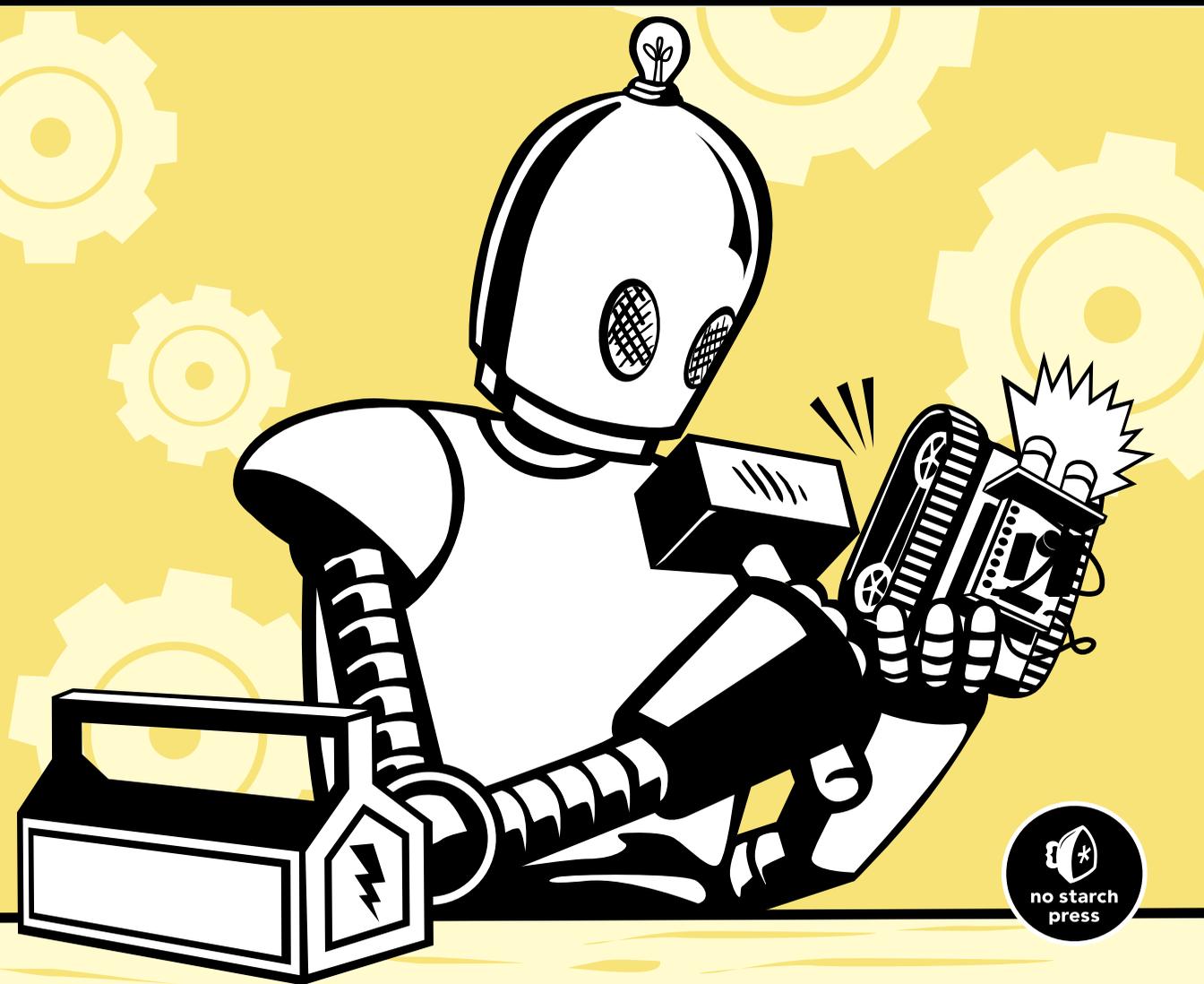


ARDUINO WORKSHOP

A *HANDS-ON* INTRODUCTION
WITH 65 PROJECTS

JOHN BOXALL



ARDUINO WORKSHOP

ARDUINO WORKSHOP

**A Hands-On Introduction
with 65 Projects**

by John Boxall



**no starch
press**

San Francisco

ARDUINO WORKSHOP. Copyright © 2013 by John Boxall.

