Introduction

ARE YOU AN adventurer? Do you boldly embark on new endeavours, tackling new skills and mastering new tools? Do you want to learn how to use technology to make your ideas burst into life? Are you curious about how you can combine computer code and electrical circuits with scissors and paper—or even needle and thread? If the answer is an emphatic “yes” then this is the book for you!

What Is an Arduino?

The Arduino is a tool for building computers that can interact with the physical world around you. You can use it to connect sensors that detect sound, light or vibration, then turn on a light, change its colour, move a motor and much more. The Arduino is the magical device that sits in the midst of all of these things. It reads in from sensors measuring the real world, makes decisions based on that data and then makes something happen in the real world, whether light, sound or movement.

The Arduino is usually a blue board about the size of your hand. It has white writing on it labelling its different sections and has all its chips and circuits exposed. There are different types of Arduino boards, and they aren’t all blue, but you will learn more about that later in the “Parts You Will Need” section and also in Adventures 7 and 8.

The Arduino is a microcontroller. A microcontroller is a simple computer. It can’t do many things at the same time but it does what it is told to do really well. You already interact with lots of microcontrollers every day because they control things like microwaves and washing machines.

There are a lot of different types of microcontroller, but the special thing about Arduino is that it is designed for people who are just starting out. So, if you are new to code or electronics, that’s okay because the Arduino is great for beginners. But don’t underestimate it—it can still take on big projects.

What You Will Learn

After completing these adventures, you will have learned how to set up the Arduino programming environment on your computer and how to write and upload code to your Arduino board. You will find out how to work with three different Arduino boards: the Uno, Leonardo and the Lilypad USB.

You will learn basic programming concepts that you can use beyond working with the Arduino. The Arduino language is based on the C/C++ language. This means that as you learn how to code Arduinos, you are also learning about how programming works on computers like a laptop or a Raspberry Pi.

Alongside programming, you will be introduced to circuits and electronics. You will learn how to use sensors to detect real-world signals like light or movement, and you will learn how to generate actions in the real world, such as playing a sound or turning on a light.

By the end of this book, you will have a broad understanding of what you can do with an Arduino and be ready to start designing and building project ideas of your own!

Parts You Will Need

It’s becoming easier to buy Arduino boards in stores. Popular retail chains like Maplin in the UK now stock Arduinos. Both of those stores also sell the electronic components that you need for the projects in this book. If it’s not convenient for you to get to a store there are also many online retailers to choose from, and some of these are listed in Appendix B.

This section explains all the parts you need to make all the projects in this book. Many of the projects use the same core parts.

Of course, the most important thing you need is an Arduino board. There are many different kinds of Arduino boards, but the Arduino Uno is the most common one and the one you use the most in this book. You also need an Arduino Leonardo for Adventure 7 and a Lilypad Arduino USB for Adventure 8. All three boards are shown in Figure I-1.

