

Make:

BASIC

Arduino Projects



26 Experiments with
Microcontrollers and Electronics
Don Wilcher

Make: Basic Arduino Projects

*26 Experiments with Microcontrollers
and Electronics*

Don Wilcher



Make: Basic Arduino Projects

by Don Wilcher

Copyright © 2014 Don Wilcher. All rights reserved.

Printed in the United States of America.

Published by Maker Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.

Maker Media books may be purchased for educational, business, or sales promotional use. Online editions are also available for most titles (<http://safaribooksonline.com>). For more information, contact O'Reilly Media's corporate/institutional sales department: 800-998-9938 or corporate@oreilly.com.

Editor: Patrick Di Justo

Production Editor: Kara Ebrahim

Copyeditor: Charles Roumeliotis

Proofreader: Jasmine Kwityn

Indexer: Ellen Troutman

Cover Designer: Juliann Brown

Interior Designer: David Futato

Illustrator: Rebecca Demarest

Photographers: Frank Teng and Don Wilcher

February 2014: First Edition

Revision History for the First Edition:

2014-02-05: First release

2014-03-07: Second release

2015-10-23: Third release

See <http://oreilly.com/catalog/errata.csp?isbn=9781449360665> for release details.

The Make logo and Maker Media logo are registered trademarks of Maker Media, Inc. *Make: Basic Arduino Projects* and related trade dress are trademarks of Maker Media, Inc.

Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this book, and Maker Media, Inc., was aware of a trademark claim, the designations have been printed in caps or initial caps.

While every precaution has been taken in the preparation of this book, the publisher and author assume no responsibility for errors or omissions, or for damages resulting from the use of the information contained herein.

ISBN: 978-1-449-36066-5

[LSI]

Contents

Preface	ix
1. The Trick Switch	1
Parts List.....	1
Let's Build a Trick Switch.....	2
Trick Switch with On/Off Indicators.....	4
Something to Think About.....	6
2. Sunrise-Sunset Light Switch	9
Parts List.....	9
Let's Build a Sunrise-Sunset Light Switch.....	10
Circuit Theory.....	12
Sunrise-Sunset Detector with Serial Monitor.....	14
Something to Think About.....	16
3. Tilt Sensing Servo Motor Controller	19
Parts List.....	19
Let's Build a Tilt Sensing Servo Motor Controller.....	20
Upload the Tilt Sensor Sketch.....	23
A Simple Animatronic Controller Using the Serial Monitor.....	24
Circuit Theory.....	27
Something to Think About.....	28
4. Twin LEDs	29
Parts List.....	29
Circuit Theory.....	31

	Twin LED Flasher.....	31
	Build the Adjustable Twin LED Flasher.....	35
	It's Alive! Build a FrankenBot Toy.....	38
	Something to Think About.....	41
5.	The Opposite Switch.....	43
	Parts List.....	43
	Circuit Theory.....	44
	The Opposite Switch (aka the NOT Logic Gate).....	45
	Build an Arduino NOT Logic Gate.....	45
	Upload the Arduino NOT Logic Gate Sketch.....	46
	Something to Think About.....	50
6.	The AND Logic Gate.....	51
	Parts List.....	51
	Circuit Theory.....	52
	The Arduino AND Logic Gate.....	55
	Upload the Arduino AND Logic Gate Sketch.....	57
	Something to Think About.....	59
7.	The OR Logic Gate.....	61
	Parts List.....	61
	Circuit Theory.....	62
	The Arduino OR Logic Gate.....	64
	Upload the Arduino OR Logic Gate Sketch.....	66
	Something to Think About.....	69
8.	Tilt Flasher.....	71
	Parts List.....	71
	Circuit Theory.....	72
	The Up-Down Sensor.....	73
	Something to Think About.....	76
9.	Multicolor RGB Flasher.....	79
	Parts List.....	79
	Circuit Theory.....	80
	The RGB Flasher.....	81
	Something to Think About.....	86

