properties** window.

An **`EditText`**—often called a *text box* or *text field* in other GUI technologies—is a *subclass* of `TextView` (presented in Chapter 2) that can display text *and* accept text input from the user. You'll specify an `EditText` for numeric input, allow users to enter only digits and restrict the maximum number of digits that can be entered.

A **`SeekBar`** represents an integer in the range 0–100 by default and allows the user to select a number in that range by moving the `SeekBar`'s thumb. You'll customize the `SeekBar` so the user can choose a tip percentage from the more limited range 0 to 30.

3.3.6 Formatting Numbers as Locale-Specific Currency and Percentage Strings

You'll use class **`NumberFormat`** (package **`java.text`**) to create *locale-specific* currency and percentage strings—an important part of *internationalizing* your apps. You also can add *accessibility* strings and internationalize the app's other text using the techniques you learned in Sections 2.7–2.8.

3.3.7 Implementing Interface `TextWatcher` for Handling `EditText` Text Changes

To respond to events when the user changes the text in this app's `EditText`, you'll use an *anonymous inner class* to implement the **`TextWatcher`** *interface* (from package **`android.text`**). In particular, you'll use method `onTextChanged` to display the currency-formatted bill amount and to calculate the tip and total as the user enters each digit. If you're not familiar with *anonymous inner classes*, visit

```
http://bit.ly/AnonymousInnerClasses
```

3.3.8 Implementing Interface `OnSeekBarChangeListener` for Handling `SeekBar` Thumb Position Changes

You'll use another anonymous inner class to implement the **`SeekBar.OnSeekBarChange-Listener`** interface (from package `android.widget`) to respond to the user moving the `SeekBar`'s *thumb*. In particular, you'll use method `onProgressChanged` to display the selected tip percentage and to calculate the tip and total as the user moves the `SeekBar`'s thumb.

3.3.9 Material Themes

A theme gives an app a look-and-feel that's consistent with Android. Projects that you create for Android 5 and higher use themes that adhere to Google's material design guidelines. There are several predefined material design themes:

- The "light" theme has a white app bar, a white app background and text that is black or shades of dark gray.
- The "light" theme with a dark app bar is the same as above, but the app bar is black with white text by default.
- The "dark" has a black app bar, a dark gray app background and text that is white or shades of light gray.

For each of these themes, there is

- a `Theme.Material` version (e.g., `Theme.Material.Light`) for apps that do not use any `AppCompat` libraries and run on Android 5 and higher, and
- a `Theme.AppCompat` version (e.g., `Theme.AppCompat.Light`) for apps that use `AppCompat` libraries and run on Android 2.1 and higher.

When designing a GUI, you can choose from the predefined themes, or even create your own new ones. For this chapter, we'll use **`Theme.AppCompat.Light.DarkActionBar`**, which is the default theme in Android Studio's app templates. Apps that use the `AppCompat` libraries must use one of the `AppCompat` themes; otherwise, some views will not render correctly. For more information about each theme and to see sample screen captures, visit

```
http://www.google.com/design/spec/style/color.html#color-themes
http://developer.android.com/training/material/theme.html
```

Performance Tip 3.1

Many of today's Android phones use AMOLED displays. On such displays, a black pixel is turned off and does not consume power. Apps that use mostly black themes can reduce power consumption by approximately 40% (`http://bit.ly/AndroidAMOLEDDisplay`).

3.3.10 Material Design: Elevation and Shadows

Google's material design guidelines recommend that objects in your user interfaces cast shadows just as real-world objects do. When you set a view's **`elevation` property**, Android automatically casts a shadow for that view. Larger `elevation` values result in more pronounced shadows. For this app, we'll set the `elevation` of the blue and orange `TextViews` that display monetary amounts.

The material design guidelines contain elevation recommendations for various on-screen components—for example, a dialog's recommended elevation is `24dp` and a menu's is `8dp`. For other recommended elevations, see:

```
http://www.google.com/design/spec/what-is-material/elevation-
   shadows.html
```

3.3.11 Material Design: Colors

App developers often customize a theme's colors to match a company's branding. If you need to customize theme colors, Google's material design guidelines for color[1] recommend that you choose a color palette consisting of a primary color—with no more than three hues (shades)—and an accent color. The primary colors typically are used to color the status bar and the app bar at the top of the screen and also can be used in your GUI. The accent color is used to tint various views in your GUI, such as `SeekBars`, `CheckBoxes` and `RadioButtons`. Once you choose a palette, you can use Android Studio's **Theme Editor** (Section 3.5.2) to modify a theme's colors.

You can find recommended sample color swatches from the material design color palette at

```
http://www.google.com/design/spec/style/color.html#color-color-
   palette
```

For palette color recommendations, visit

```
http://www.materialpalette.com/
```

This site enables you to click two colors from Google's material design color palette, then it recommends three shades of the primary color, one secondary color and colors for your app's text and icons.

In this app, we'll use color swatches displayed in the Android Studio **Theme Editor** to select

- a blue *primary color* for app bar's background color
- a darker blue *dark primary color* for the status bar that appears above the app bar, and
- an orange *accent color* used to tint the `SeekBar`.

1. `http://www.google.com/design/spec/style/color.html`.

For the amount `TextView`'s light blue color and the tip and total `TextViews`' light orange color, we used Google's material design color palette to choose lighter shades of the primary and accent colors.

3.3.12 `AndroidManifest.xml`

The **`AndroidManifest.xml`** file is created by the IDE when you create a new app project. This file contains many of the settings that you specify in the **Create New Project** dialog—the app's name, package name and `Activity` name(s) and more. You'll edit this file's XML to add a new setting that forces the *soft keyboard* to be displayed when the app begins executing. You'll also specify that the app supports only *portrait orientation*—that is, the device's longer dimension is vertical.

3.3.13 Searching in the Properties Window

The **Properties** window allows you to search for properties by their names or portions of their names, which can help you find and set properties faster. To do so, click the **Properties** window's title bar and begin typing. At the top of the property list, a **Search for** tooltip appears showing what you've typed so far, and Android Studio highlights parts of every property name in the list that matches all or part of what you've typed. Then you can scroll through the list looking at the property names containing highlights.

The window will also scroll to the specific property that best matches what you type. For example, when searching a `TextView`'s properties, if you type `"text co"` or `"textco"`, the **Properties** window will highlight portions of many properties, but it specifically scrolls to and highlights the `textColor` property.

3.4 Building the GUI

In this section, we'll show the precise steps for building the **Tip Calculator**'s GUI, including how to customize the Material theme's primary and accent colors.

3.4.1 `GridLayout` Introduction

This app uses a **`GridLayout`** (package `android.widget`) to arrange views into four *rows* and two *columns*, each indexed from 0 like the elements in an array. You can specify a `GridLayout`'s number of rows and columns in the **Properties** window. Each cell can be *empty* or can hold one or more *views*, including layouts *containing* other views. A row's *height* is determined by the row's *tallest* view. Similarly, a column's *width* is defined by the column's *widest* view. Figure 3.2 shows the **Tip Calculator**'s `GridLayout` labeled by its rows and columns—we drew horizontal lines to delineate the rows and a vertical line to delineate the columns. Views can span *multiple* rows and/or columns—for example, the **Enter Amount** `TextView` in Fig. 3.2 spans both columns in row 0.

When you drag a view onto a `GridLayout` in the **Component Tree**, the view occupies the next available grid cell—cells populate the `GridLayout` left-to-right until a given row is full, then the next view appears in the first column of the next row. As you'll see, you also can specify the exact row and column in which to place a view. We'll discuss other `GridLayout` features as we present the GUI-building steps.

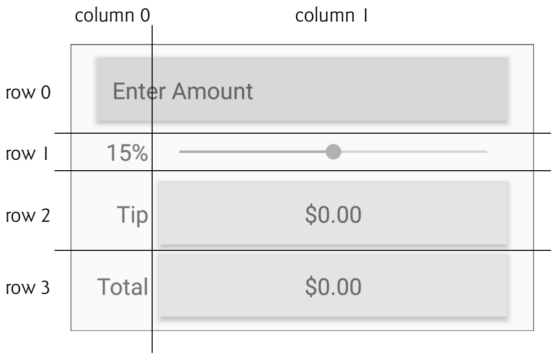


Fig. 3.2 | **Tip Calculator** GUI's `GridLayout` labeled by its rows and columns.