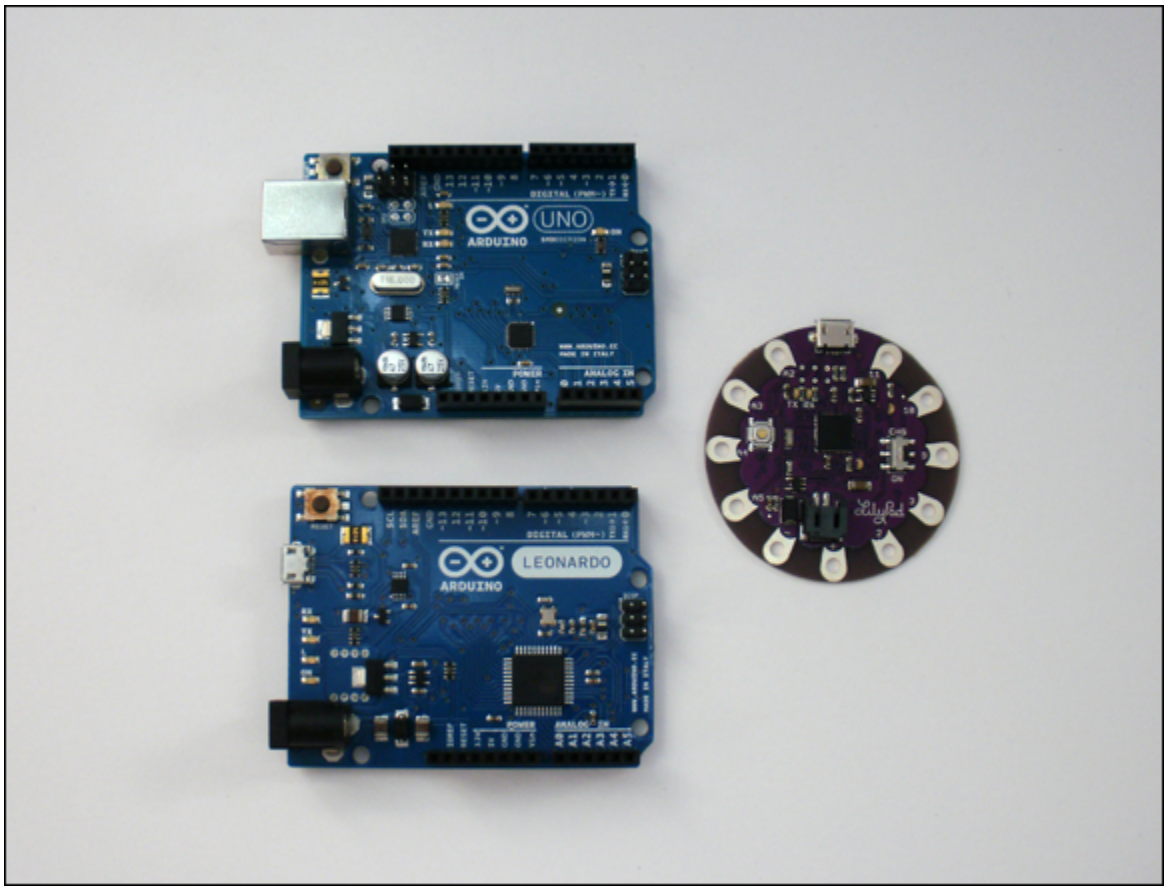

FIGURE I-1 Arduino Uno (top left), Arduino Leonardo (bottom left) and Lilypad Arduino USB (right)

You will need a USB cable to connect your Arduino board to your computer. For the Arduino Uno you need a “normal” USB cable, but for the Arduino Leonardo and Lilypad Arduino USB you need a USB Micro cable. Both are pictured in Figure I-2.

