

LEARNING MADE EASY

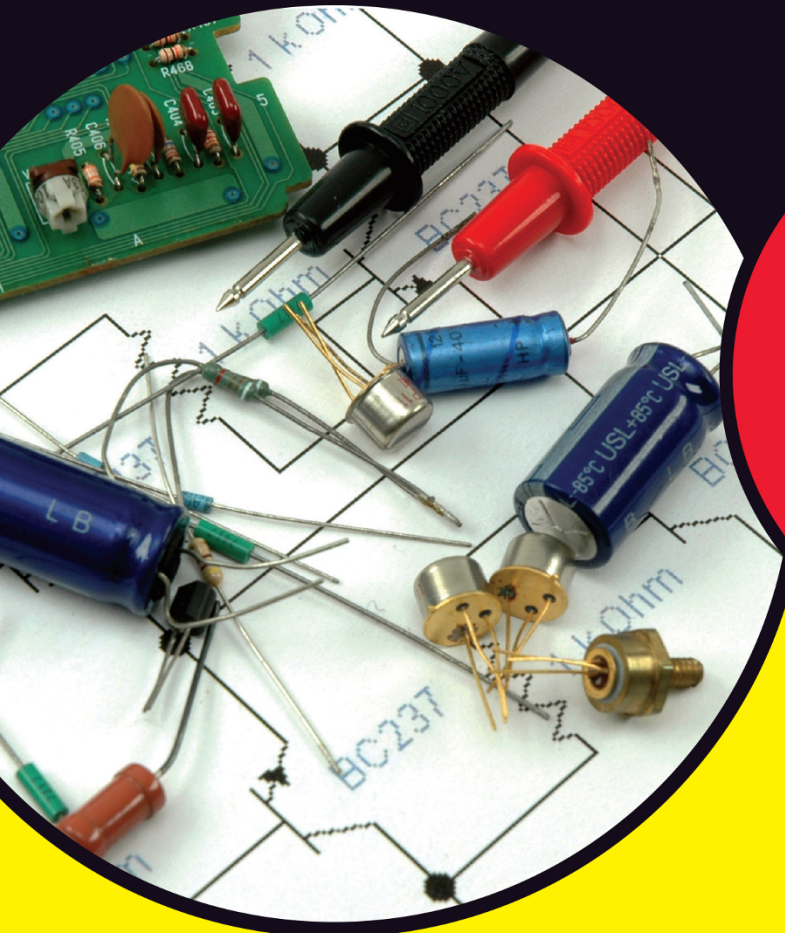


3rd Edition

Electronics

ALL-IN-ONE

for
dummies[®]
A Wiley Brand



Doug Lowe



Electronics

ALL-IN-ONE

3rd Edition

by **Doug Lowe**

for
dummies[®]
A Wiley Brand

Electronics All-in-One For Dummies®, 3rd Edition

Published by: **John Wiley & Sons, Inc.**, 111 River Street, Hoboken, NJ 07030-5774, www.wiley.com

Copyright © 2022 by John Wiley & Sons, Inc., Hoboken, New Jersey

Published simultaneously in Canada

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning or otherwise, except as permitted under Sections 107 or 108 of the 1976 United States Copyright Act, without the prior written permission of the Publisher. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at <http://www.wiley.com/go/permissions>.

Trademarks: Wiley, For Dummies, the Dummies Man logo, Dummies.com, Making Everything Easier, and related trade dress are trademarks or registered trademarks of John Wiley & Sons, Inc. and may not be used without written permission. All other trademarks are the property of their respective owners. John Wiley & Sons, Inc. is not associated with any product or vendor mentioned in this book.

LIMIT OF LIABILITY/DISCLAIMER OF WARRANTY: THE PUBLISHER AND THE AUTHOR MAKE NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS WORK AND SPECIFICALLY DISCLAIM ALL WARRANTIES, INCLUDING WITHOUT LIMITATION WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE. NO WARRANTY MAY BE CREATED OR EXTENDED BY SALES OR PROMOTIONAL MATERIALS. THE ADVICE AND STRATEGIES CONTAINED HEREIN MAY NOT BE SUITABLE FOR EVERY SITUATION. THIS WORK IS SOLD WITH THE UNDERSTANDING THAT THE PUBLISHER IS NOT ENGAGED IN RENDERING LEGAL, ACCOUNTING, OR OTHER PROFESSIONAL SERVICES. IF PROFESSIONAL ASSISTANCE IS REQUIRED, THE SERVICES OF A COMPETENT PROFESSIONAL PERSON SHOULD BE SOUGHT. NEITHER THE PUBLISHER NOR THE AUTHOR SHALL BE LIABLE FOR DAMAGES ARISING HEREFROM. THE FACT THAT AN ORGANIZATION OR WEBSITE IS REFERRED TO IN THIS WORK AS A CITATION AND/OR A POTENTIAL SOURCE OF FURTHER INFORMATION DOES NOT MEAN THAT THE AUTHOR OR THE PUBLISHER ENDORSES THE INFORMATION THE ORGANIZATION OR WEBSITE MAY PROVIDE OR RECOMMENDATIONS IT MAY MAKE. FURTHER, READERS SHOULD BE AWARE THAT INTERNET WEBSITES LISTED IN THIS WORK MAY HAVE CHANGED OR DISAPPEARED BETWEEN WHEN THIS WORK WAS WRITTEN AND WHEN IT IS READ.