`id` Property Values for This App's Views

Figure 3.3 shows the views' `id` property values. For clarity, our naming convention is to use the view's class name in the `id` property and the corresponding Java variable name. In the first row, there are actually *two* components in the *same* grid cell—the `amountTextView` (which initially displays **Enter Amount**) *hides* the `amountEditText` that receives the user input. As you'll soon see, we restrict the user's input to whole-number values entered as integer digits, so the user enters the bill amount $34.56 as `3456`. This ensures the user *cannot* enter invalid input. However, this amount should be displayed as *currency*. As the user enters each digit, we divide the amount by 100.0 and display in the `amountTextView` the locale-specific, currency-formatted amount.

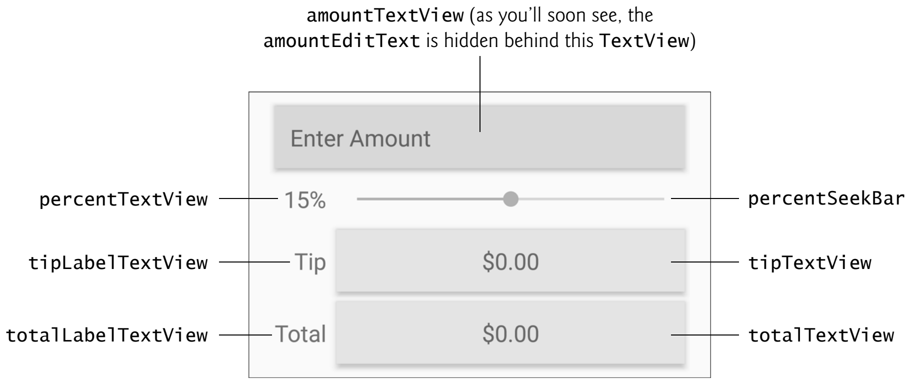


Fig. 3.3 | **Tip Calculator** views labeled with their `id` property values.

3.4.2 Creating the `TipCalculator` Project

Follow the steps in Section 2.3 to create a new project using the **Empty Activity** template. Specify the following values in the **Create New Project** dialog's **New Project** step:

- **Application name:** `Tip Calculator`
- **Company Domain:** `deitel.com` (or specify your own domain name)

For the remaining steps in the **Create New Project** dialog, use the same settings as in Section 2.3. Also, follow the steps in Section 2.5.2 to add an app icon to your project.

Once the project is open in Android Studio, in the layout editor, select **Nexus 6** from the virtual-device drop-down list (Fig. 2.11). Once again, we'll use this device as the basis for our design. Also, delete the **Hello world!** `TextView`.

3.4.3 Changing to a `GridLayout`

Recall that the default layout for an **Empty Activity** is a `RelativeLayout`. Here, you'll change that to a `GridLayout`:

1. Click the **Text** tab at the bottom of the layout editor to switch from the **Design** view to the layout's XML text.
2. At the top of the XML, change `RelativeLayout` to `GridLayout`.
3. Switch back to the layout editor's **Design** tab.

Specifying Two Columns and Default Margins for the `GridLayout`

Recall that the GUI in Fig. 3.2 consists of two columns. To specify this, select `GridLayout` in the **Component Tree** window, then change its `columnCount` property to `2`—this property appears near the top of the **Properties** window with the other layout properties. You do not need to set the `rowCount`—it will be increased as we build the GUI.

By default, there are *no margins*—spacing that separates views—around a `GridLayout`'s cells. The material design guidelines recommend `8dp` minimum spacing between views:

```
http://developer.android.com/design/style/metrics-grids.html.
```

`GridLayout` can enforce this recommended spacing. With the `GridLayout` selected in the **Component Tree**, in the **Properties** window, check the `GridLayout`'s **`useDefaultMargins` property** (which sets it to `true`) to use the recommended margins around the layout's cells.

3.4.4 Adding the `TextView`s, `EditText` and `SeekBar`

You'll now build the GUI in Fig. 3.2. You'll start with the basic layout and views in this section. In Section 3.4.5, you'll customize the views' properties to complete the design. Then, in Section 3.5, you'll change the default theme and customize two of its colors. As you add each view to the GUI, immediately set its `id` property using the names in Fig. 3.3. You'll add views to the `GridLayout` using the **Component Tree** window. If you drop a view in the wrong location in the **Component Tree**, you can drag it to the correct location.

You may also drag views directly onto the layout editor. For a `GridLayout`, the layout editor displays a grid of green guidelines to help you position the view. As you drag a view over the grid, the layout editor displays a tooltip indicating the row and column in which the view will be placed if you drop the view at that location.

Error-Prevention Tip 3.1

The cells in the layout editor's grid of green guidelines are small. If you drop a view in the wrong location, the layout editor might change the `GridLayout`'s `rowCount` and `columnCount` property values and incorrectly set the view's `layout:row` and `layout:column` property values, causing your GUI to lay out incorrectly. If so, reset the `GridLayout`'s `rowCount` and `columnCount`, based on your design, and change the view's `layout:row` and `layout:column` property values to the correct row and column for your design.

Step 1: Adding Views to the First Row

The first row consists of the amountTextView and the amountEditText—both occupy the same cell and span two columns. Each time you drop a view onto the GridLayout in the **Component Tree** window, the view is placed in the layout's *next open cell*, unless you specify otherwise by setting the view's layout:row and layout:column properties. You'll do that in this step so that the amountEditText and amountTextView appear in the same cell with the amountTextView in the foreground.

This app's TextViews use the *medium*-sized font from the app's theme. The layout editor's **Palette** provides preconfigured TextViews named **Plain Text**, **Large Text**, **Medium Text** and **Small Text** (in the **Widgets** section) for various text sizes. The **Plain Text** TextView uses the theme's default font size. For the others, the IDE configures the TextView's textAppearance property using the Material theme's styles for the corresponding font sizes.

Perform the following steps to add to the GridLayout an EditText and a TextView for receiving and displaying the bill amount:

1. This app allows you to enter only *nonnegative integers*, which the app divides by 100.0 to display the bill amount. The **Palette**'s **Text Fields** section provides *preconfigured* EditTexts for various forms of input, including person names, passwords, e-mail addresses, phone numbers, times, dates and numbers. When the user interacts with an EditText, an appropriate keyboard is displayed, based on the EditText's *input type*. From the **Palette**'s **Text Fields** section, drag and drop a **Number** EditText onto the GridLayout node in the **Component Tree** window—this creates an EditText with the id editText in the GridLayout. Change the id to amountEditText. The EditText is placed in the *first* column of the GridLayout's *first* row. Set the EditText's layout:column to 0 and the layout:columnSpan to 2—these settings ensure that the TextView spans both columns of row 0.
2. Drag a **Medium Text** TextView from the **Palette**'s **Widgets** section over the amountEditText in the **Component Tree** window—a horizontal black line appears below amountEditText, indicating that the TextView will be placed after amountEditText. The IDE creates a new TextView named textView and nests it in the GridLayout node. The default text "Medium Text" appears in the layout editor. You'll change this in *Step 5* (Section 3.4.5). Change the TextView's id to amountTextView, then set the layout:row to 0, the layout:column to 0 and the layout:columnSpan to 2—these settings ensure that the TextView spans both columns of row 0, as you'll see once we change the TextView's background color.

Step 2: Adding Views to the Second Row

Next, add the percentTextView and percentSeekBar to the GridLayout for displaying and selecting the tip percentage (be sure to set each view's id to the name we specify):

1. Drag a **Medium** TextView (percentTextView) from the **Palette**'s **Widgets** section over the amountTextView in the GridLayout node in the **Component Tree** window. The new view becomes the first view in row 1 (the second row).
2. Drag a SeekBar (percentSeekBar) from the **Palette**'s **Widgets** section over the percentTextView in the GridLayout node in the **Component Tree** window. The new view becomes the second view in row 1.

Step 3: Adding Views to the Third Row

Next, add the `tipLabelTextView` and the `tipTextView` to the `GridLayout` for displaying the tip amount:

1. Drag a **Medium** `TextView` (`tipLabelTextView`) over the `percentSeekBar` in the `GridLayout` node. The new view becomes the first view in row `2` (the third row).
2. Drag a **Medium** `TextView` (`tipTextView`) over the `tipLabelTextView` in the `GridLayout` node. The new view becomes the second view in row `2`.