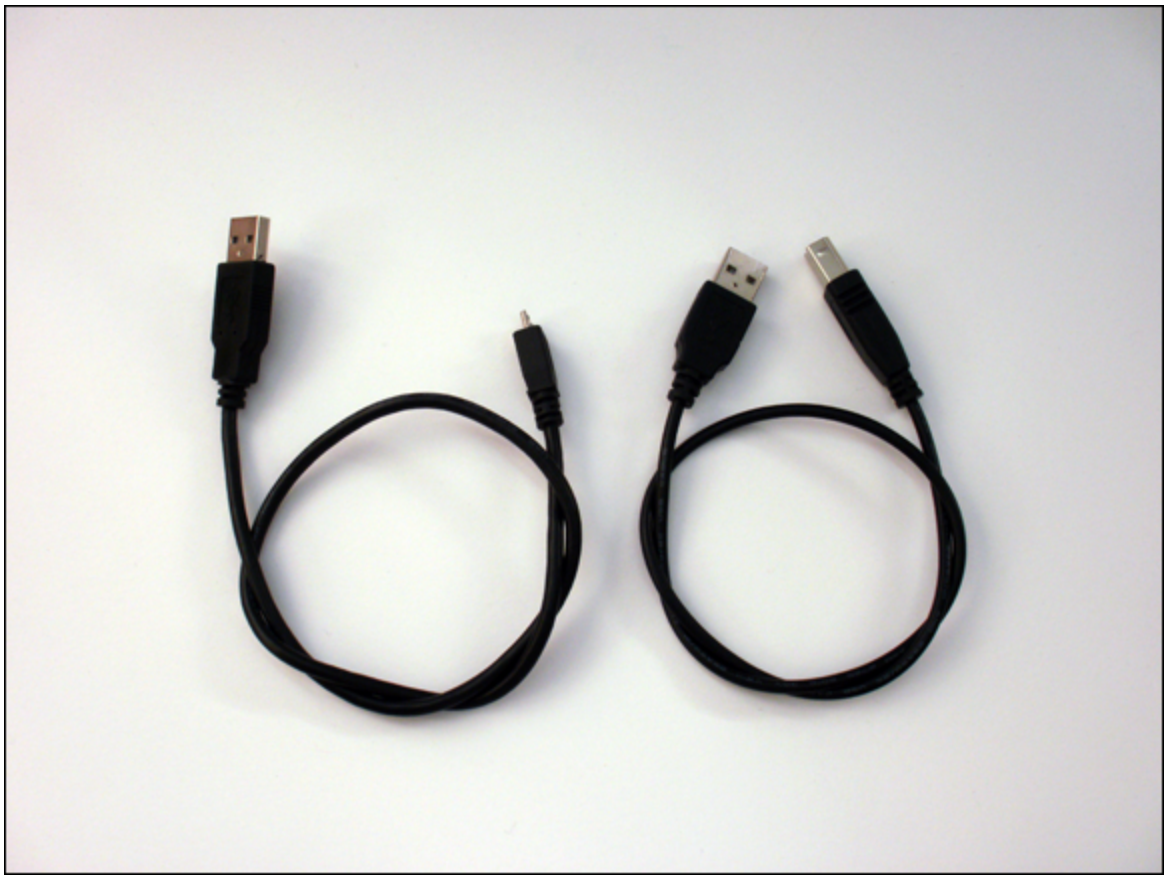

FIGURE I-2 A USB and USB Micro cable

You use breadboards to build circuits. Breadboards let you connect components easily without having to use solder. They come in different colours and sizes. The larger ones are useful for more complicated projects with lots of parts, whereas the smaller ones are good for projects that you want to fit inside a small space. Two different sizes of breadboards made from two different types of plastic are shown in Figure I-3. Adventure 3 is the only project that uses a breadboard in the completed project; the other adventures use a breadboard only to test a circuit. A larger breadboard will be easier to work with, but if you can only find smaller ones, that’s perfectly okay.