For general information on our other products and services, please contact our Customer Care Department within the U.S. at 877-762-2974, outside the U.S. at 317-572-3993, or fax 317-572-4002. For technical support, please visit <https://hub.wiley.com/community/support/dummies>.

Wiley publishes in a variety of print and electronic formats and by print-on-demand. Some material included with standard print versions of this book may not be included in e-books or in print-on-demand. If this book refers to media such as a CD or DVD that is not included in the version you purchased, you may download this material at <http://booksupport.wiley.com>. For more information about Wiley products, visit www.wiley.com.

Library of Congress Control Number: 2022932613

ISBN 978-1-119-82211-0 (pbk); ISBN 978-1-119-82212-7 (ebk); ISBN 978-1-119-82213-4 (ebk)

Contents at a Glance

Introduction	1
Book 1: Getting Started with Electronics	7
CHAPTER 1: Welcome to Electronics	9
CHAPTER 2: Understanding Electricity	21
CHAPTER 3: Creating Your Mad-Scientist Lab	37
CHAPTER 4: Staying Safe	61
CHAPTER 5: Reading Schematic Diagrams	71
CHAPTER 6: Building Projects	85
CHAPTER 7: The Secrets of Successful Soldering	121
CHAPTER 8: Measuring Circuits with a Multimeter	133
CHAPTER 9: Catching Waves with an Oscilloscope	149
Book 2: Working with Basic Electronic Components	161
CHAPTER 1: Working with Basic Circuits	163
CHAPTER 2: Working with Resistors	203
CHAPTER 3: Working with Capacitors	235
CHAPTER 4: Working with Inductors	261
CHAPTER 5: Working with Diodes and LEDs	275
CHAPTER 6: Working with Transistors	301
Book 3: Working with Integrated Circuits	331
CHAPTER 1: Introducing Integrated Circuits	333
CHAPTER 2: The Fabulous 555 Timer Chip	345
CHAPTER 3: Working with Op-Amps	383
Book 4: Beyond Direct Current	403
CHAPTER 1: Getting into Alternating Current	405
CHAPTER 2: Building Power Supplies	429
CHAPTER 3: Understanding Radio	441
CHAPTER 4: Working with Infrared	467
Book 5: Doing Digital Electronics	485
CHAPTER 1: Understanding Digital Electronics	487
CHAPTER 2: Getting Logical	503
CHAPTER 3: Working with Logic Circuits	523
CHAPTER 4: Working with Flip-Flops	561
CHAPTER 5: Introducing Microcontrollers	591

Book 6: Working with Arduino Microprocessors	597
CHAPTER 1: Introducing Arduino.....	599
CHAPTER 2: Creating Arduino Sketches.....	615
CHAPTER 3: More Arduino Programming Tricks.....	647
CHAPTER 4: An Arduino Proximity Sensor.....	665
CHAPTER 5: Adding Sound and Motion to Your Arduino Projects.....	681
CHAPTER 6: Keypads and Keyboards.....	711
Book 7: Working with Raspberry Pi	735
CHAPTER 1: Introducing Raspberry Pi.....	737
CHAPTER 2: Programming in Python.....	759
CHAPTER 3: Reading Digital and Analog Input.....	791
Book 8: Special Effects	813
CHAPTER 1: Building a Color Organ.....	815
CHAPTER 2: Animating Holiday Lights.....	827
CHAPTER 3: Building an Animatronic Prop Controller.....	851
CHAPTER 4: Re-Creating a Retro Science-Fiction Robot Head.....	881
Index	893

Table of Contents

Introduction	1
About This Book	2
Foolish Assumptions	4
Icons Used in This Book	5
Beyond the Book	5
Where to Go from Here	5
BOOK 1: GETTING STARTED WITH ELECTRONICS	7
CHAPTER 1: Welcome to Electronics	9
What Is Electricity?	10
But Really, What Is Electricity?	12
What Is Electronics?	14
What Can You Do with Electronics?	16
Making noise	16
Making light	17
Transmitting to the world	17
Computing	18
Looking inside Electronic Devices	18
CHAPTER 2: Understanding Electricity	21
Pondering the Wonder of Electricity	22
Looking for Electricity	23
Peering Inside Atoms	24
Examining the Elements	25
Minding Your Charges	26
Conductors and Insulators	27
Understanding Current	28
Understanding Voltage	30
Comparing Direct and Alternating Current	32
Understanding Power	35
CHAPTER 3: Creating Your Mad-Scientist Lab	37
Setting Up Your Mad-Scientist Lab	38
Equipping Your Mad-Scientist Lab	41
Basic hand tools	41
Magnifying glasses	43
Third hands and hobby vises	44
Soldering iron	46
Multimeter	47
Solderless breadboard	49