Step 4: Adding Views to the Fourth Row

Next, add the `totalLabelTextView` and the `totalTextView` to the `GridLayout` for displaying the tip amount:

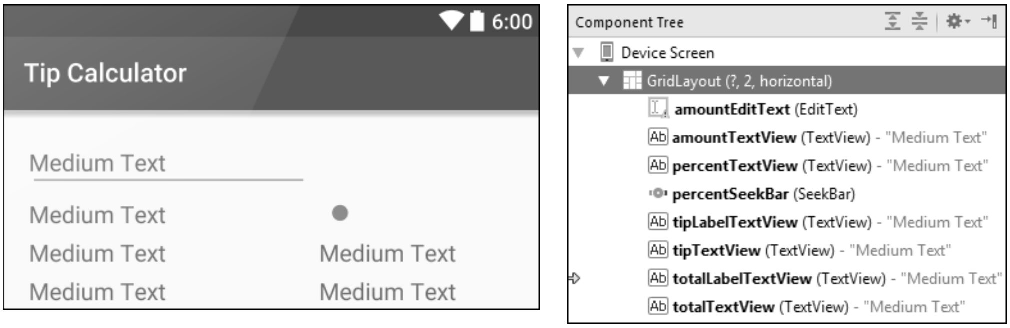
1. Drag a **Medium** `TextView` (`totalLabelTextView`) over the `tipTextView` in the `GridLayout` node. This becomes the first view in row `3` (the fourth row).
2. Drag a **Medium** `TextView` (`totalTextView`) over the `totalLabelTextView` in the `GridLayout` node. This becomes the second view in row `3`.

Reviewing the Layout So Far

The GUI and **Component Tree** window should now appear as shown in Fig. 3.4. The warning symbols shown in the layout editor and the **Component Tree** window will go away as you complete the GUI design in Section 3.4.5.

a) GUI design so far

b) **Component Tree** window showing the **Tip Calculator**'s layout and views



```
Component Tree
▼ Device Screen
    ▼ GridLayout (?, 2, horizontal)
        amountEditText (EditText)
        amountTextView (TextView) - "Medium Text"
        percentTextView (TextView) - "Medium Text"
        percentSeekBar (SeekBar)
        tipLabelTextView (TextView) - "Medium Text"
        tipTextView (TextView) - "Medium Text"
        totalLabelTextView (TextView) - "Medium Text"
        totalTextView (TextView) - "Medium Text"
```

Fig. 3.4 | GUI and the **Component Tree** window after adding the views to the `GridLayout`.

A Note Regarding the `EditText`'s Virtual Keyboard

When the virtual keyboard is displayed, the device's back button (◁) changes to a down button (▽) that enables you to dismiss the keyboard. If you do so, the down button (▽) changes to a back button (◁) that you can touch to return to the previous `Activity`—possibly a prior app or the device's home screen.

Normally, you'd touch the `EditText` to redisplay the virtual keyboard. In this app, however, the `EditText` is hidden behind a `TextView`. If you were to dismiss this app's keyboard, you'd have to leave the app and return to it to redisplay the keyboard. We could programmatically force the keyboard to stay on the screen, but this would prevent the back button from ever being displayed in this app. This, in turn, would prevent you from returning to the previous Activity—a basic Android feature that every user expects.

We used an Android virtual keyboard to demonstrate how to choose the keyboard displayed for a given EditText. Another approach would be to provide Buttons representing the digits 0–9 that always remain on the screen. We could handle their click events and use String manipulation rather than an EditText to keep track of the user input.

3.4.5 Customizing the Views

You'll now customize additional view properties. As you did in Section 2.5, you'll also create several String, dimension and color resources.

Step 5: Specifying Literal Text

Next, you'll specify the literal text for the amountTextView, percentTextView, tipLabelTextView and totalLabelTextView. When a TextView's text property is empty, its **hint property**'s value (if you specify one) is displayed—this property is commonly used with an EditText (a subclass of TextView) to help the user understand the EditText's purpose. We're using it similarly in the amountTextView to tell the user to enter a bill amount:

1. In the **Component Tree**, select amountTextView and locate its hint property in the **Properties** window.
2. Click the ellipsis (...) button to the right of the property's value to display the **Resources** dialog.
3. In the dialog, click **New Resource**, then select **New String Value...** to display the **New String Value Resource** dialog and set the **Resource name** to enter_amount and **Resource value** to "Enter Amount". Leave the other settings and click **OK** to create the new String resource and set it as amountTextView's hint.

Repeat these steps to set the text property for the percentTextView, tipLabelTextView and totalLabelTextView using the values shown in Fig. 3.5.

View	Resource name	Resource Value
percentTextView	tip_percentage	15%
tipLabelTextView	tip	Tip
totalLabelTextView	total	Total

Fig. 3.5 | String resource values and names.

Step 6: Right Aligning the TextViews in the Left Column

In Fig. 3.2, the percentTextView, tipLabelTextView and totalLabelTextView are right aligned. You can accomplish this for all three TextViews at once as follows:

1. Select the percentTextView.
2. Hold *Ctrl* on Windows/Linux or *Command* on Mac and click the tipLabelTextView and totalLabelTextView. Now all three TextViews are selected.
3. Expand the layout:gravity property's node and check the right checkbox.

Step 7: Configuring the **`amountEditText`**
In the final app, the `amountEditText` is *hidden* behind the `amountTextView` and is configured to allow only *digits* to be entered by the user. Select the `amountEditText` and set the following properties:

1. Set the **`digits`** **property** to `0123456789`—this allows *only* digits to be entered, even though the numeric keypad contains other characters, such as minus (`-`), comma (`,`) and period (`.`).
2. Set the **`maxLength`** **property** to `6`. This restricts the bill amount to a maximum of *six* digits—so the largest supported bill amount is 9999.99.

Step 8: Configuring the **`amountTextView`**
To complete the `amountTextView`'s formatting, select it and set the following properties:

1. Delete the default value of the `text` property (`"Medium Text"`)—we'll programmatically display text here, based on the user's input.
2. Expand the `layout:gravity` property's node and set the `fill` to `horizontal`. This indicates that the `TextView` should occupy all remaining horizontal space in this `GridLayout` row.
3. Set the **`background`** **property** (which specifies the view's background color) to a new color resource named `amount_background` with the value `#BBDEFB`—a light blue color chosen from Google's material design color palette.
4. Add padding around the `TextView`. A view's **`padding`** specifies extra space around a view's content. The `all` property specifies that the padding amount should be applied to the top, right, bottom and left of the view's contents. You may also set the padding for each of these individually. Expand the `padding` property's node, click the `all` property, then click the ellipsis button. Create a new dimension resource named `textview_padding` with the value `12dp`. You'll use this resource again shortly.
5. Finally, add a shadow to the view by setting the `elevation` property to a new dimension resource named `elevation` with the value `4dp`. We chose this value for demonstration purposes to emphasize the shadow effect.

Step 9: Configuring the **`percentTextView`**
Notice that the `percentTextView` is aligned higher than the `percentSeekBar`. This looks better if it's *vertically centered*. To do this, expand the `layout:gravity` property's node, then set the center value to `vertical`. Recall that you previously set the `layout:gravity` to `right`. The combination of these settings appears in the layout XML as

```
    android:layout_gravity="center_vertical|right"
```

A *vertical bar* (`|`) is used to separate multiple `layout:gravity` values—in this case indicating that the `TextView` should be *centered vertically* and *right aligned* within the grid cell.

Step 10: Configuring the **`percentSeekBar`**
Select `percentSeekBar` and configure the following properties:

1. By default, a `SeekBar`'s range is `0` to `100` and its current value is indicated by its **`progress`** **property**. This app allows tip percentages from 0 to 30 and specifies a

default of 15 percent. Set the `SeekBar`'s **`max` property** to `30` and the `progress` property to `15`.

2. Expand the `layout:gravity` property's node and set the `fill` to `horizontal` so the `SeekBar` occupies all horizontal space in the `SeekBar`'s `GridLayout` column.
3. Set the `layout:height` property to a new dimension resource (`seekbar_height`) with the value `40dp` to increase vertical space in which the `SeekBar` is displayed.