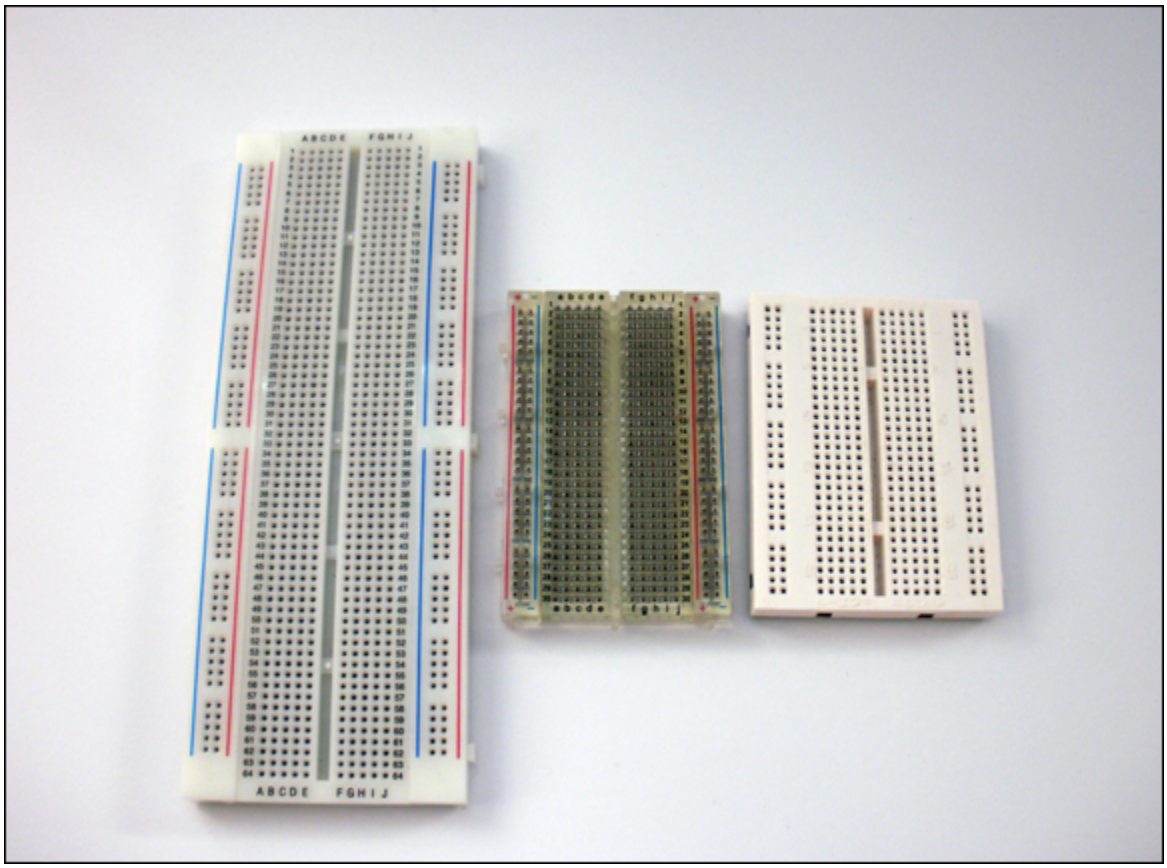

FIGURE I-3 Breadboards in different sizes and colours

Jumper wires are wires you use when you build prototype circuits to try out new concepts. They may be short pieces of stiff wire like those shown on the right in Figure I-4, or they may be more flexible wire with pins on either end like the ones on the left.

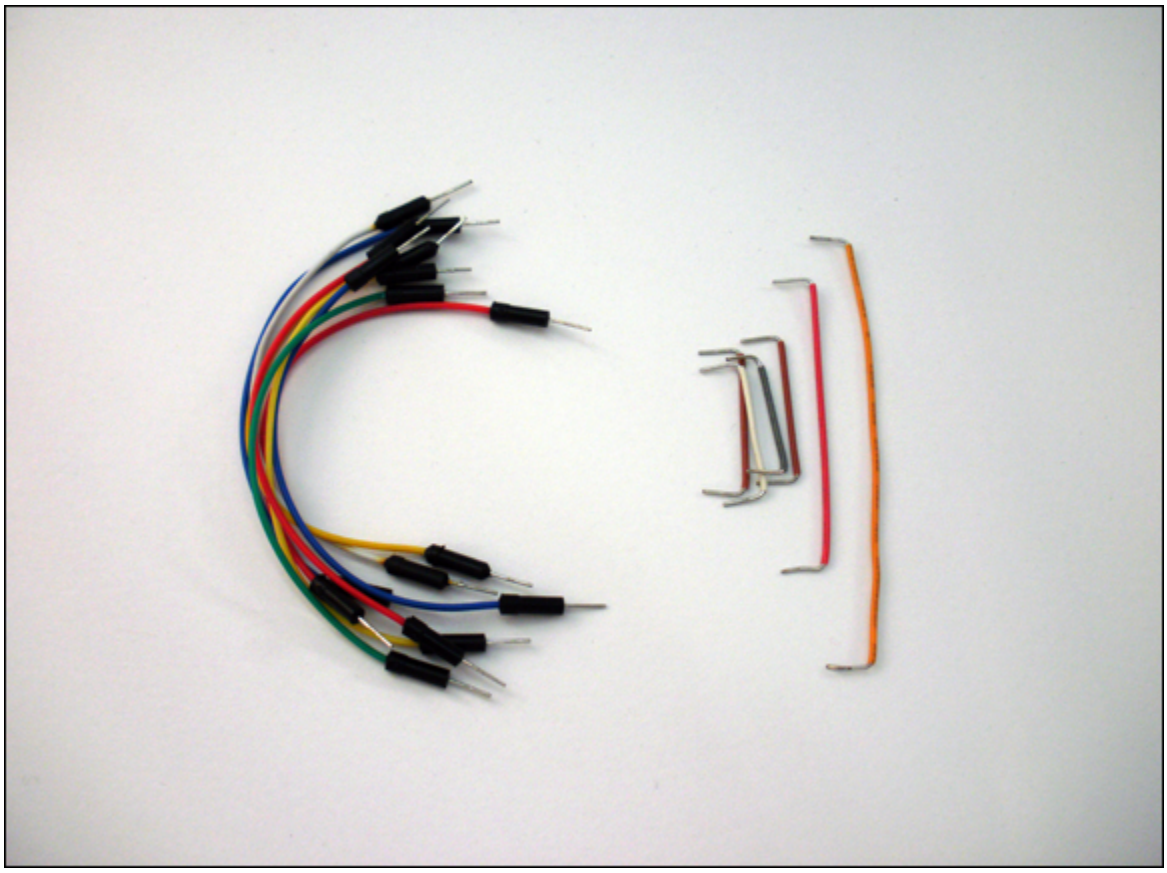

FIGURE I-4 Jumper wires

LEDs are a particular sort of light (LEDs stands for light-emitting diodes) that come in a big selection of sizes and colours. For most of the projects in this book you can use whatever size and colour of LEDs you like. The most common size is 5 mm, but the larger 10 mm LEDs can be great fun to use too. Most LEDs are single-colour, but you use an LED in Adventure 6 that has four legs instead of only two and can change colour. In Adventure 8 you use something called a Lilypad LED, which is made especially for sewing circuits. All the different types of LED used in the projects are shown in Figure I-5.