10.	The Magic Light Bulb	87
	Parts List.....	87
	Let's Build a Magic Light Bulb.....	88
	Upload the Magic Light Bulb Sketch.....	89
	Circuit Theory.....	91
	Something to Think About.....	92
11.	Metal Checker: The Electronic Switch	95
	Parts List.....	95
	Let's Build a Metal Checker.....	96
	Upload the Metal Checker Sketch.....	98
	Circuit Theory.....	100
	Something to Think About.....	101
12.	The Theremin	103
	Parts List.....	103
	Let's Build a Theremin.....	104
	Upload the Theremin Sketch.....	106
	Circuit Theory.....	109
	Something to Think About.....	110
13.	An Arduino Ohmmeter	111
	Parts List.....	111
	Let's Build an Arduino Ohmmeter.....	112
	Upload the Arduino Ohmmeter Sketch.....	113
	Circuit Theory.....	115
	Something to Think About.....	117
14.	The LCD News Reader	119
	Parts List.....	119
	Let's Build the LCD.....	120
	Upload the LCD News Reader Sketch.....	122
	Circuit Theory.....	128
	Something to Think About.....	129
15.	A Logic Tester (with an RGB LED)	131
	Parts List.....	131
	Let's Build a Logic Tester.....	132

	Upload the Logic Tester Sketch.....	133
	Circuit Theory.....	135
	Something to Think About.....	136
16.	A Logic Tester(with an LCD).....	137
	Parts List.....	137
	Let's Build a Logic Tester.....	138
	Upload the Logic Tester Sketch.....	139
	Circuit Theory.....	141
	Something to Think About.....	142
17.	The Amazing Pushbutton (with Processing).....	143
	Parts List.....	143
	Let's Build an Amazing Pushbutton.....	144
	Upload the Amazing Pushbutton Sketch.....	146
	Download and Install Processing Notes.....	148
	Let's Visualize Digital Data with Processing.....	148
	Troubleshooting Tips for Processing.....	155
	Something to Think About.....	156
18.	The Terrific Tilt Switch (with Processing).....	157
	Parts List.....	157
	Let's Build a Terrific Tilt Switch.....	158
	Upload the Terrific Tilt Switch Sketch.....	159
	Let's Visualize Digital Data with Processing.....	162
	Something to Think About.....	167
19.	The Rocket Launching Game (with Processing).....	169
	Parts List.....	169
	Let's Build a Rocket Game.....	170
	Upload the MultiDigital4 Sketch.....	171
	The Rocket Launcher with Processing.....	174
	Something to Think About.....	181
20.	Temperature Indicator (with Processing).....	183
	Parts List.....	183
	Let's Build a Temperature Indicator.....	184
	Upload the Temperature Indicator Sketch.....	185

	The Negative Temperature Coefficient (NTC) Sensor with Processing...	188
	Something to Think About.....	191
21.	Sweeping Servo.....	193
	Parts List.....	193
	Let's Build a Servo Motor Tester.....	194
	Upload the Sweeping Sketch.....	195
	Something to Think About.....	198
22.	Electronic Cricket.....	199
	Parts List.....	199
	Let's Build an Electronic Cricket.....	200
	Upload the Electronic Cricket Sketch.....	201
	Something to Think About.....	204
23.	A Pocket Stage Light.....	205
	Parts List.....	205
	Let's Build a Pocket Stage Light.....	206
	Upload the Pocket Stage Light Sketch.....	208
	Something to Think About.....	211
24.	Electronic Pixel.....	213
	Parts List.....	213
	Let's Build an Electronic Pixel.....	214
	Upload the Electronic Pixel Sketch.....	216
	Something to Think About.....	219
25.	The Metronome.....	221
	Parts List.....	221
	Let's Build a Metronome.....	222
	Upload the Metronome Sketch.....	225
	Something to Think About.....	228
26.	The Secret Word Game.....	231
	Parts List.....	231
	Let's Build a Secret Word Game.....	232
	Upload the Secret Word Game Sketch.....	234
	Rules for the Secret Word Game.....	237
	Something to Think About.....	237

Index..... 239

Preface

So, you've been playing around with Arduino, but are looking for some fun projects to try out with it. *Make: Basic Arduino Projects* is here to help you! It's got a wealth of cool devices and gadgets to build with Arduino and some common components. The projects in the book explain the world of electronics using a fun and hands-on approach.

The motivation behind writing this book is based on several conversations with Brian Jepson (Make: books' Publisher) and the need for a book that allows people to explore Arduino and the universe of electronic parts that go along with it. The Arduino is a very popular Maker platform that allows you to explore electronics with an interactive approach. As awesome as a box of parts is, it's difficult for people with little electronics experience to begin making things with it. This book solves that problem by letting you learn more about electronics while you make fun projects with the parts in this kit. *Basic Arduino Projects* is a practical guide that illustrates how a bunch of electronic parts, coupled with Arduino, can be transformed into awesome devices and gadgets for education and play.