*Step 11: Configuring the **`tipTextView`** and **`totalTextView`***

To complete the formatting of the `tipTextView` and `totalTextView`, select both and set the following properties:

1. Delete the default value of the `text` property (`"Medium Text"`)—we'll programmatically display the calculated tip and total.
2. Expand the `layout:gravity` property's node and set the `fill` to `horizontal` so each `TextView` occupies all horizontal space in the `TextViews`' `GridLayout` column.
3. Set the `background` property to a new color resource named `result_background` with the value `#FFE0B2`—a light orange color chosen from Google's material design color palette.
4. Set the `gravity` property to `center` so the calculated tip and total amounts will be centered within these `TextViews`.
5. Expand the `padding` property's node, click the ellipsis button for the `all` value, then select the dimension resource named `textview_padding` that you created previously for the `amountTextView`.
6. Finally, add a shadow to each view by setting the `elevation` property to the `elevation` dimension resource you created earlier.

3.5 Default Theme and Customizing Theme Colors

Each app has a theme that defines the default look-and-feel of the standard views you use. The theme is specified in the app's `AndroidManifest.xml` file (Section 3.7). You can customize aspects of the theme, such those that define an app's color scheme, by defining **`style` resources** in the `styles.xml` file located in the in the app's `res/values` folder.

3.5.1 parent Themes

The `style.xml` resource file contains a `style` with the name `"AppTheme"` that's referenced from the app's `AndroidManifest.xml` file to specify the app's theme. This `style` also specifies a `parent` theme, which is similar to a superclass in Java—the new `style` inherits its `parent` theme's attributes and their default values. Just as in a Java subclass, a `style` can override `parent` theme attributes with values customized for specific apps. A company might do this, for example, to use the company's branding colors. We'll use this concept in Section 3.5.2 to customize three colors used in the app's theme.

As we mentioned previously, Android Studio's app templates now include support for the `AppCompat` libraries that enable you to use newer Android features in older Android versions. By default, Android Studio sets the `parent` theme to

```
Theme.AppCompat.Light.DarkActionBar
```

one of several predefined themes from the `AppCompat` library—apps that use this theme have a light background, except for the dark app bar at the top of the app. Each `AppCompat` theme uses Google's material design recommendations to style your apps' GUIs.

3.5.2 Customizing Theme Colors

Section 3.3.11 discussed where a theme's primary, dark primary and accent colors are applied in an app's on-screen elements. In this section, you'll use the new Android Studio **Theme Editor** to change the app's primary, dark primary and accent colors, thus overriding the values of the `android:colorPrimary`, `android:colorPrimaryDark` and `android:colorAccent` theme attributes shown in Fig. 3.6. These are three of many theme attributes you can override. For the complete list, visit:

```
http://developer.android.com/reference/android/R.attr.html
```

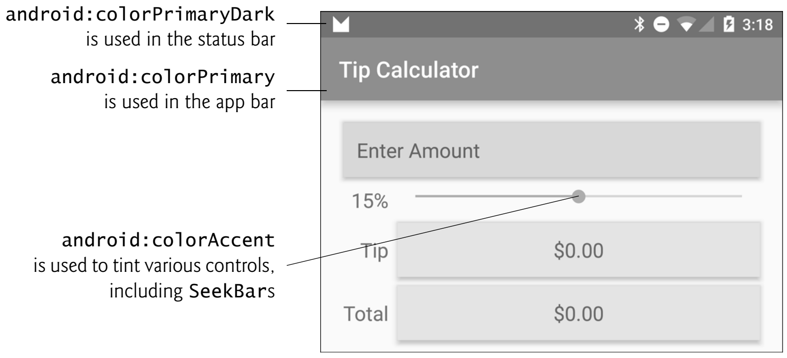

android:colorPrimaryDark is used in the status bar
android:colorPrimary is used in the app bar
android:colorAccent is used to tint various controls, including SeekBars
3:18
Tip Calculator
Enter Amount
15%
Tip
$0.00
Total
$0.00

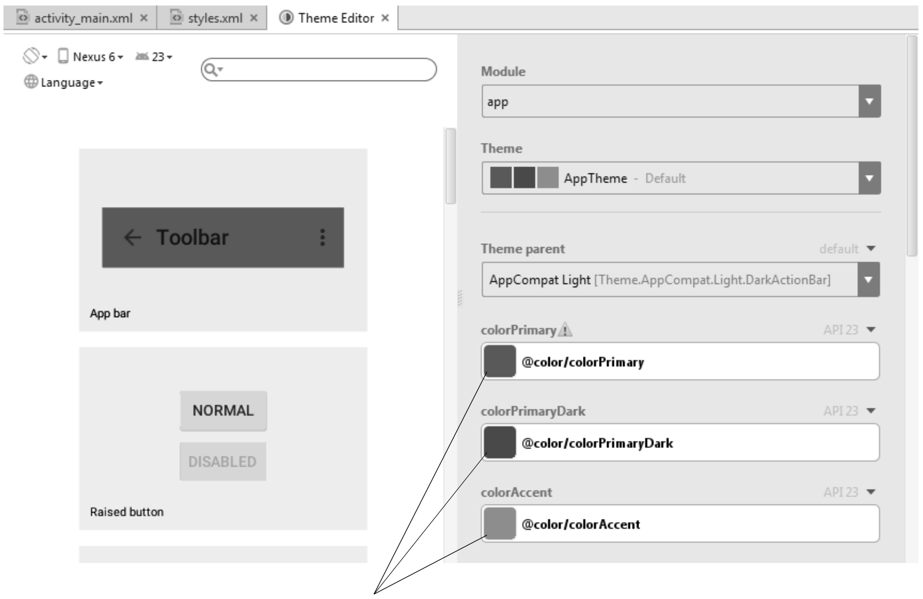
Fig. 3.6 | Theme attributes for the primary, primary dark and accent colors.

Modifying the Theme's Primary, Dark Primary and Accent Colors

To customize the colors:

1. Open `styles.xml`. In the editor's upper-right corner, click the **Open editor** link to display the **Theme Editor** (Fig. 3.7) showing the current colors for `colorPrimary` (dark blue), `colorPrimaryDark` (a darker shade of `colorPrimary`) and `colorAccent` (bright pink)—these are the default colors specified in Android Studio's **Empty Activity** app template. For this app, we'll change `colorPrimary` and `colorPrimaryDark` to lighter blues and change `colorAccent` to orange.
2. Customize the app's `colorPrimary` value by clicking its color swatch (Fig. 3.7) to display the **Resources** dialog (Fig. 3.8). In the dialog, click the **Material Blue 500** color swatch, then click **OK** to change `colorPrimary`'s value—hovering the mouse cursor over a color swatch displays its color name in a tooltip. The number **500** represents a particular shade of the **Material Blue** color. Shades of each color range from 50 (a light shade) to 900 (a dark shade)—you can view samples of each color's shades at

```
https://www.google.com/design/spec/style/color.html#color-
   color-palette
```



Color swatches for the theme's `colorPrimary`, `colorPrimaryDark` and `colorAccent` attributes

Fig. 3.7 | **Theme Editor** shows styled view previews on the left and theme attributes on the right.

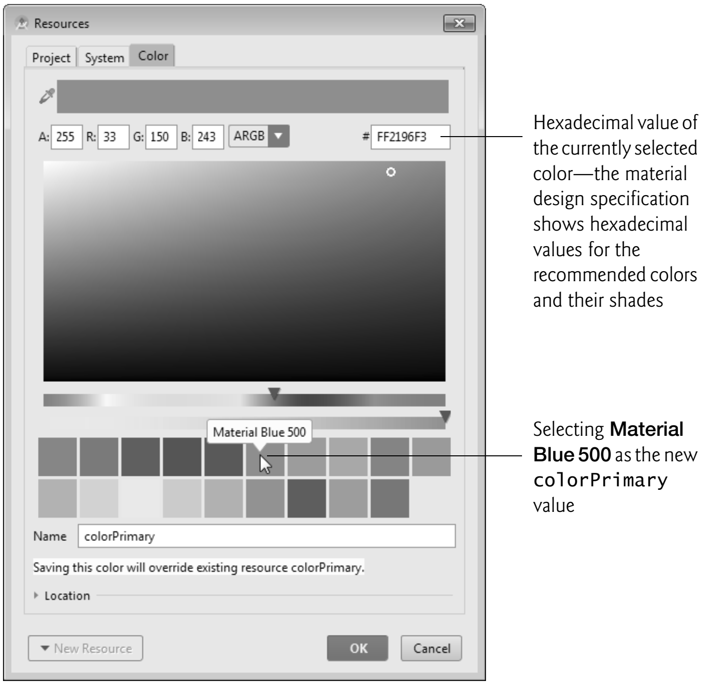
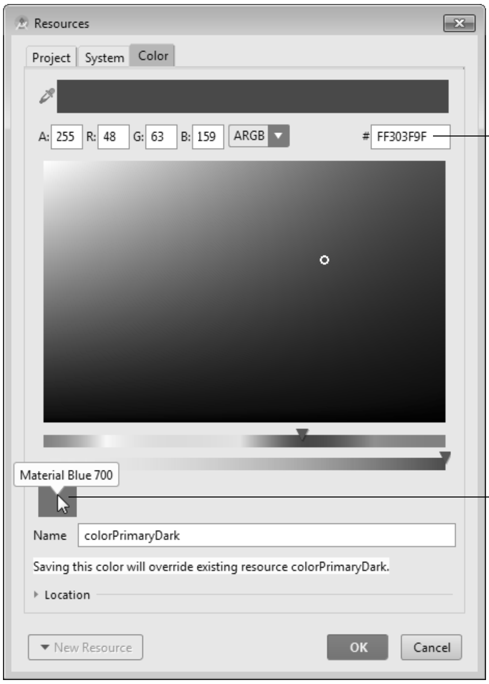

