SECOND EDITION

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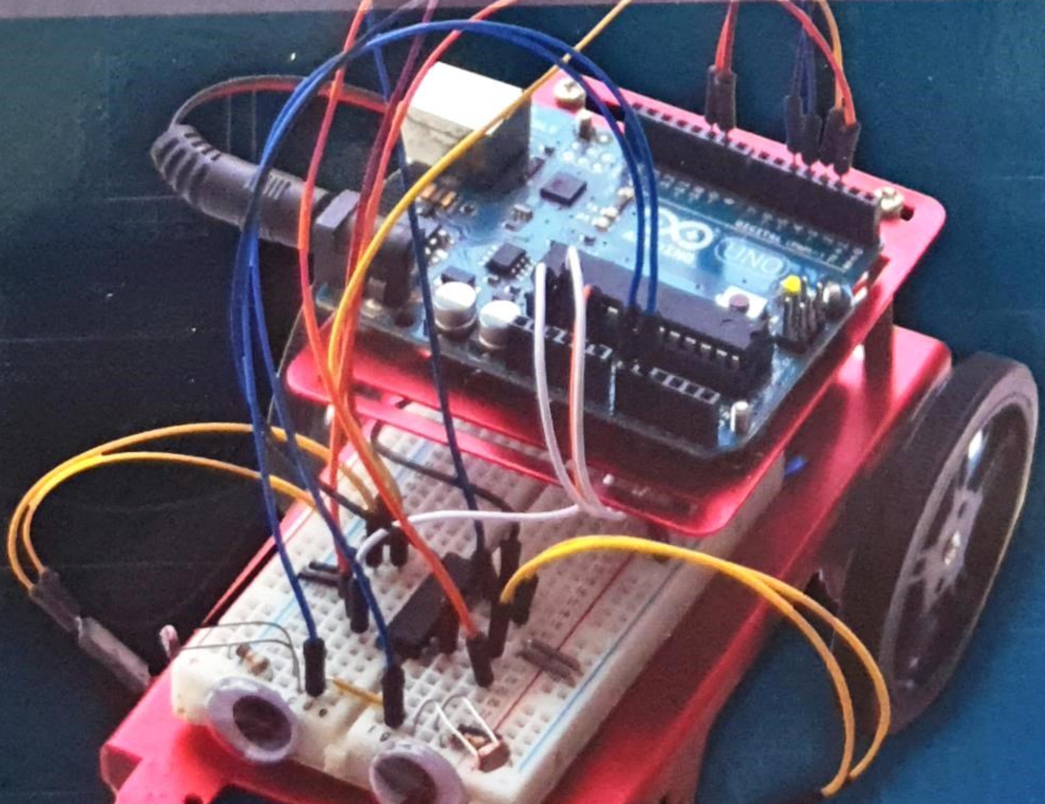
JEREMY BLUM

EXPLORING ARDUINO®

TOOLS AND TECHNIQUES FOR ENGINEERING WIZARDRY



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EXPLORING ARDUINO®

Tools and Techniques for Engineering Wizardry

Second Edition

Jeremy Blum

WILEY

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Introduction

When the first edition of this book came out in 2013, I opened it with the following greeting:

> *You have excellent timing. As I often like to say, "We're living in the future."*

I think I backed myself into a corner with that introduction, because if 2013 was "the future," then I'm not quite sure what to call the present! The *far future*? The *future-future*? My point is, the march of progress has been swift, and the possibilities for what you can do with even a cursory knowledge of embedded electronics and software continue to expand every day.

Since the first edition of this book was released, electronics and software have continued to become increasingly accessible with every passing day. In 2013, I was hesitant to include a chapter about connecting your hardware projects to the internet because the process for doing so was still quite fussy. The "Internet of Things" (IoT) was just an emerging nerdy buzzword in 2013. Now, it's a key part of the global vernacular. It seems like every product for sale nowadays contains a microcontroller. Everything is "smart" and most of those things also feature phone or web connectivity. I bet you didn't think you'd be buying a Bluetooth-enabled toothbrush back when "Bluetooth" just referred to people talking to themselves through their wireless cellphone headsets.

Considering all this, I felt it was time to release a new edition of *Exploring Arduino*. This second edition expands upon everything that was covered in the first edition. It updates all the projects with new challenges and details, clarifies questions that people had from the first edition, and adds a plethora of new content, including a lot more details on wireless connectivity, new Arduino hardware, changes to the Arduino ecosystem and software, and more.

Why Arduino?

With the tools available to you today, many of which you'll learn about in this book, you have the opportunity and the ability to bend the physical world to your whim. Until very recently, it has not been possible for someone to pick up a microcontroller and use it to control their world within minutes. A *microcontroller* is a programmable integrated circuit (IC) that gives you the power to define the operation of complex mechanical, electrical, and software systems using relatively simple commands. The possibilities are endless, and the Arduino microcontroller platform will become your new favorite tool as you explore the world of electronics, programming, human-computer interaction, art, control systems, and more. Throughout the course of this book, you'll use the Arduino to do everything from detecting motion to creating wireless control systems to communicating over the internet.