Wire	50
Batteries	51
Other things to stock up on	53
Stocking up on Basic Electronic Components	54
Resistors	54
Capacitors	55
Diodes	56
Light-emitting diodes	57
Transistors	58
Integrated circuits	59
One Last Thing	59
CHAPTER 4: Staying Safe	61
Facing the Realities of Electrical Dangers	62
Household electrical current can kill you!	62
Even relatively small voltages can hurt you	64
Sometimes voltage hides in unexpected places	65
Other Ways to Stay Safe	66
Keeping Safety Equipment on Hand	69
Protecting Your Stuff from Static Discharges	69
CHAPTER 5: Reading Schematic Diagrams	71
Introducing a Simple Schematic Diagram	72
Laying Out a Circuit	73
To Connect or Not to Connect	74
Looking at Commonly Used Symbols	75
Simplifying Ground and Power Connections	78
Labeling Components in a Schematic Diagram	80
Representing Integrated Circuits in a Schematic Diagram	82
CHAPTER 6: Building Projects	85
Looking at the Process of Building an Electronic Project	86
Envisioning Your Project	87
Designing Your Circuit	89
Prototyping Your Circuit on a Solderless Breadboard	94
Understanding how solderless breadboards work	94
Laying out your circuit	96
Assembling the coin-toss circuit on a solderless breadboard	98
What if it doesn't work?	104
Constructing Your Circuit on a Printed Circuit Board (PCB)	104
Understanding how printed circuit boards work	105
Using a preprinted PCB	106
Building the coin-toss circuit on a PCB	108

	Finding an Enclosure for Your Circuit	113
	Working with a project box	114
	Mounting the coin-toss circuit in a box	115
CHAPTER 7:	The Secrets of Successful Soldering	121
	Understanding How Solder Works	122
	Procuring What You Need to Solder	123
	Buying a soldering iron	123
	Stocking up on solder	124
	Other goodies you need	125
	Preparing to Solder	126
	Soldering a Solid Solder Joint	127
	Checking Your Work	130
	Desoldering	131
CHAPTER 8:	Measuring Circuits with a Multimeter	133
	Looking at Multimeters	133
	What a Multimeter Measures	137
	Ammeter	137
	Voltmeter	138
	Ohmmeter	138
	Other measurements	139
	Schematic symbols for meter functions	139
	Using Your Multimeter	141
	Measuring current	143
	Measuring voltage	145
	Measuring resistance	146
CHAPTER 9:	Catching Waves with an Oscilloscope	149
	Understanding Oscilloscopes	150
	Examining Waveforms	152
	Calibrating an Oscilloscope	155
	Displaying Signals	157
	BOOK 2: WORKING WITH BASIC ELECTRONIC COMPONENTS	161
CHAPTER 1:	Working with Basic Circuits	163
	What Is a Circuit?	164
	Using Batteries	166
	Building a Lamp Circuit	169
	Project 1: A Simple Lamp Circuit	170
	Parts	170
	Steps	170

Working with Switches	171
The many ways to throw the switch	172
Making connections with poles and throws	173
Building a Switched Lamp Circuit	175
Project 2: A Lamp Controlled by a Switch	177
Parts	178
Steps	178
Understand Series and Parallel Circuits	179
Building a Series Lamp Circuit	181
Project 3: A Series Lamp Circuit	181
Parts	182
Steps	183
Building a Parallel Lamp Circuit	183
Project 4: A Parallel Lamp Circuit	184
Parts	185
Steps	185
Using Switches in Series and Parallel	186
Building a Series Switch Circuit	187
Project 5: A Series Switch Circuit	188
Parts	189
Steps	189
Building a Parallel Switch Circuit	190
Project 6: A Parallel Switch Circuit	190
Parts	191
Steps	192
Switching between Two Lamps	193
Project 7: Controlling Two Lamps with One Switch	193
Parts	194
Steps	195
Building a Three-Way Lamp Switch	196
Project 8: A Three-Way Light Switch	198
Parts	198
Steps	199
Reversing Polarity	199
Project 9: A Polarity-Reversing Circuit	200
Parts	201
Steps	201
CHAPTER 2: Working with Resistors	203
What Is Resistance?	204
Measuring Resistance	204
Looking at Ohm's Law	206
Introducing Resistors	208
Reading Resistor Color Codes	209
Reading a resistor's value	210
Understanding resistor tolerance	211