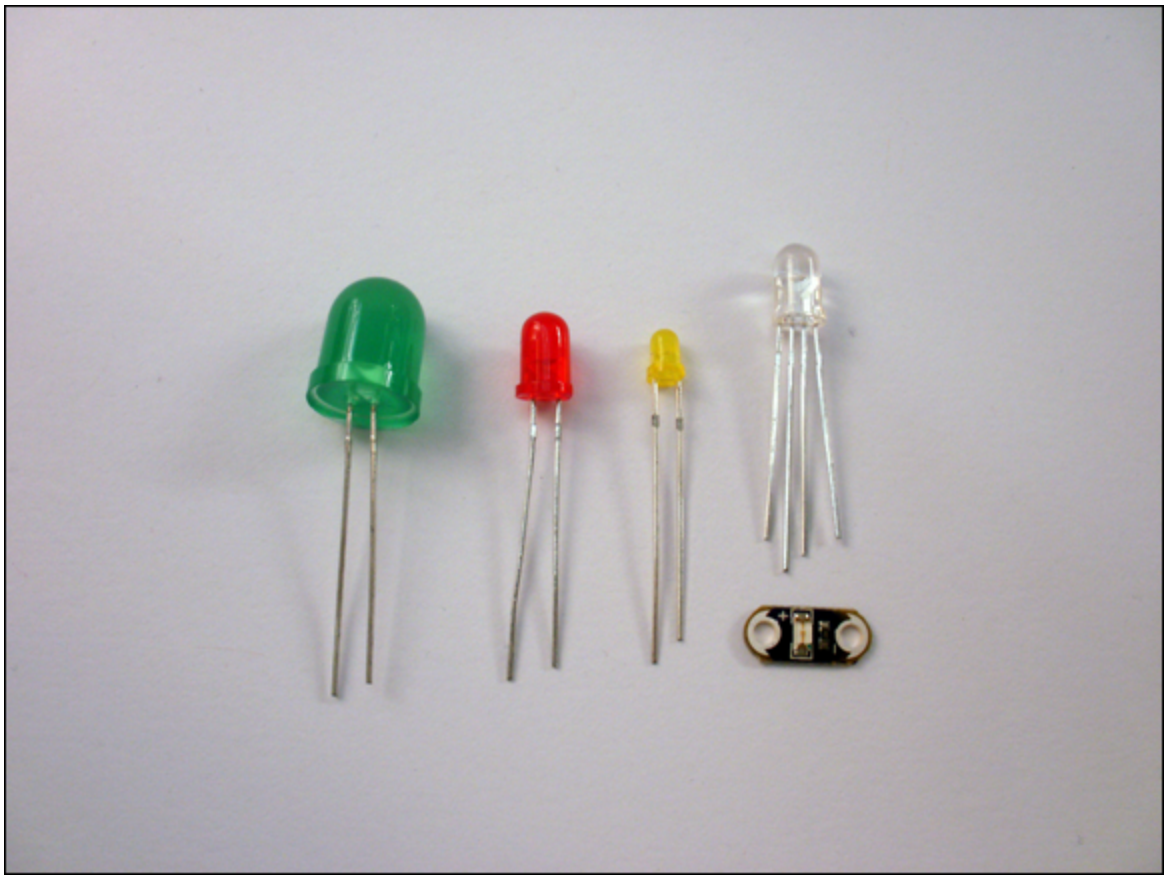

FIGURE I-5 Different types of LED, with a colour-changing LED on the right and below it a Lilypad LED

Resistors are a component you read more about in the adventures. They come in different values of resistance, which is measured in ohms (Ω). You don't need many different resistances for the projects in the book but as resistors are small and quite cheap it's a good idea to buy extra. You need resistors of 68 or 100 Ω, 220 Ω, 10k (10,000) Ω, 1M (1,000,000) Ω and 10M (10,000,000) Ω. Figure I-6 shows the different resistors.