Whether you are completely new to any kind of engineering or are a seasoned veteran looking to get started with embedded systems design, the Arduino is a great place to start. Are you looking for a general reference for Arduino development? This book is perfect for you, too. It walks you through a number of separate projects, but you'll also find it easy to return to the book for code snippets, best practices, system schematics, and more. The electrical engineering, systems design, and programming practices that you'll learn while reading this book are widely applicable beyond the Arduino platform and will prepare you to take on an array of engineering projects, whether they use the Arduino or some other platform.

Who This Book Is For

This book is for Arduino enthusiasts of all experience levels. Chapters build upon each other, utilizing concepts and project components from previous chapters to develop more complex ideas. But don't worry. Whenever you face new, complex ideas, a cross-reference reminds you where you first encountered any relevant building-block concepts so that you can easily refresh your memory.

This book assumes that you have little or no previous experience working with programming or electrical engineering. Using feedback from readers of the first edition of this book, I've taken special care to be very detailed in my explanation of the more confusing topics you may encounter. To effectively support readers of various experience levels, the book features several optional sections and *sidebars*, or short excerpts, that explain a particular concept in greater detail. Although these sidebars are not necessary for you to gain a good understanding of how to use the Arduino, they do provide a closer look at technical topics for the more curious reader.

What You'll Learn in This Book

This book is not a recipe book. If you want to follow step-by-step instructions that tell you exactly how to build a particular project without actually explaining why you are doing what you are doing, this book is not for you. You can think of this book as an introduction to electrical engineering, computer science, product design, and high-level thinking using the Arduino as a vehicle to help you experience these concepts in a hands-on manner.

When building hardware components of the Arduino projects demonstrated in this book, you'll learn not just how to wire things together, but also how to read schematics, why particular parts are used for particular functions, and how to read datasheets that will allow you to choose appropriate parts to build your own projects. When writing software, I provide complete program code, but you will first be stepped through several iterative processes to create the final program. This will help to reinforce specific program functions, good code-formatting practices, and algorithmic understanding.

This book will teach physics concepts, algorithms, digital design principles, and Arduino-specific programming concepts. It is my hope that working through the projects in this book will not just make you a well-versed Arduino developer, but also give you the skills you need to develop more-complex electrical systems, and to pursue engineering endeavors in other fields, and with different platforms.

Features Used in This Book

The following features and icons are used in this book to help draw your attention to some of the most important or useful information in the book:

WARNING Be sure to take heed when you see one of these asides. They appear when particular steps could cause damage to your electronics if performed incorrectly.

TIP These asides contain quick hints about how to perform the task at hand more easily and effectively.

NOTE These asides contain additional information that may be of importance to you, including links to videos and online material that will make it easier to follow along with the development of a particular project.

SAMPLE HEADING

These asides go into additional depth about the current topic or a related topic.

Getting the Parts

In preparing the projects outlined in this book, I've taken special care to use components that are readily available through a variety of retailers, both in the United States and internationally. I've also partnered with Adafruit (`adafruit.com`), a popular retailer of hobbyist electrical components. You can purchase all the components required for completing the projects in this book from Adafruit. A convenient listing of Adafruit parts for each chapter is available at `exploringarduino.com/kits`.

At the beginning of each chapter, you'll find a detailed list of parts that you need to complete that chapter—all of these parts are available from many sources. The companion website for this book, `www.wiley.com/go/exploringarduino2e`, also provides links to multiple sources where you can find the parts for each chapter.

What You'll Need

In addition to the actual parts that you'll use to build your Arduino projects, there are a few other tools and materials that you'll need on your Arduino adventures. Most importantly, you'll need a computer that is compatible with the Arduino integrated development environment (IDE) (Mac OS X 10.7 Lion or newer, Windows XP or later, or a Linux distro). I will provide instructions for all operating systems when warranted.

Arduino now also has an entirely web-based editor, but this book will generally focus on the desktop IDE. All the instructions for the desktop software generally apply to the online IDE as well. The first version of this book was read by people all over the world, representing a wide range of internet speeds and reliability. To ensure that Arduino remains easily accessible to all, I'll mostly provide instructions that use the offline IDE, as constant internet access isn't always an option for everybody.

You may also want some additional tools that will be used throughout the book to debug and assemble hardware. These tools are not only necessary to complete the projects in this book. As you develop your electrical engineering skillset, they will come in handy for other projects, too. I recommend the following:

- A soldering iron and solder (Note: A few shields and microcontroller boards used in the final chapters of this book may be sold with some soldering required—this usually involves easy soldering of thru-hole pins to a circuit board.)
- A multimeter (This will be useful for debugging concepts within this book, but is not required.)
- A set of small screwdrivers
- Tweezers
- Wire cutters and wire strippers
- A hot glue gun
- A magnifying glass (Electronics are small, and sometimes it's necessary to read the tiny, laser-etched markings on integrated circuits in order to look up their datasheets online.)