In addition, being an electrical engineer and educator, I'm very sensitive to delivering good instructional content to my students (adults and teenagers). This book was written to attract young readers to the exciting world of electronics by building cool and creative projects using Arduino. This book is also intended for Makers and novices who have heard about the Arduino but never experienced the fun and excitement that comes from building cool electronic gadgets and devices with this open hardware platform.

By building and experimenting with the projects in this book, young readers, Makers, and electronic novices will learn how to:

- Read electronic circuit schematic and block diagrams.
- Assemble electronic circuits using the MakerShield prototyping board.

- Build basic logic circuits using the Arduino as a programmable computer brain.
- Use an LCD display for displaying text and special characters.
- Create simple electronic controllers for LEDs and servo motors.

Last, you will learn how to create gadgets and devices for education and play using imagination and some common electronic components. Enjoy the Maker adventure!

Conventions Used in This Book

The following typographical conventions are used in this book:

Italic

Indicates new terms, URLs, email addresses, filenames, and file extensions.

Constant width

Used for program listings, as well as within paragraphs to refer to program elements such as variable or function names, databases, data types, environment variables, statements, and keywords.

Constant width bold

Shows commands or other text that should be typed literally by the user.

Constant width italic

Shows text that should be replaced with user-supplied values or by values determined by context.



This icon signifies a tip, suggestion, or general note.



This icon indicates a warning or caution.

Using Code Examples

Supplemental material (code examples, exercises, etc.) is available for download at http://www.family-science.net/electro_arduino.htm.


This book is here to help you get your job done. In general, if example code is offered with this book, you may use it in your programs and documentation. You do not need to contact us for permission unless you're reproducing a significant portion of the code. For example, writing a program that uses several chunks of code from this book does not require permission. Selling or distributing a CD-ROM of examples from O'Reilly books does require permission. Answering a question by citing this

book and quoting example code does not require permission. Incorporating a significant amount of example code from this book into your product's documentation does require permission.

We appreciate, but do not require, attribution. An attribution usually includes the title, author, publisher, and ISBN. For example: "*Make: Basic Arduino Projects* by Don Wilcher (Maker Media). Copyright 2014 Don Wilcher, 978-1-449-36066-5."

If you feel your use of code examples falls outside fair use or the permission given here, feel free to contact us at bookpermissions@makermedia.com.

Safari® Books Online

 *Safari Books Online* is an on-demand digital library that delivers expert content in both book and video form from the world's leading authors in technology and business.

Technology professionals, software developers, web designers, and business and creative professionals use Safari Books Online as their primary resource for research, problem solving, learning, and certification training.

Safari Books Online offers a range of [product mixes](#) and pricing programs for [organizations](#), [government agencies](#), and [individuals](#). Subscribers have access to thousands of books, training videos, and prepublication manuscripts in one fully searchable database from publishers like MAKE, O'Reilly Media, Prentice Hall Professional, Addison-Wesley Professional, Microsoft Press, Sams, Que, Peachpit Press, Focal Press, Cisco Press, John Wiley & Sons, Syngress, Morgan Kaufmann, IBM Redbooks, Packt, Adobe Press, FT Press, Apress, Manning, New Riders, McGraw-Hill, Jones & Bartlett, Course Technology, and dozens [more](#). For more information about Safari Books Online, please visit us [online](#).

How to Contact Us

Please address comments and questions concerning this book to the publisher:

MAKE
1005 Gravenstein Highway North
Sebastopol, CA 95472
800-998-9938 (in the United States or Canada)
707-829-0515 (international or local)
707-829-0104 (fax)

MAKE unites, inspires, informs, and entertains a growing community of resourceful people who undertake amazing projects in their backyards, basements, and garages. MAKE celebrates your right to tweak, hack, and bend any technology to your will. The MAKE audience continues to be a growing culture and community that believes in bettering ourselves, our environment, our educational system—our

entire world. This is much more than an audience, it's a worldwide movement that Make is leading—we call it the Maker Movement.

For more information about MAKE, visit us online:

MAKE magazine: <http://makezine.com/magazine/>

Maker Faire: <http://makerfaire.com>

Makezine.com: <http://makezine.com>

Maker Shed: <http://makershed.com/>

We have a web page for this book, where we list errata, examples, and any additional information. You can access this page at <http://oreil.ly/basic-arduino>.

To comment or ask technical questions about this book, send email to bookquestions@oreilly.com.

Acknowledgments

I would like to thank Brian Jepson (Publisher) for believing in the book concept and allowing me to explore Arduino in creative ways. Also, I would like to thank Patrick Di Justo (Editor) for pulling out the really cool projects from the original book proposal and coaching me to present them in fun and entertaining ways for young readers.