Understanding Resistor Power Ratings	213
Limiting Current with a Resistor	214
Project 10: Using a Current-Limiting Resistor	216
Parts	217
Steps	217
Combining Resistors	218
Combining resistors in series	219
Combining resistors in parallel	220
Mixing series and parallel resistors	221
Combining resistors in series and parallel	223
Project 11: Resistors in Series and Parallel	223
Parts	223
Steps	225
Dividing Voltage	228
Dividing Voltage with Resistors	229
Project 12: A Voltage Divider Circuit	229
Parts	230
Steps	231
Varying Resistance with a Potentiometer	232
CHAPTER 3: Working with Capacitors	235
What Is a Capacitor?	236
Counting Capacitance	239
Reading Capacitor Values	240
The Many Sizes and Shapes of Capacitors	242
Calculating Time Constants for Resistor/Capacitor Networks	245
Combining Capacitors	247
Combining capacitors in parallel	248
Connecting capacitors in series	248
Putting Capacitors to Work	250
Charging and Discharging a Capacitor	250
Project 13: Charging and Discharging a Capacitor	251
Parts	252
Steps	253
Blocking DC while Passing AC	254
Project 14: Blocking Direct Current	256
Parts	257
Steps	258
CHAPTER 4: Working with Inductors	261
What Is Magnetism?	262
The north and south of magnetism	263
Pondering permanent magnets	264
Examining Electromagnets	264

Inducing Current	265
Inductance and the art of resisting change	266
Regarding henry	268
Calculating RL Time Constants	269
Calculating Inductive Reactance	271
Combining Inductors	271
Putting Inductors to Work	272
CHAPTER 5: Working with Diodes and LEDs	275
What Is a Semiconductor?	276
Doping: It's not just for athletes	278
Understanding p-n junctions	279
Introducing Diodes	281
The Many Types of Diodes	283
Rectifier diodes	283
Signal diodes	284
Zener diodes	284
Using a Diode to Block Reverse Polarity	286
Project 15: Blocking Reverse Polarity	286
Parts	287
Steps	287
Putting Rectifiers to Work	289
Building Rectifier Circuits	291
Project 16: Rectifier Circuits	292
Parts	293
Steps	293
Introducing Light Emitting Diodes	294
Using LEDs to Detect Polarity	297
Project 17: An LED Polarity Detector	298
Parts	298
Steps	299
CHAPTER 6: Working with Transistors	301
What's the Big Deal about Transistors?	302
Why were transistors invented?	303
Looking inside a transistor	304
Examining transistor specifications	307
Amplifying with a Transistor	308
Using a Transistor as a Switch	312
An LED Driver Circuit	314
Project 18: A Transistor LED Driver	315
Parts	316
Steps	317
Looking at a Simple NOT Gate Circuit	318
Building a NOT Gate	319

Project 19: A NOT Gate	319
Parts	321
Steps	321
Oscillating with a Transistor	323
Building an LED Flasher	325
Project 20: An LED Flasher	327
Parts	328
Steps	328
Wrapping Up Our Exploration of Discrete Components	330
BOOK 3: WORKING WITH INTEGRATED CIRCUITS	331
CHAPTER 1: Introducing Integrated Circuits	333
What Exactly Is an Integrated Circuit?	334
Looking at How Integrated Circuits Are Made	335
Integrated Circuit Packages	336
Using ICs in Schematic Diagrams	339
Powering ICs.	340
Avoiding Static and Heat Damage.	341
Reading IC Data Sheets.	342
Popular Integrated Circuits	343
555 Timer	343
741 and LM324 Op-Amp.	344
78xx Voltage Regulator.	344
74xx Logic Family.	344
CHAPTER 2: The Fabulous 555 Timer Chip	345
Looking at How the 555 Works	346
Understanding 555 Modes.	348
Using the 555 in Monostable (One-Shot) Mode	349
Looking at a typical 555 monostable circuit	349
Looking at the resistor-capacitor circuit in a monostable timer	350
Calculating the time interval for a monostable circuit.	351
Using the 555 in Astable (Oscillator) Mode	352
Looking at a typical astable circuit	353
Controlling the time intervals in an astable 555 circuit	354
Calculating the duty cycle.	356
Using the 555 in Bistable (Flip-Flop) Mode	357
Using the 555 Timer Output	359
Doubling Up with the 556 Dual Timer	361
Making a One-Shot Timer.	364
Project 21: A One-Shot 555 Timer Circuit.	366
Parts	366
Steps	367

Making an LED Flasher	369
Project 22: An LED Flasher	370
Parts	371
Steps	372
Using a Set/Reset Switch	373
Project 23: An LED Flasher with a Set/Reset Switch	374
Parts	375
Steps	376
Making a Beeper	377
Project 24: An Audible Beeper	379
Parts	379
Steps	380
CHAPTER 3: Working with Op-Amps	383
Looking at Operational Amplifiers	384
Understanding Open Loop-Amplifiers	388
Looking at Closed Loop-Amplifiers	391
Using an Op-Amp as a Unity Gain Amplifier	393
Configuring a unity follower	394
Configuring a unity inverter	394
Using an Op-Amp as a Voltage Comparator	395
Adding Voltages	398
Working with Op-Amp ICs	401
BOOK 4: BEYOND DIRECT CURRENT	403
CHAPTER 1: Getting into Alternating Current	405
What Is Alternating Current?	406
Measuring Alternating Current	408
Understanding Alternators	411
Understanding Motors	413
Understanding Transformers	413
Working with Line Voltage	416
Using Line Voltage in Your Projects	417
Being safe with line voltage	418
Understanding hot, neutral, and ground	419
Wires and Connectors for Working with Line Voltage	421
Using Fuses to Protect Line-Voltage Circuits	423
Using Relays to Control Line-Voltage Circuits	425
CHAPTER 2: Building Power Supplies	429
Using a Power Adapter	430
Understanding What a Power Supply Does	431
Transforming Voltage	432
Turning AC into DC	433