Resources
Project
System
Color
A: 255 R: 33 G: 150 B: 243 ARGB
# FF2196F3
Material Blue 500
Name colorPrimary
Saving this color will override existing resource colorPrimary.
Location
New Resource
OK
Cancel
Hexadecimal value of the currently selected color—the material design specification shows hexadecimal values for the recommended colors and their shades
Selecting Material Blue 500 as the new colorPrimary value

Fig. 3.8 | Selecting the **Material Blue 500** color swatch for `colorPrimary`.

3. Next, click the `colorPrimaryDark` color swatch in the **Theme Editor** to display the **Resources** dialog. The **Theme Editor** recognizes the new `colorPrimary` value and automatically displays a color swatch containing the recommended darker `colorPrimary` shade you should use for `colorPrimaryDark`—in this case, **Material Blue 700**. Click that color swatch (Fig. 3.9), then click **OK**.


Resources
Project
System
Color
ARGB
Material Blue 700
Location
New Resource
OK
Cancel
Value before the new color is selected
Selecting **Material Blue 700** as the new `colorPrimaryDark` value

A: 255 R: 48 G: 63 B: 159 # FF303F9F

Name colorPrimaryDark

Saving this color will override existing resource colorPrimaryDark.

Fig. 3.9 | Selecting the **Material Blue 700** color swatch for `colorPrimaryDark`.

4. Next, click the `colorAccent` color swatch in the **Theme Editor** to display the **Resources** dialog. Again, the **Theme Editor** recognizes that you changed the `colorPrimary` value and displays swatches for various complementary accent colors. In the dialog, click the **Orange accent 400** color swatch, then click **OK** to change `colorAccent`'s value (Fig. 3.10), then click **OK**.

You've now completed the app's design, which should appear as shown in Fig. 3.11.

3.5.3 Common `View` Property Values as Styles

As you'll see in later apps, `style` resources can define common property values that should be applied to multiple views. You apply a `style` resource to a given view by setting its **`style` property**. Any subsequent changes you make to a `style` are automatically applied to all views using the `style`. For example, consider the `tipTextView` and `totalTextView` that we configured identically in Step 11 of Section 3.4.5. We could have defined a `style` resource specifying the `layout:gravity`, `background`, `gravity`, `padding` and `elevation` properties' values, then set both `TextViews`' `style` properties to the same `style` resource.

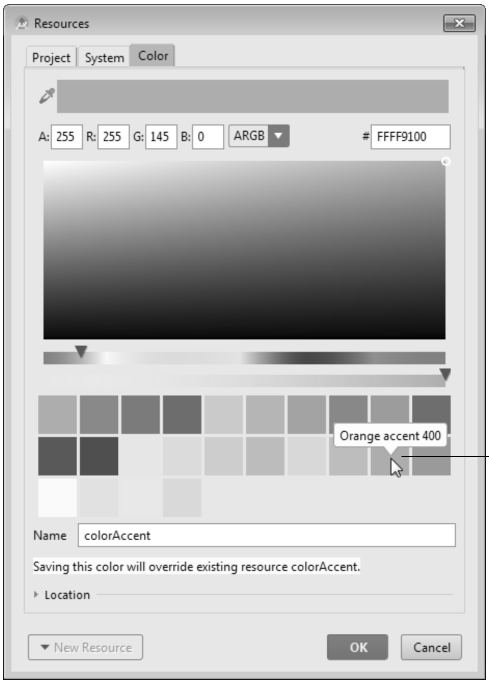

Resources
Project
System
Color
A: 255 R: 255 G: 145 B: 0 ARGB
# FFFF9100
Orange accent 400
Name colorAccent
Saving this color will override existing resource colorAccent.
Location
New Resource
OK
Cancel
Selecting **Orange accent 400** as the new `colorAccent` value

Fig. 3.10 | Selecting the **Orange accent 400** color swatch for `colorAccent`.

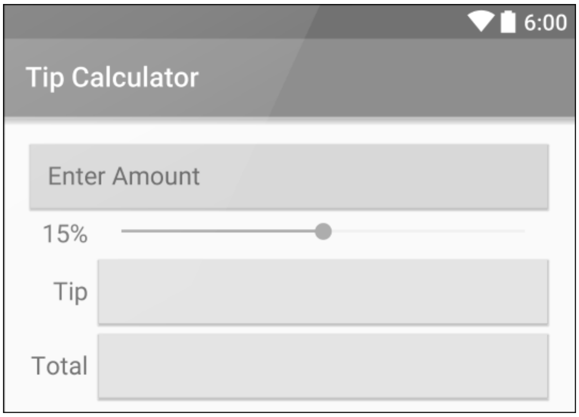


Fig. 3.11 | Completed design.

3.6 Adding the App's Logic

Class `MainActivity` (Figs. 3.12–3.18) implements the **Tip Calculator** app's logic. It calculates the tip and total bill amounts, then displays them in locale-specific currency format. To view the file, in the Project window, expand the `app/Java/com.deitel.tipcalcula-`

`tor` node and double click `MainActivity.java`. You'll need to enter most of the code in Figs. 3.12–3.18.

3.6.1 package and import Statements

Figure 3.12 shows the `package` statement and `import` statements in `MainActivity.java`. The `package` statement in line 3 was inserted when you created the project. When you open a Java file in the IDE, the `import` statements are collapsed—one is displayed with a ⊕ to its left. You can click the ⊕ to see the complete list of `import` statements.

```
 1  // MainActivity.java
 2  // Calculates a bill total based on a tip percentage
 3  package com.deitel.tipcalculator;
 4
 5  import android.os.Bundle; // for saving state information
 6  import android.support.v7.app.AppCompatActivity; // base class
 7  import android.text.Editable; // for EditText event handling
 8  import android.text.TextWatcher; // EditText listener
 9  import android.widget.EditText; // for bill amount input
10  import android.widget.SeekBar; // for changing the tip percentage
11  import android.widget.SeekBar.OnSeekBarChangeListener; // SeekBar listener
12  import android.widget.TextView; // for displaying text
13
14  import java.text.NumberFormat; // for currency formatting
15
```

Fig. 3.12 | `MainActivity`'s `package` and `import` statements.

Lines 5–14 `import` the classes and interfaces the app uses:

- Class `Bundle` of package `android.os` (line 5) stores key–value pairs of information—typically representing an app's state or data that needs to be passed between activities. When another app is about to appear on the screen—e.g., when the user *receives a phone call* or *launches another app*—Android gives the currently executing app the opportunity to *save its state* in a `Bundle`. The Android runtime might subsequently kill the app—e.g., to reclaim its memory. When the app returns to the screen, the Android runtime passes the `Bundle` of the previously saved state to `Activity` method `onCreate` (Section 3.6.4). Then, the app can use the saved state to return the app to the state it was in when another app became active. We'll use `Bundle`s in Chapter 8 to pass data between activities.
- Class `AppCompatActivity` of package `android.support.v7.app` (line 6) provides the basic *lifecycle methods* of an app—we'll discuss these shortly. `AppCompatActivity` is an indirect subclass of `Activity` (package `android.app`) that supports using newer Android features apps running on current and older Android platforms.
- Interface `Editable` of package `android.text` (line 7) allows you to modify the content and markup of text in a GUI.
- You implement interface `TextWatcher` of package `android.text` (line 8) to respond to events when the user changes the text in an `EditText`.