My final acknowledgment goes to my wife, Mattalene, who patiently worked with me on editing this book, keeping me on task with the writing/project builds, and reviewing the email revision messages from my editors. To my children, Tiana, D'Vonn, and D'Mar, thanks for being great kids while I worked on the book during family time.

The Trick Switch

Resistor-Capacitor Timing Basics

In electronics, sometimes we want to keep a device on for a certain amount of time even when an electrical switch is turned off. Ordinary pushbuttons used to turn electronic devices on and off can easily be operated by a timed delay switch. How awesome would it be to create such a device to delay turning off a simple LED? Such a gadget could be used to trick your friends, family, or even the local Makerspace when they see the LED staying on after the pushbutton has been released. With a few electronic components, you can make an LED (light-emitting diode) stay on for a few extra seconds when a pushbutton switch is turned off. [Figure 1-1](#) shows an assembled Trick Switch. The electronic components required to build the Trick Switch are shown in the Parts List.

Parts List

- Arduino microcontroller
- SW1: mini pushbutton
- LED1: red LED
- C1: 100 uF electrolytic capacitor
- R1: 10K ohm resistor (brown, black, orange stripes)
- R2: 330 ohm resistor (orange, orange, brown stripes)
- Full-size clear breadboard

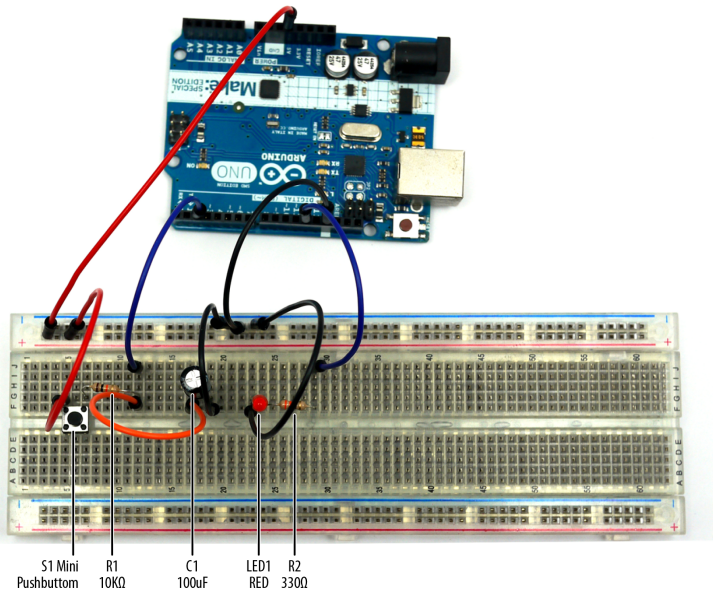


Figure 1-1. Trick Switch circuit built on a full-size clear breadboard (both the 100 μ F electrolytic capacitor and red LED negative pins are wired to ground)



Tech Note

You can create your own electrical circuits and test them using diagrams with an online simulator called [Circuit Lab](#).

Let's Build a Trick Switch

When you press the pushbutton switch on this device, the LED turns on. The capacitor will begin storing electrical energy from the +5VDC power supply circuit of the Arduino. Releasing the pushbutton switch cuts off the flow of electricity from the source, but the energy stored in the capacitor keeps the Arduino running for a few extra seconds. The Arduino keeps the LED lit until the capacitor's stored energy is empty. You can build the Trick Switch using the electronic components from the Parts List and the Fritzing wiring diagram shown in [Figure 1-2](#). Here are the steps required to build the electronic device:

1. Place the required parts on your workbench or lab tabletop.
2. Wire the electronic parts using the Fritzing wiring diagram of [Figure 1-2](#) or the actual Trick Switch device shown in [Figure 1-1](#).
3. Type the Pushbutton sketch shown in [Example 1-1](#) into the Arduino text editor.

4. Upload the Pushbutton sketch to the Arduino.
5. Press the mini pushbutton for a moment. The red LED turns on. After one to two minutes, the red LED will turn off.