All rights reserved. No part of this work may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage or retrieval system, without the prior written permission of the copyright owner and the publisher.

Printed in USA

First printing

17 16 15 14 13 1 2 3 4 5 6 7 8 9

ISBN-10: 1-59327-448-3

ISBN-13: 978-1-59327-448-1

Publisher: William Pollock

Production Editor: Serena Yang

Cover Illustration: Charlie Wylie

Interior Design: Octopod Studios

Developmental Editor: William Pollock

Technical Reviewer: Marc Alexander

Copyeditor: Lisa Theobald

Compositor: Susan Glinert Stevens

Proofreader: Emelie Battaglia

Circuit diagrams made using Fritzing (<http://fritzing.org/>)

For information on distribution, translations, or bulk sales, please contact No Starch Press, Inc. directly:

No Starch Press, Inc.

38 Ringold Street, San Francisco, CA 94103

phone: 415.863.9900; fax: 415.863.9950; info@nostarch.com; www.nostarch.com

Library of Congress Cataloging-in-Publication Data

A catalog record of this book is available from the Library of Congress.

No Starch Press and the No Starch Press logo are registered trademarks of No Starch Press, Inc. Other product and company names mentioned herein may be the trademarks of their respective owners. Rather than use a trademark symbol with every occurrence of a trademarked name, we are using the names only in an editorial fashion and to the benefit of the trademark owner, with no intention of infringement of the trademark.

The information in this book is distributed on an “As Is” basis, without warranty. While every precaution has been taken in the preparation of this work, neither the author nor No Starch Press, Inc. shall have any liability to any person or entity with respect to any loss or damage caused or alleged to be caused directly or indirectly by the information contained in it.

For the two people who have always believed in me:
my mother and my dearest Kathleen

BRIEF CONTENTS

Acknowledgments	xix
Chapter 1: Getting Started	1
Chapter 2: Exploring the Arduino Board and the IDE	19
Chapter 3: First Steps	33
Chapter 4: Building Blocks	55
Chapter 5: Working with Functions	95
Chapter 6: Numbers, Variables, and Arithmetic.	111
Chapter 7: Liquid Crystal Displays	147
Chapter 8: Expanding Your Arduino	161
Chapter 9: Numeric Keypads	187
Chapter 10: Accepting User Input with Touchscreens	195
Chapter 11: Meet the Arduino Family.	207
Chapter 12: Motors and Movement	225
Chapter 13: Using GPS with Your Arduino	257
Chapter 14: Wireless Data	271
Chapter 15: Infrared Remote Control	285
Chapter 16: Reading RFID Tags.	295

Chapter 17: Data Buses	307
Chapter 18: Real-time Clocks	321
Chapter 19: The Internet	337
Chapter 20: Cellular Communications	349
Index	365

CONTENTS IN DETAIL

ACKNOWLEDGMENTS

xix

1

GETTING STARTED

1

The Possibilities Are Endless	2
Strength in Numbers	6
Parts and Accessories	6
Required Software	7
Mac OS X	7
Windows XP and Later	11
Ubuntu Linux 9.04 and Later	15
Safety	18
Looking Ahead	18

2

EXPLORING THE ARDUINO BOARD AND THE IDE

19

The Arduino Board	19
Taking a Look Around the IDE	25
The Command Area	25
The Text Area	26
The Message Window Area	26
Creating Your First Sketch in the IDE	27
Comments	27
The Setup Function	28
Controlling the Hardware	28
The Loop Function	28
Verifying Your Sketch	30
Uploading and Running Your Sketch	31
Modifying Your Sketch	31
Looking Ahead	31

3

FIRST STEPS

33

Planning Your Projects	34
About Electricity	34
Current	34
Voltage	35
Power	35
Electronic Components	35
The Resistor	35
The Light-Emitting Diode	39
The Solderless Breadboard	41
Project #1: Creating a Blinking LED Wave	43
The Algorithm	43
The Hardware	43

The Sketch	43
The Schematic	44
Running the Sketch	45
Using Variables	45
Project #2: Repeating with for Loops	46
Varying LED Brightness with Pulse-Width Modulation	47
Project #3: Demonstrating PWM	49
More Electric Components	49
The Transistor	50
The Rectifier Diode	50
The Relay	51
Higher-Voltage Circuits	52
Looking Ahead	53