- Package `android.widget` (lines 9, 10 and 12) contains the *widgets* (i.e., views) and layouts that are used in Android GUIs. This app uses `EditText` (line 9), `SeekBar` (line 10) and `TextView` (line 12) widgets.
- You implement interface `SeekBar.OnSeekBarChangeListener` of package `android.widget` (line 11) to respond to the user moving the `SeekBar`'s *thumb*.
- Class `NumberFormat` of package `java.text` (line 14) provides numeric formatting capabilities, such as *locale-specific* currency and percentage formats.

3.6.2 MainActivity Subclass of AppCompatActivity

Class `MainActivity` (Figs. 3.13–3.18) is the **Tip Calculator** app's `Activity` subclass. When you created the `TipCalculator` project, the IDE generated this class as a subclass of `AppCompatActivity` (an indirect subclass of `Activity`) and provided an override of class `Activity`'s inherited `onCreate` method (Fig. 3.15). Every `Activity` subclass *must* override this method. We'll discuss `onCreate` shortly.

```
16  // MainActivity class for the Tip Calculator app
17  public class MainActivity extends Activity {
18
```

Fig. 3.13 | Class `MainActivity` is a subclass of `Activity`.

3.6.3 Class Variables and Instance Variables

Figure 3.14 declares class `MainActivity`'s variables. The `NumberFormat` objects (lines 20–23) are used to format currency values and percentages, respectively. `NumberFormat`'s `static` method `getCurrencyInstance` returns a `NumberFormat` object that formats values as currency using the device's locale. Similarly, `static` method `getPercentInstance` formats values as percentages using the device's locale.

```
19     // currency and percent formatter objects
20     private static final NumberFormat currencyFormat =
21        NumberFormat.getCurrencyInstance();
22     private static final NumberFormat percentFormat =
23        NumberFormat.getPercentInstance();
24
25     private double billAmount = 0.0; // bill amount entered by the user
26     private double percent = 0.15; // initial tip percentage
27     private TextView amountTextView; // shows formatted bill amount
28     private TextView percentTextView; // shows tip percentage
29     private TextView tipTextView; // shows calculated tip amount
30     private TextView totalTextView; // shows calculated total bill amount
31
```

Fig. 3.14 | `MainActivity` class's instance variables.

The bill amount entered by the user into `amountEditText` will be read and stored as a `double` in `billAmount` (line 25). The tip percentage (an integer in the range 0–30) that the user sets by moving the `Seekbar` *thumb* will be divided by 100.0 to create a `double` for use in calculations, then stored in `percent` (line 26). For example, if you select `25` with the `SeekBar`, `percent` will store `0.25`, so the app will multiply the bill amount by `0.25` to calculate the 25% tip.

Software Engineering Observation 3.3

For precise monetary calculations, use class `BigDecimal` (package `java.math`)—rather than type `double`—to represent the monetary amounts and perform calculations.

Line 27 declares the `TextView` that displays the currency-formatted bill amount. Line 28 declares the `TextView` that displays the tip percentage, based on the `SeekBar` *thumb's* position (see the **15%** in Fig. 3.1(a)). The variables in line 29–30 will refer to the `TextViews` in which the app displays the calculated tip and total.

3.6.4 Overriding `Activity` Method onCreate

The `onCreate` method (Fig. 3.15)—which is *autogenerated* with lines 33–36 when you create the app's project—is called by the system when an `Activity` is *started*. Method `onCreate` typically initializes the `Activity`'s instance variables and views. This method should be as simple as possible so that the app *loads quickly*. In fact, if the app takes longer than five seconds to load, the operating system will display an **ANR (Application Not Responding) dialog**—giving the user the option to *forcibly terminate the app*. You'll learn how to prevent this problem in Chapter 9.

```
32      // called when the activity is first created
33      @Override
34      protected void onCreate(Bundle savedInstanceState) {
35         super.onCreate(savedInstanceState); // call superclass's version
36         setContentView(R.layout.activity_main); // inflate the GUI
37
38         // get references to programmatically manipulated TextViews
39         amountTextView = (TextView) findViewById(R.id.amountTextView);
40         percentTextView = (TextView) findViewById(R.id.percentTextView);
41         tipTextView = (TextView) findViewById(R.id.tipTextView);
42         totalTextView = (TextView) findViewById(R.id.totalTextView);
43         tipTextView.setText(currencyFormat.format(0)); // set text to 0
44         totalTextView.setText(currencyFormat.format(0)); // set text to 0
45
46         // set amountEditText's TextWatcher
47         EditText amountEditText =
48            (EditText) findViewById(R.id.amountEditText);
49         amountEditText.addTextChangedListener(amountEditTextWatcher);
50
51         // set percentSeekBar's OnSeekBarChangeListener
52         SeekBar percentSeekBar =
53            (SeekBar) findViewById(R.id.percentSeekBar);
54         percentSeekBar.setOnSeekBarChangeListener(seekBarListener);
55      }
56
```

Fig. 3.15 | Overriding `Activity` method `onCreate`.

***onCreate*'s *Bundle* Parameter**

During the app's execution, the user could change the device's configuration—for example, by *rotating the device*, *connecting to a Bluetooth keyboard* or *sliding out a hard keyboard*. For a good user experience, the app should continue operating smoothly through such configuration changes. When the system calls `onCreate`, it passes a `Bundle` argument containing the `Activity`'s saved state, if any. Typically, you save state in `Activity` methods `onPause` or `onSaveInstanceState` (demonstrated in later apps). Line 35 calls the superclass's `onCreate` method, which is *required* when overriding `onCreate`.

*Generated **R** Class Contains Resource IDs*

As you build your app's GUI and add *resources* (such as `strings` in the `strings.xml` file or views in the `activity_main.xml` file) to your app, the IDE generates a class named **`R`** that contains *nested classes* representing each type of resource in your project's `res` folder. The nested classes are declared `static`, so that you can access them in your code with `R.`*ClassName*. Within class `R`'s nested classes, the IDE creates `static final int` constants that enable you to refer to your app's resources programmatically (as we'll discuss momentarily). Some of the nested classes in class `R` include

- class **`R.drawable`**—contains constants for any `drawable` items, such as *images*, that you put in the various `drawable` folders in your app's `res` folder
- class **`R.id`**—contains constants for the *views* in your *XML layout files*
- class **`R.layout`**—contains constants that represent each *layout file* in your project (such as, `activity_main.xml`), and
- class **`R.string`**—contains constants for each `String` in the `strings.xml` file.

Inflating the GUI

The call to **`setContentView`** (line 36) receives the constant **`R.layout.activity_main`** which indicates the XML file that represents `MainActivity`'s GUI—in this case, the constant represents the `activity_main.xml` file. Method `setContentView` uses this constant to load the corresponding XML document, which Android parses and converts into the app's GUI. This process is known as **inflating the GUI.**

Getting References to the Widgets

Once the layout is *inflated*, you can *get references to the individual widgets* so that you can interact with them programmatically. To do so, you use class `Activity`'s `findViewById` method. This method takes an `int` constant representing a specific view's **Id** and returns a reference to the view. The name of each view's **`R.id`** constant is determined by the component's **Id** property that you specified when designing the GUI. For example, `amountEditText`'s constant is `R.id.amountEditText`.

Lines 39–42 obtain references to the `TextViews` that we change programmatically in the app. Line 39 obtains a reference to the `amountTextView` that's updated when the user enters the bill amount. Line 40 obtains a reference to the `percentTextView` that's updated when the user changes the tip percentage. Lines 41–42 obtain references to the `TextViews` where the calculated tip and total are displayed.

Displaying Initial Values in the `TextViews`
Lines 43–44 set `tipTextView`'s and `totalTextView`'s text to `0` in a *locale-specific* currency format by calling the `currencyFormat` object's **`format` method**. The text in each of these `TextViews` will change as the user enters the bill amount.

Registering the Event Listeners
Lines 47–49 get the `amountEditText` and call its `addTextChangedListener` method to register the `TextWatcher` object that responds to events generated when the user changes the `EditText`'s contents. We define this listener (Fig. 3.18) as an anonymous-inner-class object and assign it to the `amountEditTextWatcher` instance variable. Though we could have defined the anonymous inner class in place of `amountEditTextWatcher` in line 49, we chose to define it later in the class so that the code is easier to read.

Software Engineering Observation 3.4
Rather than defining anonymous inner classes in large methods, define them as `private final` instance variables to make your code easier to debug, modify and maintain.