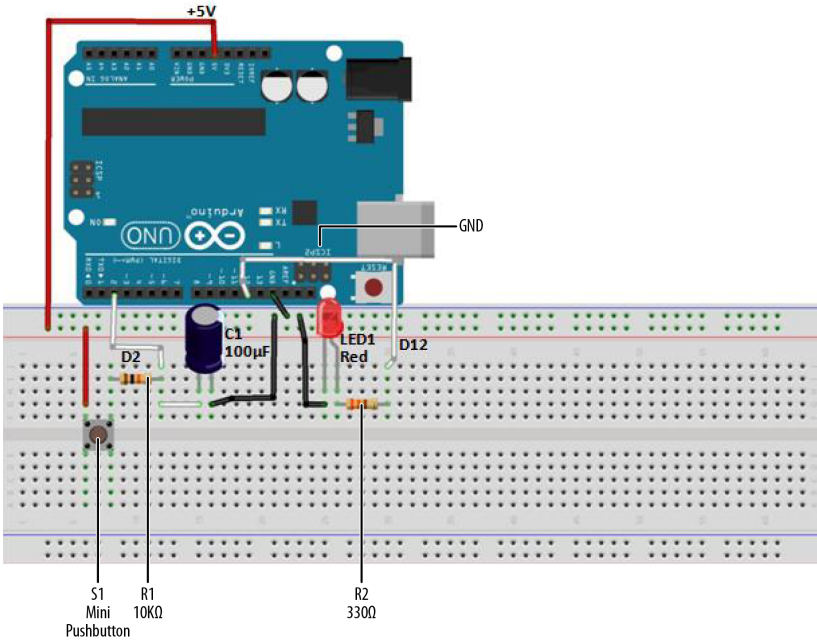


Figure 1-2. Trick Switch Fritzing diagram



Troubleshooting Tip

If the Trick Switch device doesn't work, check for incorrect resistor values, incorrect wiring, sketch typos, and improper orientation of polarized electronic components (the LED and capacitor).

Example 1-1. Pushbutton sketch

/*

Pushbutton Sketch

Reads the capacitor voltage at digital pin 2 and turns on and off a light-emitting diode (LED) connected to digital pin 12.

17 Nov 2012
by Don Wilcher


```

*/

// constants won't change; they're used here to
// set pin numbers:
const int buttonPin = 2;    // the number of the pushbutton pin
const int ledPin = 12;     // the number of the LED pin

// variables will change:
int buttonStatus = 0;      // variable for reading the pushbutton status

void setup() {
  // initialize the LED pin as an output:
  pinMode(ledPin, OUTPUT);
  // initialize the pushbutton pin as an input:
  pinMode(buttonPin, INPUT);
}

void loop(){
  // read the status of the pushbutton value:
  buttonStatus = digitalRead(buttonPin);

  // check if the pushbutton is pressed
  // if it is, the buttonEvent is HIGH:
  if (buttonStatus == HIGH) {
    // turn LED on:
    digitalWrite(ledPin, HIGH);
  }
  else {
    // turn LED off:
    digitalWrite(ledPin, LOW);
  }
}

```



Tech Note

The ledPin value can be changed to 13 to operate the onboard LED.

Trick Switch with On/Off Indicators

In developing new products, electronics designers are always improving designs by adding features and functions that excite the customer. The Trick Switch device you built can be improved by adding an LED indicator. This LED indicates when the Trick Switch timing cycle is done. [Figure 1-3](#) shows you where to add a green LED to the Trick Switch on the full-size clear breadboard.

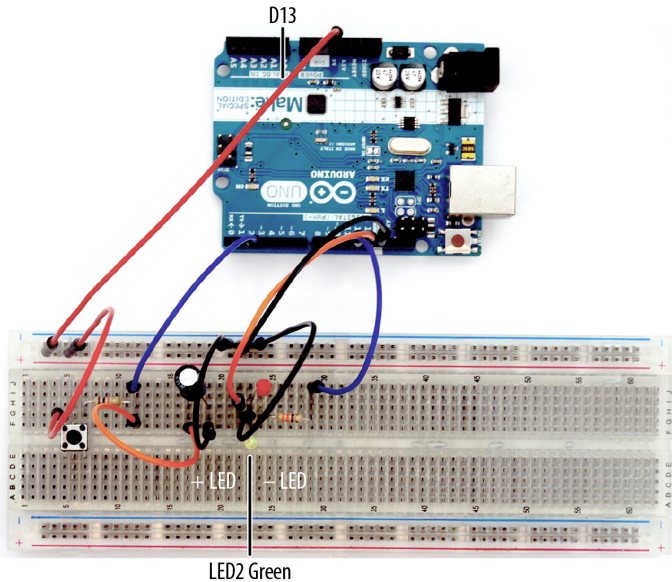


Figure 1-3. Adding a green LED indicator to the Trick Switch circuit built on a full-size clear breadboard

To complete the new product design, you need to make a few changes to the Push-button sketch. Modify the sketch using the code changes shown in [Example 1-2](#).