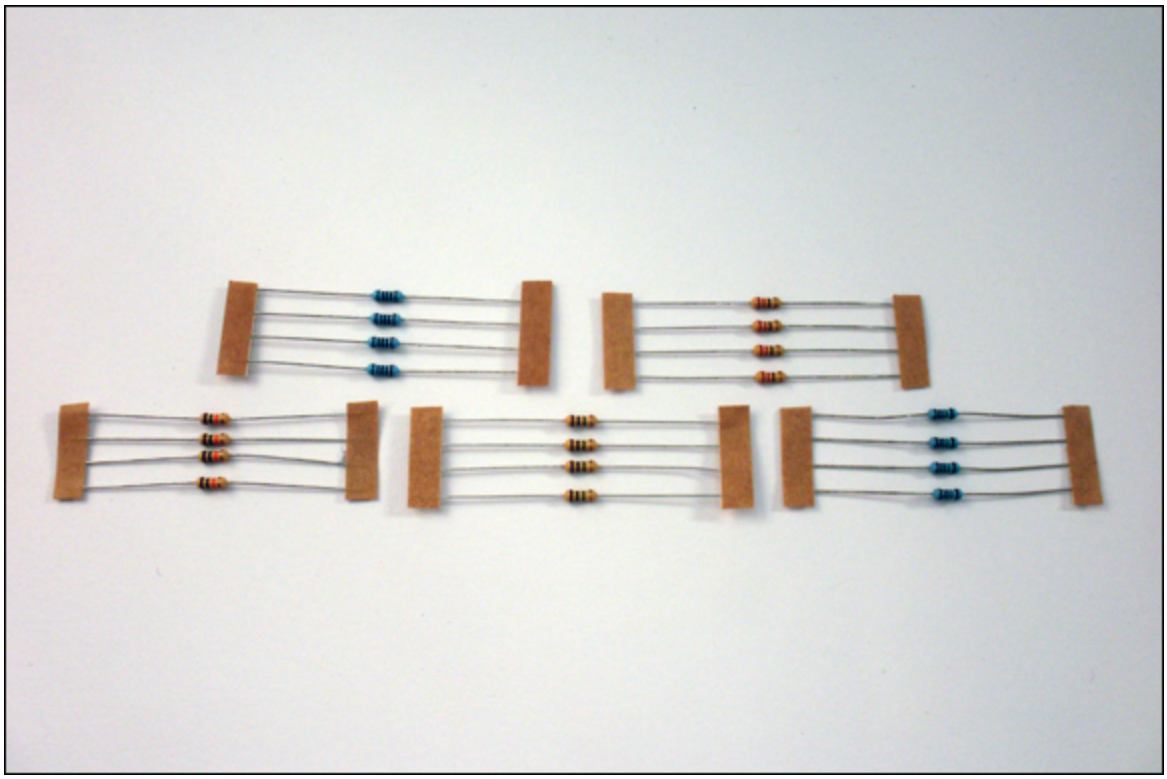

FIGURE I-6 Resistors needed for the projects in this book: 100Ω (top left), 220Ω (top right), 10kΩ (bottom left), 1MΩ (bottom middle) and 10MΩ (bottom right)

Potentiometers are the electronic components behind volume knobs or dials on a stereo. They come in many different sizes and shapes. Some fit into a breadboard on their own, like the blue one in Figure I-7, whereas others need wires soldered to them that can connect to a breadboard, like the one in the middle in Figure I-7. Larger ones are easier to mount in a project and may be called panel-mount potentiometers.