4

BUILDING BLOCKS

55

Using Schematic Diagrams	56
Identifying Components	56
Wires in Schematics	58
Dissecting a Schematic	59
The Capacitor	60
Measuring the Capacity of a Capacitor	60
Reading Capacitor Values	61
Types of Capacitors	61
Digital Inputs	63
Project #4: Demonstrating a Digital Input	65
The Algorithm	65
The Hardware	65
The Schematic	65
The Sketch	69
Modifying Your Sketch	70
Understanding the Sketch	70
Creating Constants with #define	70
Reading Digital Input Pins	70
Making Decisions with if	71
Making More Decisions with if-then-else	71
Boolean Variables	72
Comparison Operators	72
Making Two or More Comparisons	73
Project #5: Controlling Traffic	74
The Goal	74
The Algorithm	74
The Hardware	75
The Schematic	75
The Sketch	76
Running the Sketch	79
Analog vs. Digital Signals	79
Project #6: Creating a Single-Cell Battery Tester	80
The Goal	81
The Algorithm	81
The Hardware	81

The Schematic	81
The Sketch	82
Doing Arithmetic with an Arduino	83
Float Variables	84
Comparison Operators for Calculations	84
Improving Analog Measurement Precision with a Reference Voltage	84
Using an External Reference Voltage	85
Using the Internal Reference Voltage	86
The Variable Resistor	86
Piezoelectric Buzzers	87
Piezo Schematic	88
Project #7: Trying Out a Piezo Buzzer	88
Project #8: Creating a Quick-Read Thermometer	90
The Goal	90
The Hardware	90
The Schematic	91
The Sketch	91
Hacking the Sketch	93
Looking Ahead	93

5

WORKING WITH FUNCTIONS

95

Project #9: Creating a Function to Repeat an Action	96
Project #10: Creating a Function to Set the Number of Blinks	97
Creating a Function to Return a Value	98
Project #11: Creating a Quick-Read Thermometer That Blinks the Temperature	98
The Hardware	99
The Schematic	99
The Sketch	100
Displaying Data from the Arduino in the Serial Monitor	101
The Serial Monitor	102
Project #12: Displaying the Temperature in the Serial Monitor	103
Debugging with the Serial Monitor	105
Making Decisions with while Statements	105
do-while	105
Sending Data from the Serial Monitor to the Arduino	106
Project #13: Multiplying a Number by Two	106
long Variables	107
Project #14: Using long Variables	107
Looking Ahead	109

6

NUMBERS, VARIABLES, AND ARITHMETIC

111

Generating Random Numbers	112
Using Ambient Current to Generate a Random Number	112
Project #15: Creating an Electronic Die	113
The Hardware	114
The Schematic	114
The Sketch	115
Modifying the Sketch	116

A Quick Course in Binary	116
Byte Variables	117
Increasing Digital Outputs with Shift Registers	118
Project #16: Creating an LED Binary Number Display	119
The Hardware	119
Connecting the 74HC595	119
The Sketch	121
Project #17: Making a Binary Quiz Game	122
The Algorithm	122
The Sketch	122
Arrays	124
Defining an Array	124
Referring to Values in an Array	125
Writing to and Reading from Arrays	125
Seven-Segment LED Displays	126
Controlling the LED	127
Project #18: Creating a Single-Digit Display	129
The Hardware	129
The Schematic	129
The Sketch	130
Displaying Double Digits	131
Project #19: Controlling Two Seven-Segment LED Display Modules	131
The Hardware	131
The Schematic	132
Modulo	133
Project #20: Creating a Digital Thermometer	134
The Hardware	134
The Sketch	134
LED Matrix Display Modules	135
The LED Matrix Schematic	136
Making the Connections	137
Bitwise Arithmetic	139
The Bitwise AND Operator	139
The Bitwise OR Operator	139
The Bitwise XOR Operator	140
The Bitwise NOT Operator	140
Bitshift Left and Right	140
Project #21: Creating an LED Matrix	141
Project #22: Creating Images on an LED Matrix	142
Project #23: Displaying an Image on an LED Matrix	144
Project #24: Animating an LED Matrix	145
The Sketch	145
Looking Ahead	146