Lines 52–53 get a reference to the `percentSeekBar`. Line 54 calls the `SeekBar`'s `setOnSeekBarChangeListener` method to register the `OnSeekBarChangeListener` object that responds to *events* generated when the user moves the `SeekBar`'s thumb. Figure 3.17 defines this listener as an anonymous-inner-class object that's assigned to the instance variable `seekBarListener`.

Note Regarding Android 6 Data Binding
Android now has a **Data Binding support library** that you can use with Android apps targeting Android 2.1 (API level 7) and higher. You now can include in your layout XML files data-binding expressions that manipulate Java objects and dynamically update data in your apps' user interfaces.

In addition, each layout XML file that contains views with `id`s has a corresponding autogenerated class. For each view with an `id`, the class has a `public final` instance variable referencing that view. You can create an instance of this "`Binding`" class to replace all calls to `findViewById`, which can greatly simplify your `onCreate` methods in `Activity` and `Fragment` classes with complex user interfaces. Each instance variable's name is the `id` specified in the layout for the corresponding view. The "`Binding`" class's name is based on the layout's name—for `activity_main.xml`, the class name is `ActivityMainBinding`.

At the time of this writing, the Data Binding library is an early beta release that's subject to substantial changes, both in the syntax of data-binding expressions and in the Android Studio tool support. You can learn more about Android data binding at

```
https://developer.android.com/tools/data-binding/guide.html
```

3.6.5 `MainActivity` Method `calculate`

Method `calculate` (Fig. 3.16) is called by the `EditText`'s and `SeekBar`'s listeners to update the tip and total `TextViews` each time the user *changes* the bill amount. Line 60 displays the tip percentage in the `percentTextView`. Lines 63–64 calculate the tip and total, based on the `billAmount`. Lines 67–68 display the amounts in currency format.

```
57       // calculate and display tip and total amounts
58       private void calculate() {
59          // format percent and display in percentTextView
60          percentTextView.setText(percentFormat.format(percent));
61
62          // calculate the tip and total
63          double tip = billAmount * percent;
64          double total = billAmount + tip;
65
66          // display tip and total formatted as currency
67          tipTextView.setText(currencyFormat.format(tip));
68          totalTextView.setText(currencyFormat.format(total));
69       }
70
```

Fig. 3.16 | `MainActivity` Method `calculate`.

3.6.6 Anonymous Inner Class That Implements Interface `OnSeekBarChangeListener`

Lines 72–87 (Fig. 3.17) create the *anonymous-inner-class* object that responds to `percentSeekBar`'s *events*. The object is assigned to the instance variable `seekBarListener`. Line 54 (Fig. 3.15) registered `seekBarListener` as `percentSeekBar`'s `OnSeekBarChangeListener` *event-handling* object. For clarity, we define all but the simplest event-handling objects in this manner so that we do not clutter the `onCreate` method with this code.

```
71       // listener object for the SeekBar's progress changed events
72       private final OnSeekBarChangeListener seekBarListener =
73          new OnSeekBarChangeListener() {
74             // update percent, then call calculate
75             @Override
76             public void onProgressChanged(SeekBar seekBar, int progress,
77                boolean fromUser) {
78                percent = progress / 100.0; // set percent based on progress
79                calculate(); // calculate and display tip and total
80             }
81
82             @Override
83             public void onStartTrackingTouch(SeekBar seekBar) { }
84
85             @Override
86             public void onStopTrackingTouch(SeekBar seekBar) { }
87          };
88
```

Fig. 3.17 | Anonymous inner class that implements interface `OnSeekBarChangeListener`.

Overriding Method **`onProgressChanged`** *of Interface* **`OnSeekBarChangeListener`**

Lines 75–86 (Fig. 3.17) implement interface `OnSeekBarChangeListener`'s methods. Method `onProgressChanged` is called whenever the `SeekBar`'s thumb position changes. Line 78 calculates the `percent` value using the method's `progress` parameter—an `int` representing the `SeekBar`'s *thumb* position. We divide this by 100.0 to get the percentage. Line 79 calls method `calculate` to recalculate and display the tip and total.

Overriding Methods **`onStartTrackingTouch`** *and* **`onStopTrackingTouch`** *of Interface* **`OnSeekBarChangeListener`**

Java requires that you override *every* method in an interface that you implement. This app does not need to know when the user starts moving the `SeekBar`'s thumb (`onStartTrackingTouch`) or stops moving it (`onStopTrackingTouch`), so we simply provide an empty body for each (lines 82–86) to fulfill the interface contract.

Android Studio Tools for Overriding Methods

Android Studio can create for you empty methods that override inherited methods from the class's superclasses or that implement interface methods. When you place the cursor in a class's body, then select the **Code > Override Methods...** menu option, the IDE displays a **Select Methods to Override/Implement** dialog that lists every method you can override in the current class. This list includes all the inherited methods in the class's hierarchy and the methods of any interfaces implemented throughout the class's hierarchy.

Error-Prevention Tip 3.2

Using Android Studio's **Code > Override Methods...** *menu option helps you write code faster and with fewer errors.*

3.6.7 Anonymous Inner Class That Implements Interface `TextWatcher`

Lines 90–114 of Fig. 3.18 create an *anonymous-inner-class* object that responds to `amountEditText`'s *events* and assign it to the instance variable `amountEditTextWatcher`. Line 49 (Fig. 3.15) registered this object to *listen* for `amountEditText`'s events that occur when the text changes.

```
 89     // listener object for the EditText's text-changed events
 90     private final TextWatcher amountEditTextWatcher = new TextWatcher() {
 91        // called when the user modifies the bill amount
 92        @Override
 93        public void onTextChanged(CharSequence s, int start,
 94           int before, int count) {
 95
 96           try { // get bill amount and display currency formatted value
 97              billAmount = Double.parseDouble(s.toString()) / 100.0;
 98              amountTextView.setText(currencyFormat.format(billAmount));
 99           }
100           catch (NumberFormatException e) { // if s is empty or non-numeric
101              amountTextView.setText("");
102              billAmount = 0.0;
103           }
104
105           calculate(); // update the tip and total TextViews
106        }
107
```

Fig. 3.18 | Anonymous inner class that implements interface `TextWatcher`. (Part 1 of 2.)

```
108          @Override
109          public void afterTextChanged(Editable s) { }
110
111          @Override
112          public void beforeTextChanged(
113             CharSequence s, int start, int count, int after) { }
114       };
115    }
```

Fig. 3.18 | Anonymous inner class that implements interface `TextWatcher`. (Part 2 of 2.)

Overriding Method `onTextChanged` *of Interface* `TextWatcher`

The `onTextChanged` method (lines 92–106) is called whenever the text in the `amountEditText` is *modified*. The method receives four parameters. In this example, we use only `CharSequence s`, which contains a copy of `amountEditText`'s text. The other parameters indicate that the `count` characters starting at `start` *replaced* previous text of length `before`.

Line 97 converts the user input from `amountEditText` to a `double`. We allow users to enter only whole numbers in pennies, so we divide the converted value by 100.0 to get the actual bill amount—e.g., if the user enters 2495, the bill amount is 24.95. Line 98 displays the updated bill amount. If an exception occurs, lines 101–102 clear the `amountTextView` and set the `billAmount` to `0.0`. Lines 105 calls `calculate` to recalculate and display the tip and total, based on the current bill amount.

Other Methods of the `amountEditTextWatcher` `TextWatcher`

This app does *not* need to know what changes are about to be made to the text (`beforeTextChanged`) or that the text has already been changed (`afterTextChanged`), so we simply override each of these `TextWatcher` interface methods with an *empty* body (lines 108–113) to fulfill the interface contract.

3.7 AndroidManifest.xml

In this section, you'll modify the `AndroidManifest.xml` file to specify that this app's `Activity` supports only a device's portrait orientation and that the virtual keyboard should always be displayed when the `Activity` first appears on the screen or navigates back to the `Activity`. To open the manifest, double click `AndroidManifest.xml` in the **Project** window's `manifests` folder. Figure 3.19 shows the completed manifest with our changes highlighted—the rest of the file was autogenerated by Android Studio when we created the app's project. We'll discuss some aspects of the manifest here. For a list of all the elements a manifest may contain, their attributes and their values, visit

```
http://developer.android.com/guide/topics/manifest/manifest-
   intro.html
```

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
   package="com.deitel.tipcalculator" >

```

Fig. 3.19 | `AndroidManifest.xml` contents. (Part 1 of 2.)