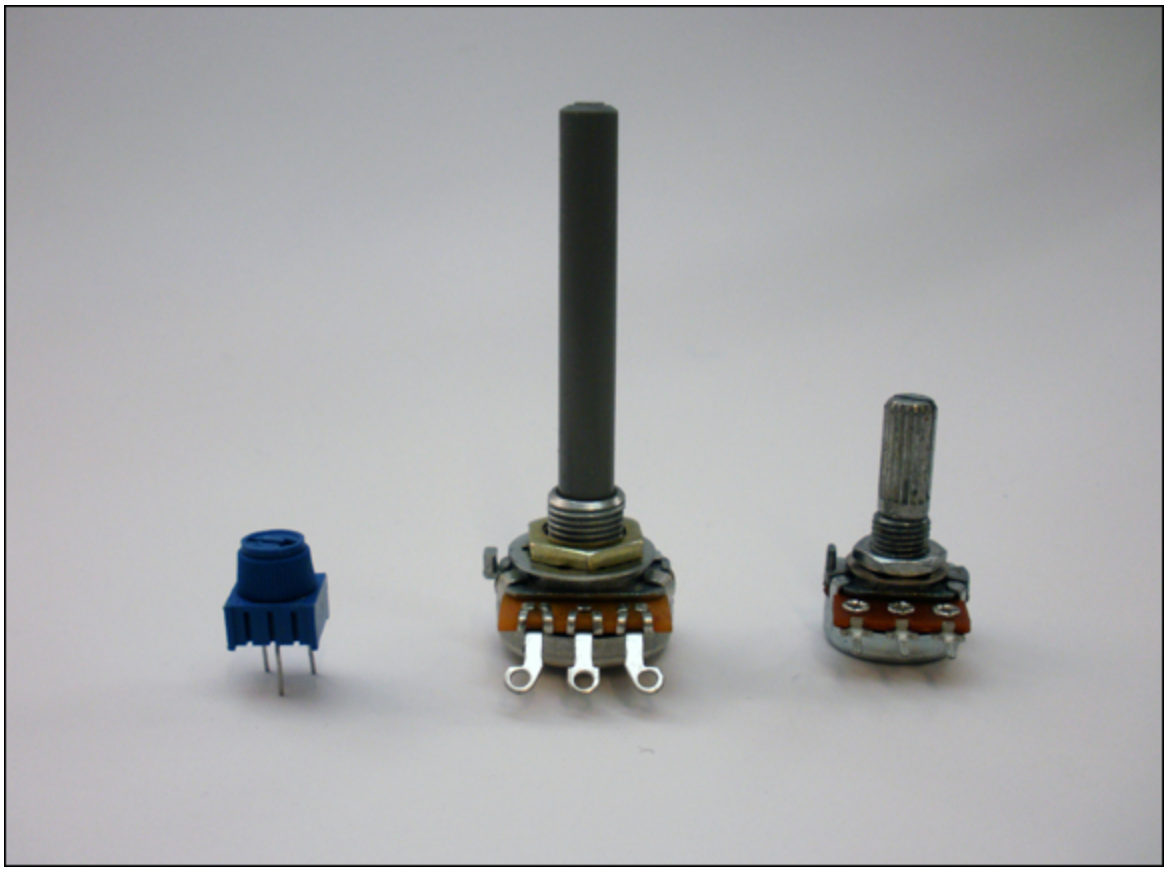

FIGURE I-7 Three different types of potentiometer

A servo, shown in Figure I-8, is a motor that you use in Adventure 3.