7

LIQUID CRYSTAL DISPLAYS

147

Character LCD Modules	148
Using a Character LCD in a Sketch	149
Displaying Text	150
Displaying Variables or Numbers	151

Project #25: Defining Custom Characters	152
Graphic LCD Modules	153
Connecting the Graphic LCD	154
Using the LCD	155
Controlling the Display	155
Project #26: Seeing the Text Functions in Action	155
Creating More Complex Display Effects	156
Project #27: Creating a Temperature History Monitor	157
The Algorithm	158
The Hardware	158
The Sketch	158
The Result	160
Modifying the Sketch	160
Looking Ahead	160
8	
EXPANDING YOUR ARDUINO	161
Shields	162
ProtoShields	164
Project #28: Creating a Custom Shield with Eight LEDs	165
The Hardware	165
The Schematic	165
The Layout of the ProtoShield Board	166
The Design	166
Soldering the Components	167
Modifying the Custom Shield	169
Expanding Sketches with Libraries	169
Importing a Shield's Libraries	169
MicroSD Memory Cards	173
Testing Your MicroSD Card	174
Project #29: Writing Data to the Memory Card	175
Project #30: Creating a Temperature-Logging Device	177
The Hardware	177
The Sketch	177
Timing Applications with millis() and micros().	179
Project #31: Creating a Stopwatch	181
The Hardware	181
The Schematic	181
The Sketch	182
Interrupts	184
Interrupt Modes	184
Configuring Interrupts	185
Activating or Deactivating Interrupts	185
Project #32: Using Interrupts	185
The Sketch	185
Looking Ahead	186

9**NUMERIC KEYPADS 187**

Using a Numeric Keypad	187
Wiring a Keypad	188
Programming for the Keypad	189
Testing the Sketch	189
Making Decisions with switch-case	190
Project #33: Creating a Keypad-Controlled Lock	190
The Sketch	191
How It Works	192
Testing the Sketch	193
Looking Ahead	193

10**ACCEPTING USER INPUT WITH TOUCHSCREENS 195**

Touchscreens	195
Connecting the Touchscreen	196
Project #34: Addressing Areas on the Touchscreen	197
The Hardware	197
The Sketch	197
Testing the Sketch	198
Mapping the Touchscreen	199
Project #35: Creating a Two-Zone On/Off Touch Switch.	200
The Sketch	200
How It Works	202
Testing the Sketch	202
Project #36: Creating a Three-Zone Touch Switch.	202
The Touchscreen Map	203
The Sketch	203
How It Works	205
Looking Ahead	205

11**MEET THE ARDUINO FAMILY 207**

Project #37: Creating Your Own Breadboard Arduino	208
The Hardware	208
The Schematic	211
Running a Test Sketch	214
The Many Arduino Boards	217
Arduino Uno	219
Freetronics Eleven	219
The Freeduino	220
The Boarduino	220
The Arduino Nano	221
The Arduino LilyPad	221
The Arduino Mega 2560	222
The Freetronics EtherMega	222
The Arduino Due	223
Looking Ahead	224

12	
MOTORS AND MOVEMENT	225
Making Small Motions with Servos	225
Selecting a Servo	226
Connecting a Servo	227
Putting a Servo to Work	227
Project #38: Building an Analog Thermometer	228
The Hardware	228
The Schematic	229
The Sketch	229
Using Electric Motors	231
The TIP120 Darlington Transistor	231
Project #39: Controlling the Motor	232
The Hardware	232
The Schematic	233
The Sketch	234
Project #40: Building and Controlling a Tank Robot	235
The Hardware	235
The Schematic	238
The Sketch	240
Sensing Collisions	243
Project #41: Detecting Tank Bot Collisions with a Microswitch	243
The Schematic	243
The Sketch	244
Infrared Distance Sensors	246
Wiring It Up	247
Testing the IR Distance Sensor	247
Project #42: Detecting Tank Bot Collisions with IR Distance Sensor	249
Ultrasonic Distance Sensors	251
Connecting the Ultrasonic Sensor	252
Using the Ultrasonic Sensor	252
Testing the Ultrasonic Distance Sensor	252
Project #43: Detecting Tank Bot Collisions with an Ultrasonic Distance Sensor	254
The Sketch	254
Looking Ahead	256
13	
USING GPS WITH YOUR ARDUINO	257
What Is GPS?	258
Testing the GPS Shield	259
Project #44: Creating a Simple GPS Receiver	261
The Hardware	261
The Sketch	261
Displaying the Position on the LCD	262
Project #45: Creating an Accurate GPS-based Clock	263
The Hardware	263
The Sketch	264