```
 5      <application
 6         android:allowBackup="true"
 7         android:icon="@mipmap/ic_launcher"
 8         android:label="@string/app_name"
 9         android:supportsRtl="true"
10         android:theme="@style/AppTheme" >
11         <activity
12            android:name=".MainActivity"
13            android:label="@string/app_name"
14            android:screenOrientation="portrait"
15            android:windowSoftInputMode="stateAlwaysVisible">
16            <intent-filter>
17               <action android:name="android.intent.action.MAIN" />
18
19               <category android:name="android.intent.category.LAUNCHER" />
20            </intent-filter>
21         </activity>
22      </application>
23
24   </manifest>
```

Fig. 3.19 | `AndroidManifest.xml` contents. (Part 2 of 2.)

3.7.1 `manifest` Element

The **`manifest` element** (lines 2–24) indicates that this XML file's contents represent the app's manifest. This element's `package` attribute specifies the app's Java package name that was configured when you created the app's project (Section 3.4.2). Recall that for apps you submit to the Google Play store, the package name is used as the app's unique identifier.

3.7.2 `application` Element

The `manifest` element's nested **`application` element** (lines 5–21) specifies attributes of the application, including

- **`android:allowBackup`**—Whether or not the app's data should be backed up automatically by Android so that the data can be restored to the device or a new device at a later time.
- **`android:icon`**—The app icon that you touch in the launcher to execute the app.
- **`android:label`**—The app's name that's typically displayed below the icon in the launcher and often displayed in the app bar when the app is executing.
- **`android:supportsRtl`**—Whether or not the app's interface can be flipped horizontally to support right-to-left languages like Arabic and Hebrew.
- **`android:theme`**—The theme that determines the default look-and-feel of the app's views.

Elements nested in the `application` element define the app's components, such as its activities.

3.7.3 `activity` Element

The `application` element's nested **`activity` element** (lines 10–20) describes an `Activity`. An app can have many activities, one of which is designated as the `Activity` that's displayed when the user touches the app's icon in the launcher to execute the app. Each `activity` element specifies at least the following attributes:

- **`android:name`**—The `Activity`'s class name. The notation `".MainActivity"` is shorthand for `"com.deitel.MainActivity"` (where `com.deitel` is the reverse of the domain name you specified when creating the app's project).
- **`android:label`**—The `Activity`'s name. This is often displayed in the app bar when the `Activity` is on the screen. For single `Activity` apps, this name is typically the same as the app's name.

For `MainActivity`, we added the following attributes:

- **`android:screenOrientation`**—In general, most apps should support *both* portrait and landscape orientations. In *portrait* orientation, the device's longer dimension is vertical. In *landscape orientation*, the device's longer dimension is horizontal. In the **Tip Calculator** app, rotating the device to landscape orientation on a typical phone would cause the numeric keypad to obscure most of the **Tip Calculator**'s GUI. For this reason, we set this property to `"portrait"` to support *only* portrait orientation.
- **`android:windowSoftInputMode`**—In the **Tip Calculator** app, the soft keypad should be displayed immediately when the app executes and should reappear each time the user returns to the **Tip Calculator** app. For this reason we set this property to `"stateAlwaysVisible"`. This will *not* display the soft keyboard if a hard keyboard is present.

3.7.4 `intent-filter` Element

`Intents` are Android's mechanism for communicating between executable components—such as activities, background services and the operating system. You *state your intent*, then Android uses **intent messaging** to coordinate the executable components to accomplish what you intend to do. This *loose coupling* makes it easy to mix and match parts of different applications. You tell Android what you want to accomplish, then let Android find the installed applications with activities that can handle the task.

Inter-App Communication

One example of how `Intents` are used is *coordinating efforts between separate apps*. Consider how photo sharing can be handled in Android:

- Most social-networking Android apps provide their own photo-sharing capabilities. Each app can advertise in its manifest its specific `Activity` that uploads a photo to the user's account.
- Other apps can use these photo-sharing capabilities, rather than implementing their own. For example, a photo-editing app can provide a **Share Photo** option. The app can respond to a user's photo-sharing request by *stating its intent* to share a photo—that is, creating a photo-sharing `Intent` and passing it to Android.

- Android looks at the `Intent` to determine which installed applications provide activities that can share photos.
- If there's only *one* such app, Android executes that app's photo-sharing `Activity`.
- If there are *many* such apps, Android displays a list of apps and asks the *user to decide* which app's photo-sharing `Activity` should execute.

A key benefit of this loosely coupled approach is that the photo-editing app's developer does not need to incorporate support for every possible social-networking site. By issuing a photo-sharing `Intent`, the app automatically supports *any* app that declares a photo-sharing `Activity` in its manifest, including those apps the user has already installed and any the user chooses to install in the future. For a list of the items that can be used with Intents, visit

```
http://developer.android.com/reference/android/content/
   Intent.html#constants
```

Executing Apps
Another example of how `Intents` are used is in *launching activities*. When you touch an app's icon in the device's launcher app, your intent is to execute the app. In this case, the launcher issues an `Intent` to execute that app's main `Activity` (discussed momentarily). Android responds to this `Intent` by launching the app and executing the specific `Activity` designated in the app's manifest as the main `Activity`.

Determining Which Activity to Execute
Android uses information in the manifest to determine the activities that can respond to `Intents` and which `Intents` each `Activity` can handle. In the manifest, the `activity` element's nested **`intent-filter` element** (Fig. 3.19, lines 16–20) determines which `Intent` types can launch an `Activity`. If an `Intent` matches only one `Activity`'s `intent-filter`, Android executes that `Activity`. If there are multiple matches, Android presents a list from which the user can choose an app, then executes the appropriate `Activity` in that app.

Android also passes the `Intent` to the `Activity`, because an `Intent` often contains data the `Activity` can use to perform its task. For example, a photo-editing app can include in a share-photo `Intent` the specific photo to share.

The `intent-filter` element must contain one or more **`action` elements**. The action `"android.intent.action.MAIN"` in line 17 of Fig. 3.19 indicates that `MainActivity` is the `Activity` to execute when the app launches. The optional **`category` element** in line 19 specifies what initiates the `Intent`—for `"android.intent.category.LAUNCHER"`, it's the device's launcher. This category also indicates that the `Activity` should appear as an icon in the device's launcher with the icons for the user's other installed apps.

We'll discuss and program with `Intents` in the next chapter. For more information on `Intents` and `Intent` filters, visit

```
http://developer.android.com/guide/components/intents-filters.html
```

3.8 Wrap-Up

In this chapter, you created the interactive **Tip Calculator** app. We discussed the app's capabilities, then you test-drove it to calculate the tip and total, based on the bill amount.

You built the app's GUI using Android Studio's layout editor, **Component Tree** window and **Properties** window. You also edited the layout's XML and used the **Theme Editor** to customize the `Theme.AppCompat.Light.DarkActionBar` theme's primary, dark primary and accent colors that were set by the IDE when you created the project. We presented the code for class `MainActivity`, a subclass of `AppCompatActivity` (and an indirect subclass of `Activity`) that defined the app's logic.

In the app's GUI, you used a `GridLayout` to arrange the views into rows and columns. You displayed text in `TextViews` and received input from an `EditText` and a `SeekBar`.

The `MainActivity` class required many Java object-oriented programming capabilities, including classes, objects, methods, interfaces, anonymous inner classes and inheritance. We explained the notion of inflating the GUI from its XML file into its screen representation. You learned about Android's `Activity` class and part of the `Activity` lifecycle. In particular, you overrode the `onCreate` method to initialize the app when it's launched. In the `onCreate` method, you used `Activity` method `findViewById` to get references to each of the views the app interacts with programmatically. You defined an anonymous inner class that implements the `TextWatcher` interface so the app can calculate new tips and totals as the user enters the bill amount in the `EditText`. You also defined an anonymous inner class that implements the `OnSeekBarChangeListener` interface so the app can calculate a new tip and total as the user changes the tip percentage by moving the `SeekBar`'s thumb.

Finally, you edited the `AndroidManifest.xml` file to specify that the `MainActivity` supports only portrait orientation and that the `MainActivity` should always display the keypad. We also discussed the other elements that Android Studio placed in the manifest when you created the project.

In Chapter 4, you'll build the **Flag Quiz** app in which the user is shown a graphic of a country's flag and must guess the country from 2, 4, 6 or 8 choices. You'll use a menu and checkboxes to customize the quiz, specifying the number of guess options and limiting the flags to specific regions of the world.

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