	Half-wave rectifier	434
	Full-wave rectifier	435
	Bridge rectifier	435
	Filtering Rectified Current	436
	Regulating Voltage.	438
CHAPTER 3:	Understanding Radio	441
	Understanding Radio Waves	442
	Transmitting and Receiving Radio.	445
	Understanding radio transmitters	445
	Understanding radio receivers	446
	Understanding AM Radio	449
	Understanding FM Radio	451
	Building a Crystal Radio	454
	Looking at a simple crystal radio circuit.	455
	Gathering your parts.	456
	Building the coil	457
	Assembling the circuit.	460
	Stringing up an antenna	462
	Connecting to ground	464
	Using the crystal radio	465
CHAPTER 4:	Working with Infrared	467
	Introducing Infrared Light	467
	Detecting Infrared Light	469
	Project 25: A Simple IR Detector	471
	Parts	472
	Steps	472
	Creating Infrared Light	473
	Building a Proximity Detector	475
	Building a Common-Emitter Proximity Detector	476
	Project 26: A Common-Emitter Proximity Detector	477
	Parts	479
	Steps	479
	Building a Common-Collector Proximity Detector	480
	Project 27: A Common-Collector Proximity Detector.	482
	Parts	483
	Steps	483
	BOOK 5: DOING DIGITAL ELECTRONICS	485
CHAPTER 1:	Understanding Digital Electronics	487
	Distinguishing Analog and Digital Electronics	487
	Understanding Binary.	490
	Knowing your number systems.	490

Counting by ones	490
Doing the logic thing	493
Using Switches to Build Gates	495
Project 28: A Simple AND Circuit	497
Parts	497
Steps	498
Project 29: A Simple OR Circuit	499
Parts	499
Steps	500
Project 30: A Simple XOR Circuit	501
Parts	502
Steps	502
CHAPTER 2: Getting Logical	503
Introducing Boolean Logic and Logic Gates	504
Looking at NOT Gates	505
Looking at AND Gates	506
Looking at OR Gates	509
Looking at NAND Gates	511
Looking at NOR Gates	513
Looking at XOR and XNOR Gates	514
De Marvelous De Morgan's Theorem	516
All You Need Is NAND (Or NOR)	519
Universal NAND gates	519
Universal NOR gates	520
Using Software to Practice with Gates	521
CHAPTER 3: Working with Logic Circuits	523
Creating Logic Gates with Transistors	523
A transistor NOT gate circuit	524
Project 31: A Transistor NOT Gate	525
Parts	527
Steps	527
A transistor AND gate circuit	528
A transistor NAND gate circuit	529
Project 32: A Transistor NAND Gate	530
Parts	532
Steps	532
A transistor OR gate circuit	534
A transistor NOR gate circuit	534
Project 33: A Transistor NOR Gate	536
Parts	537
Steps	538
Introducing Integrated Circuit Logic Gates	539
Introducing the Versatile 4000-Series Logic Gates	542

Building Projects with the 4011 Quad Two-Input NAND Gate	544
Project 34: A CMOS NAND Gate	546
Parts	547
Steps	547
Project 35: A CMOS AND Gate	549
Parts	550
Steps	551
Project 36: A CMOS OR Gate	552
Parts	554
Steps	554
Project 37: A CMOS NOR Gate	556
Parts	557
Steps	557
CHAPTER 4: Working with Flip-Flops	561
Looking at Latches	562
Project 38: An Active-High Latch	566
Parts	567
Steps	567
Project 39: An Active-Low Latch	569
Parts	570
Steps	570
Looking at Gated Latches	572
Project 40: A Gated D Latch	575
Parts	576
Steps	576
Introducing Flip-Flops	579
Project 41: A D Flip-Flop	582
Parts	584
Steps	584
Project 42: A Toggle Flip-Flop	586
Parts	588
Steps	588
Debouncing a Clock Input	589
CHAPTER 5: Introducing Microcontrollers	591
Introducing Microcontrollers	592
Programming a Microcontroller	593
Working with I/O Pins	594
BOOK 6: WORKING WITH ARDUINO MICROPROCESSORS	597
CHAPTER 1: Introducing Arduino	599
Introducing the Arduino UNO	599
Buying an UNO Starter Kit	603