Example 1-2. Pushbutton sketch modified to include LED indicators

```
// constants won't change; they're used here to
// set pin numbers:
const int buttonPin = 2;      // the number of the pushbutton pin
const int ledPin = 12;       // the number of the LED pin
const int ledPin13 = 13;     // onboard LED

void setup() {
  // initialize the LED pins as outputs:
  pinMode(ledPin, OUTPUT);
  pinMode(ledPin13, OUTPUT);
  // initialize the pushbutton pin as an input:
  pinMode(buttonPin, INPUT);
}

void loop(){
  // read the state of the pushbutton value:
  int buttonStatus;
  buttonStatus = digitalRead(buttonPin);

  // check if the pushbutton is pressed
  // if it is, the buttonStatus is HIGH:
  if (buttonStatus == HIGH) {
```

```

// turn LED on:
digitalWrite(ledPin, HIGH);
// turn off onboard LED:
digitalWrite(ledPin13,LOW);
}
else {
// turn LED off:
digitalWrite(ledPin, LOW);
// turn on onboard LED:
digitalWrite(ledPin13, HIGH);
}
}
}

```

After you've saved the sketch changes and uploaded them to the Arduino, the green LED will turn on. When you press the mini pushbutton, the green LED will turn off, and the red LED will turn on. Pretty awesome stuff. Enjoy!

The block diagram in [Figure 1-4](#) shows the electronic component blocks and the electrical signal flow for the Trick Switch. A Fritzing electronic circuit schematic diagram of the switch is shown in [Figure 1-5](#). Electronic circuit schematic diagrams are used by electrical/electronic engineers to design and build cool electronic products for society.

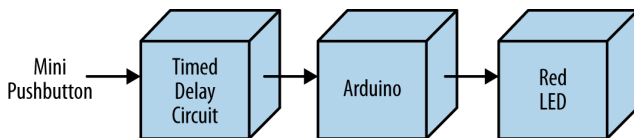


Figure 1-4. Trick Switch block diagram

Something to Think About

Try different resistor and capacitor values and see what happens. Can you detect any patterns? How can a small piezo buzzer be used with the Trick Switch?

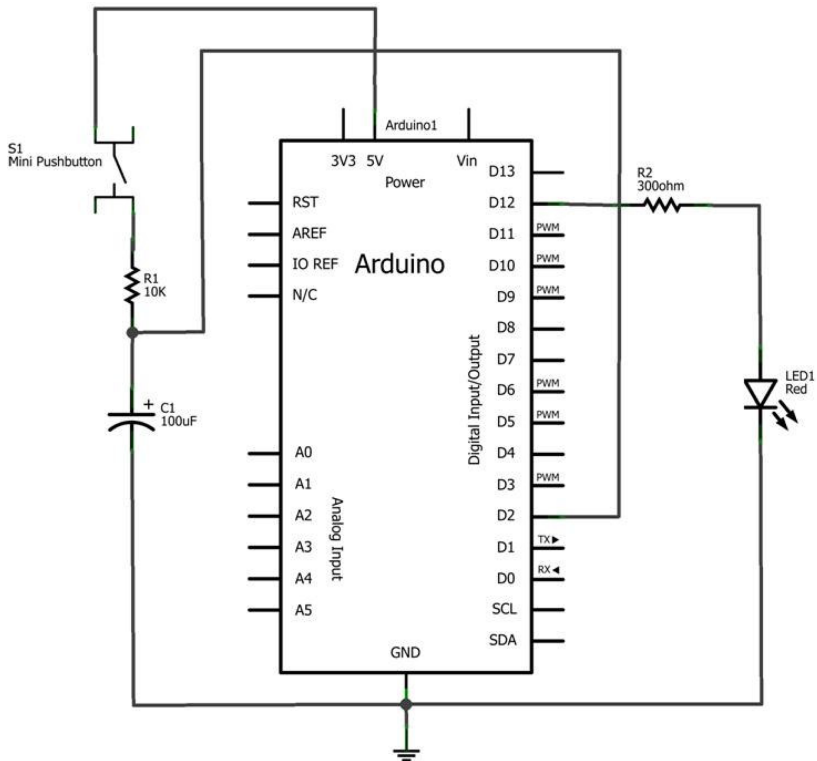


Figure 1-5. Trick Switch circuit schematic diagram