Project #46: Recording the Position of a Moving Object over Time	265
The Hardware	265
The Sketch	266
Displaying Locations on a Map	268
Looking Ahead	269

14

WIRELESS DATA	271
Using Low-cost Wireless Modules	271
Project #47: Creating a Wireless Remote Control	272
The Hardware for the Transmitter Circuit	273
The Transmitter Schematic	273
The Hardware for the Receiver Circuit	274
The Receiver Schematic	274
The Transmitter Sketch	275
The Receiver Sketch	276
Using XBee Wireless Data Modules for Greater Range and Faster Speed	277
Project #48: Transmitting Data with an XBee	279
The Sketch	279
Setting Up the Computer to Receive Data	279
Project #49: Building a Remote Control Thermometer	281
The Hardware	281
The Layout	281
The Sketch	282
Operation	283
Looking Ahead	284

15

INFRARED REMOTE CONTROL	285
What Is Infrared?	285
Setting Up for Infrared	286
The IR Receiver	286
The Remote Control	287
A Test Sketch	287
Testing the Setup	288
Project #50: Creating an IR Remote Control Arduino	289
The Hardware	289
The Sketch	289
Expanding the Sketch	290
Project #51: Creating an IR Remote Control Tank	291
The Hardware	291
The Sketch	291
Looking Ahead	293

16

READING RFID TAGS	295
Inside RFID Devices	296
Testing the Hardware	297
The Schematic	297
Testing the Schematic	297

Project #52: Creating a Simple RFID Control System	299
The Sketch	299
How It Works	300
Storing Data in the Arduino's Built-in EEPROM	301
Reading and Writing to the EEPROM	302
Project #53: Creating an RFID Control with "Last Action" Memory	303
The Sketch	303
How It Works	306
Looking Ahead	306

17**DATA BUSES** **307**

The I ² C Bus	308
Project #54: Using an External EEPROM	309
The Hardware	309
The Schematic	310
The Sketch	311
The Result	312
Project #55: Using a Port Expander IC	313
The Hardware	313
The Schematic	313
The Sketch	314
The SPI Bus	315
Pin Connections	316
Implementing the SPI	316
Sending Data to an SPI Device	317
Project #56: Using a Digital Rheostat	318
The Hardware	318
The Schematic	318
The Sketch	319
Looking Ahead	320

18**REAL-TIME CLOCKS** **321**

Connecting the RTC Module	322
Project #57: Adding and Displaying Time and Date with an RTC	322
The Hardware	322
The Sketch	323
How It Works	325
Project #58: Creating a Simple Digital Clock	326
The Hardware	326
The Sketch	327
How It Works and Results	330
Project #59: Creating an RFID Time-Clock System	330
The Hardware	331
The Sketch	331
How It Works	335
Looking Ahead	336

19	
THE INTERNET	337
What You'll Need	337
Project #60: Building a Remote-Monitoring Station.	339
The Hardware	339
The Sketch	339
Troubleshooting	341
How It Works	342
Project #61: Creating an Arduino Tweeter	343
The Hardware	343
The Sketch	343
Controlling Your Arduino from the Web	344
Project #62: Setting Up a Remote Control for Your Arduino	345
The Hardware	345
The Sketch	346
Controlling Your Arduino Remotely	347
Looking Ahead	348
20	
CELLULAR COMMUNICATIONS	349
The Hardware	350
Preparing the Power Shield	351
Hardware Configuration and Testing	352
Changing the Operating Frequency	354
Project #63: Building an Arduino Dialer.	356
The Hardware	356
The Schematic	356
The Sketch	357
How It Works	358
Project #64: Building an Arduino Texter	358
The Sketch	359
How It Works	359
Project #65: Setting Up an SMS Remote Control	360
The Hardware	360
The Schematic	361
The Sketch	361
How It Works	363
Looking Ahead	364
INDEX	365



Lituz.com

**To'liq qismini
Shu tugmani
bosish orqali
sotib oling!**