	Installing the Arduino IDE.....	603
	Connecting to an UNO.....	604
	Looking at a Simple Arduino Sketch.....	605
	Running the Blink Program.....	607
	Using a Digital I/O Pin to Control an LED.....	608
	Project 43: Blinking an LED with an Arduino UNO.....	612
	Parts.....	613
	Steps.....	613
CHAPTER 2:	Creating Arduino Sketches.....	615
	Introducing C.....	616
	Working with a Prototyping Shield.....	619
	Building a Test Circuit.....	621
	Project 44: An Arduino LED Test Circuit.....	622
	Parts.....	623
	Steps.....	623
	Flashing the LEDs.....	625
	Using Comments.....	627
	Creating Identifiers.....	629
	Using Variables.....	629
	Doing Math.....	631
	A Program That Uses Variables and Math.....	632
	Using If Statements.....	634
	Using While Loops.....	638
	Using For Loops.....	641
	Crafting Your Own Functions.....	644
CHAPTER 3:	More Arduino Programming Tricks.....	647
	Using a Push Button with an Arduino.....	647
	Checking the Status of a Switch in Arduino.....	649
	Project 45: A Push-Button Controlled Arduino LED Flasher.....	652
	Parts.....	653
	Steps.....	654
	Randomizing Your Programs.....	655
	Reading a Value from a Potentiometer.....	658
	Project 46: A Variable-Rate LED Flasher.....	660
	Parts.....	662
	Steps.....	662
CHAPTER 4:	An Arduino Proximity Sensor.....	665
	Using an Ultrasonic Range Finder.....	665
	Looking at the HC-SR04 Range Finder.....	666
	Generating a trigger pulse.....	667
	Reading pulse input.....	668

Doing the math	668
Using an LCD	669
Connecting an LCD to Arduino	670
Programming the LCD	671
Building a Proximity Sensor	673
Project 47: An Arduino Proximity Sensor	674
Parts	675
Steps	676
CHAPTER 5: Adding Sound and Motion to Your Arduino Projects	681
Using a Speaker with an Arduino	681
Using the tone function	683
Connecting a speaker to an Arduino	684
Project 48: Creating Sound with a Speaker	686
Parts	687
Steps	687
Sounding the alarm with Morse code	688
Playing a siren	690
Playing a song	692
Using an MP3 Shield	694
Assembling the Music Maker shield	695
Preparing the micro-SD card	695
Programming the Music Maker shield	696
Building an Arduino Music Player	699
Project 49: Using a Music Maker Shield to Play Sounds	699
Parts	700
Steps	700
Using a Servo with an Arduino	702
Connecting a servo to an Arduino	702
Programming a servo	704
Building a servo project	707
Project 50: Using a Servo with an Arduino	707
Parts	709
Steps	709
CHAPTER 6: Keypads and Keyboards	711
Using a Keypad	711
How a keypad works	712
Connecting a keypad to an Arduino	713
Programming a keypad	714
Setting Up a Keypad	716

Defining the number of rows and columns	717
Defining the row and column pins	717
Defining the keymap	718
Using a Keypad variable	718
Detecting when a key has been pressed	719
Building a Keypad Circuit	720
Project 51: Using a Keypad	720
Parts	721
Steps	722
Using an Arduino for Computer Keyboard Input	724
Using the Keyboard library	725
Sending a line via the keyboard	726
Using the switch statement to simplify choices	727
Pressing and holding keys	728
Building a Windows Keypad Gadget	730
Project 52: A Windows Keypad Gadget	730
Parts	731
Steps	731
BOOK 7: WORKING WITH RASPBERRY PI	735
CHAPTER 1: Introducing Raspberry Pi	737
Introducing the Raspberry Pi	738
Considering Raspberry Pi Versions	740
Setting Up a Raspberry Pi	741
Installing the Raspberry Pi Operating System	742
Starting Up Your Raspberry Pi	744
Understanding the File System	746
Writing Your First Raspberry Pi Program	748
Examining GPIO Ports	751
Connecting an LED to a GPIO Port	753
Flashing an LED in Python	754
Building a Raspberry Pi LED Flasher	755
Project 51: Blinking an LED with a Raspberry Pi	756
Parts	757
Steps	758
CHAPTER 2: Programming in Python	759
Looking Closer at Python	760
Building a Test Circuit	761
Project 52: A Raspberry Pi LED Test Board	762
Parts	763
Steps	764
Flashing the LEDs	765
Using Comments	768
Creating Identifiers	770

	Using Constants	770
	Using Variables	772
	Creating Your Own Functions	775
	Using If Statements	778
	Using While Loops	781
	Using For Loops	784
	Looking at Python Lists	787
CHAPTER 3:	Reading Digital and Analog Input	791
	Using a GPIO Port for Digital Input	791
	Checking the Status of a Switch in Python	794
	Project 53: A Push-Button-Controlled Raspberry Pi LED Flasher	796
	Parts	798
	Steps	798
	Reading Analog Input	799
	Enabling SPI on Your Raspberry Pi	803
	Using the MCP3008 in Python	804
	Using the mcp3008 Package	805
	Project 54: A Variable-Rate LED Flasher	808
	Parts	809
	Steps	810
	BOOK 8: SPECIAL EFFECTS	813
CHAPTER 1:	Building a Color Organ	815
	Examining the Color Organ Project	816
	Understanding How the Color Organ Works	818
	Getting What You Need to Build the Color Organ	819
	Assembling the Color Organ	819
	Using the Color Organ	825
CHAPTER 2:	Animating Holiday Lights	827
	Introducing the ShowTime PC Controller	828
	Looking at a Basic Light-O-Rama Setup	830
	Understanding Channels and Sequences	832
	Choosing Lights for Your Display	833
	Designing Your Layout	835
	Assembling the ShowTime PC Controller	835
	Connecting the Controller to a Computer	837
	Testing the ShowTime PC Controller	838
	Using the Light-O-Rama Sequence Editor	840
	Understanding Sequences	841
	Creating a Musical Sequence	842
	Visualizing Your Show	847

CHAPTER 3: Building an Animatronic Prop Controller	851
Looking at the Requirements of Animatronic Prop Control	852
Examining a Typical Animatronic Prop	854
Building the Prop Controller	858
Programming the Prop-1 Controller	863
Sending Commands to the RC-4 or AP-16+ Modules	864
Programming the RC-4 Relay Control Module	866
Turning all relays off	867
Turning an individual relay on or off	867
Setting all four relays at once	868
Using symbols to make RC-4 commands more readable	869
A sample program for controlling all four RC-4 relays	869
Programming the AP-16+ Audio Player Module	871
Resetting the AP-16+	873
Changing the volume	874
Playing a specific file	874
Waiting for a file to finish playing	875
A Sample AP-16+ Program	876
Programming the PIR Motion Detector	877
Looking at Complete Jack-in-the-Box Program	878
CHAPTER 4: Re-Creating a Retro Science-Fiction Robot Head ..	881
Looking to Robby and B-9 For Inspiration	882
Conceiving VIN-e	884
Introducing VIN-e 1.0	885
The dome	885
The base	886
The central pillar	886
The eyes and nose	887
The mouth	888
The “vacuum tubes”	888
The antenna	889
Looking at VIN-e’s Electronics	889
A Final Word about Safety	891
INDEX	893

Introduction

W elcome to the amazing world of electronics!

Ever since I was a kid, I've been fascinated with electronics. When I was about 10 years old, my dad bought me an electronic experimenter's kit from the local RadioShack store. I still have it; it's pictured here.



I have incredible memories of evenings spent with my dad, wiring the sample circuits to make squawking police sirens, flashing lights, a radio receiver, and even a telegraph machine.

The best part was dreaming that when I grew up, I'd have a job in the field of electronics, that someday I'd understand exactly how those resistors, capacitors, inductors, transistors, and integrated circuits actually worked, and I'd use that knowledge to design televisions or computers or communication satellites.

Well, that dream didn't come true. Instead, I went into a closely related field: computer programming. But my love of electronics never died, and I've spent the last 40 years or so experimenting with electronics as a hobbyist.

This book is an introduction to electronics for people who have always been fascinated by electronics but didn't make a career out of it. In these pages, you'll find clear and concise explanations of the most important concepts that form the basis of all electronic devices, concepts such as the nature of electricity (if you think you really know what it is, you're kidding yourself); the difference between voltage, amperage, and wattage; and how basic components such as resistors, capacitors, diodes, and transistors work.

Not only will you gain an appreciation for the electronic devices that are a part of everyday life, but you'll also learn how to build simple circuits that will not only impress your friends but may actually be useful!

About This Book

Electronics All-in-One For Dummies, 3rd Edition, is intended to be a reference for the most important topics you need to know when you dabble in building your own electronic circuits. It's a big book made up of eight smaller books, which we at the home office like to call *minibooks*. Each of these minibooks covers the basics of one key topic for working with electronics, such as circuit building techniques, how electronic components like diodes and transistors work, or using integrated circuits.

This book doesn't pretend to be a comprehensive reference for every detail on every possible topic related to electronics. Instead, it shows you how to get up and running fast so that you have more time to do the things you really want to do. Designed using the easy-to-follow For Dummies format, this book helps you get the information you need without laboring to find it.

Whenever one big thing is made up of several smaller things, confusion is always a possibility. That's why this book is designed with multiple access points to help you find what you want. At the beginning of the book is a detailed table of contents that covers the entire book. Then each minibook begins with a minitable of contents that shows you at a minigance what chapters are included in that minibook. Useful running footers appear at the bottom of each page to point out the topic discussed on that page, and handy thumb tabs run down the side of the pages to help you find each minibook quickly. Finally, a comprehensive index lets you find information anywhere in the entire book.

This isn't the kind of book you pick up and read from start to finish as if it were a cheap novel. If I ever see you reading it at the beach, I'll kick sand in your face. Beaches are for reading romance novels or murder mysteries, not electronics books. Although you could read this book straight through from start to finish, this book is designed like a reference book, the kind of book you can pick up, open to just about any page, and start reading.

You don't have to memorize anything in this book. It's a "need-to-know" book: You pick it up when you need to know something. Need a reminder on how to calculate the correct load resistor for an LED circuit? Pick up the book. Can't remember the pinouts for a 555 timer IC? Pick up the book. After you find what you need, put the book down and get on with your life.

You can find a total of 54 projects strewn throughout this book's chapters. You'll find a plethora of simple projects you can build to demonstrate the operation of typical circuits. For example, in the chapter on transistors, you'll find several simple projects that demonstrate common uses for transistors, such as driving an LED, creating an oscillator, or inverting an input.

I suggest you build each of the projects as you read the chapters. Reading about electronics circuits is one thing, but to understand how a circuit works, you really need to build it and see it in operation. Most of the projects are simple enough that you can build them in 20 to 30 minutes, assuming you have the parts on hand.

If you are lucky enough to have a store that carries electronic components in your community, you're in luck! If you want to build one of the projects on a Saturday afternoon, you can buzz over to your local electronics store, pick up the parts you'll need, take them home, and build the circuit.

Of course, you can also purchase the components you need at any other store that stocks electronic hobbyist components, and you can find many sources for purchasing the parts online.

Finally, most of the electronic circuits described in this book are perfectly safe: They run from common AA or 9 V batteries and therefore don't work with voltages large enough to hurt you.

However, you'll occasionally come across circuits that work with higher voltages, which can be dangerous. Any project that involves line voltage (that is, that you plug into an electrical outlet) should be considered potentially dangerous and handled with the utmost care. In addition, even battery-powered circuits that use large capacitors can build up charges that can deliver a potentially painful shock.

When you work with electronics, you'll also encounter dangers other than those posed by electricity. Soldering irons are hot and can burn you. Wire cutters are sharp and can cut you. And there are plenty of small parts that can fall on the floor and find themselves in the mouths of kids or pets.

Safety is an important enough topic that I've devoted a chapter to it in Book 1. I strongly urge you to read Book 1, Chapter 4 *before* you build anything.

Please be careful! The projects that are presented in Book 8 all work directly with line-level voltage and should be considered dangerous. You must exercise great care if you decide to build any of those projects, as a single mistake could kill you or someone else. Those projects are offered as educational prototypes that are designed to be operated only within the safe confines of your workbench, where you can control the power connections so that no one is exposed to dangerous voltages.

Foolish Assumptions

Throughout this book, I make very few assumptions about what you may know about the subject of electronics. I certainly don't assume that you've ever taken a class on electronics, have ever assembled a circuit, or are well versed in advanced science or math.

In fact, there are really very few things I do assume:

- » **You're curious about the fascinating world of electronics.** For example, if you've ever wondered how a radio works or what makes a computer possible, this book is for you.
- » **You like to build things.** The best way to learn *about* electronics is to *do* electronics. This book has plenty of simple projects for you to build and back your knowledge up with first hand experience.
- » **You have a space to work and some basic tools.** You'll need at least a small workspace and basic tools such as a screwdriver and wire cutters.
- » **You can afford to spend a little money to get the parts you need.** Although a few of the projects later in the book require that you purchase items that may cost as much as a hundred dollars or more, most of the components you need can be purchased for just a few dollars.

Icons Used in This Book

Like any *For Dummies* book, this one is chock-full of helpful icons that draw your attention to items of particular importance. You find the following icons throughout this book:



TIP

Pay special attention to this icon; it lets you know that some particularly useful tidbit is at hand.



TECHNICAL
STUFF

Hold it — overly technical stuff is just around the corner. Obviously, because this is an electronics book, almost every paragraph of the entire book could get this icon. So I reserve it for those paragraphs that go into greater depth, down into explaining how something works under the covers — probably deeper than you really need to know to use a feature, but often enlightening. You also sometimes find this icon when I want to illustrate a point with an example that uses some electronics gadget that hasn't been covered so far in the book but is covered later. In those cases, the icon is just a reminder that you shouldn't get bogged down in the details of the illustration and should instead focus on the larger point.



WARNING

Danger, Will Robinson! This icon highlights information that may help you avert disaster. You should definitely pay attention to the warning icons because they will let you know about potential safety hazards.



REMEMBER

Did I tell you about the memory course I took?

Beyond the Book

In addition to the material in the print or e-book you're reading right now, this product also comes with some access-anywhere goodies on the web. Check out the free Cheat Sheet for some safety rules to follow, a list of electronic resistor color codes, and more. To get this Cheat Sheet, simply go to www.dummies.com and type **Electronics All-in-One For Dummies Cheat Sheet** in the Search box.

Where to Go from Here

Yes, you *can* get there from here. With this book in hand, you're ready to plow right into the exciting hobby of electronics. Browse through the table of contents and decide where you want to start. Be bold! Be courageous! Be adventurous! And above all, have fun!

1

Getting Started with Electronics

Contents at a Glance

CHAPTER 1: Welcome to Electronics	9
CHAPTER 2: Understanding Electricity	21
CHAPTER 3: Creating Your Mad-Scientist Lab	37
CHAPTER 4: Staying Safe	61
CHAPTER 5: Reading Schematic Diagrams	71
CHAPTER 6: Building Projects	85
CHAPTER 7: The Secrets of Successful Soldering	121
CHAPTER 8: Measuring Circuits with a Multimeter	133
CHAPTER 9: Catching Waves with an Oscilloscope	149