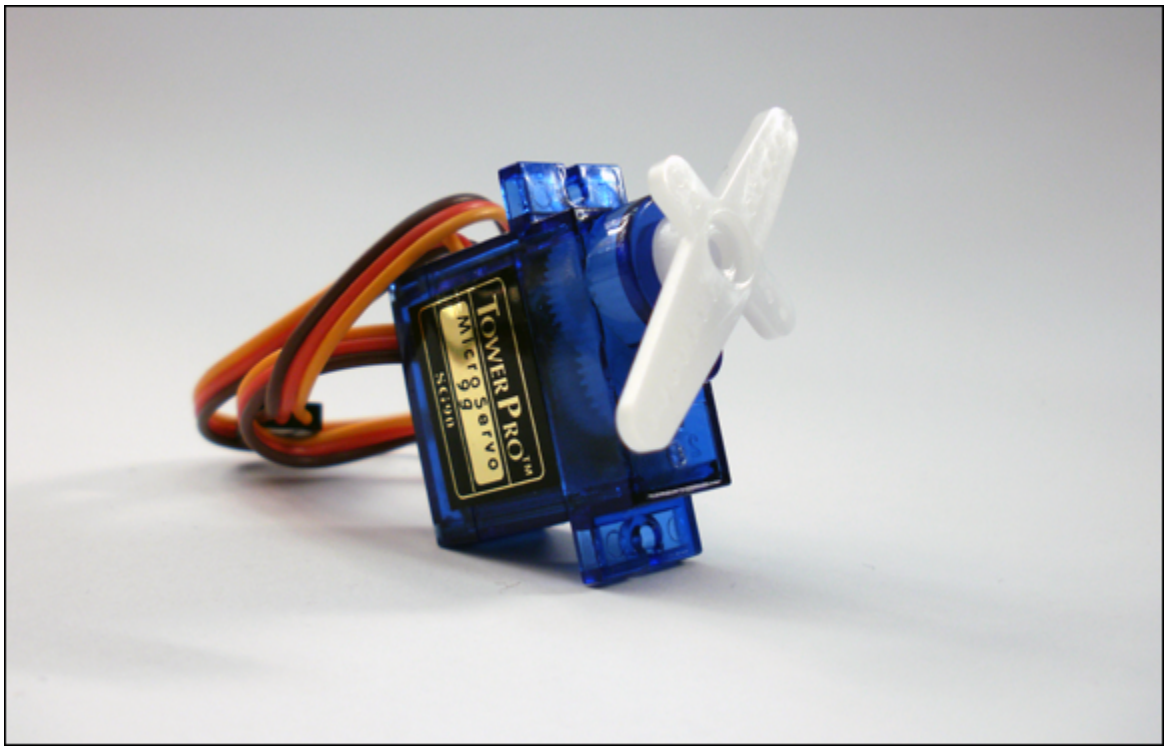

FIGURE I-8 A servo motor

Buttons are another component that come in many shapes and sizes. You might have never noticed this before, but there are many different kinds of button! All the projects in this book use push-to-make (the opposite of push-to-break) buttons so those are the ones to buy; as long as they are push-to-make, you can use any kind of button you would like. Tactile push buttons are very little buttons that fit in a breadboard, so they are good to have when you are testing your circuit. For your actual projects, panel mount push buttons are better. Both are shown in Figure I-9.

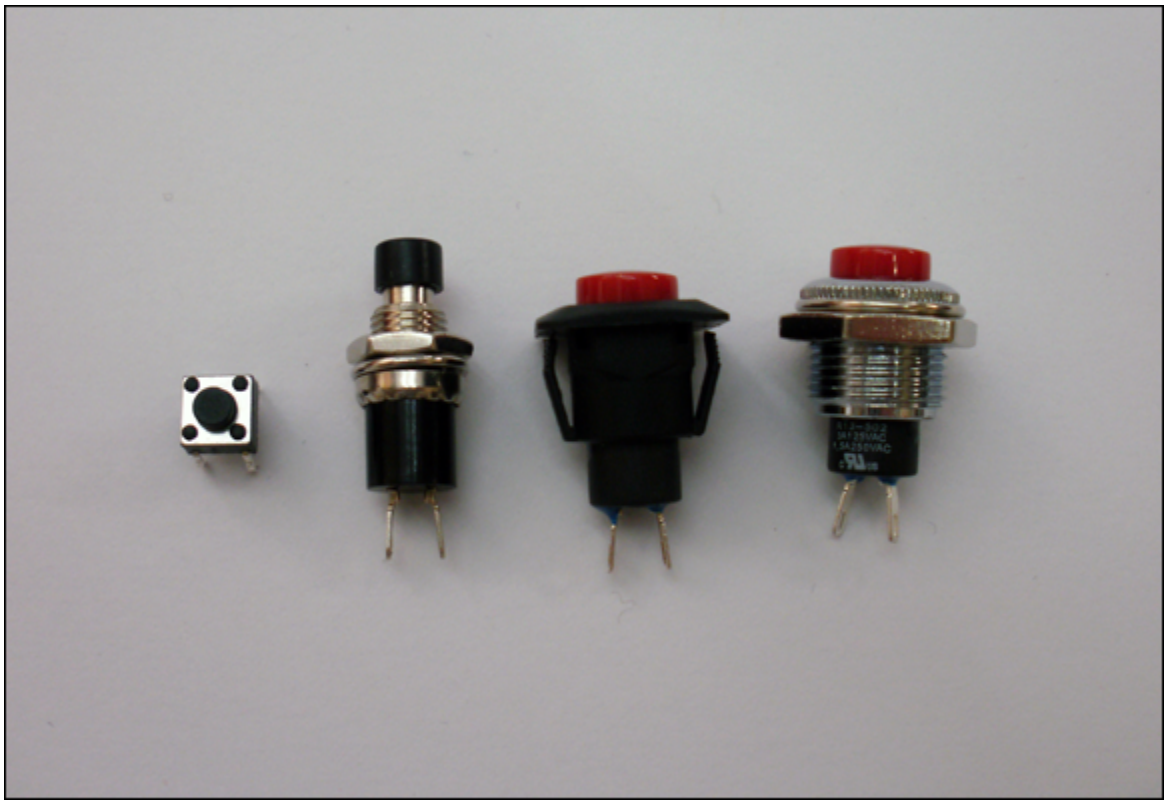

FIGURE I-9 A tactile push button (left) and three different panel mount buttons (right)

In Adventure 4 you discover how to use shift registers, which are small black chips you can use to control a lot of LEDs. You want a chip that is a 74HC595 shift register—you find out what that means in the adventure. You need to buy a chip with 16 legs on it, as shown in Figure I-10.

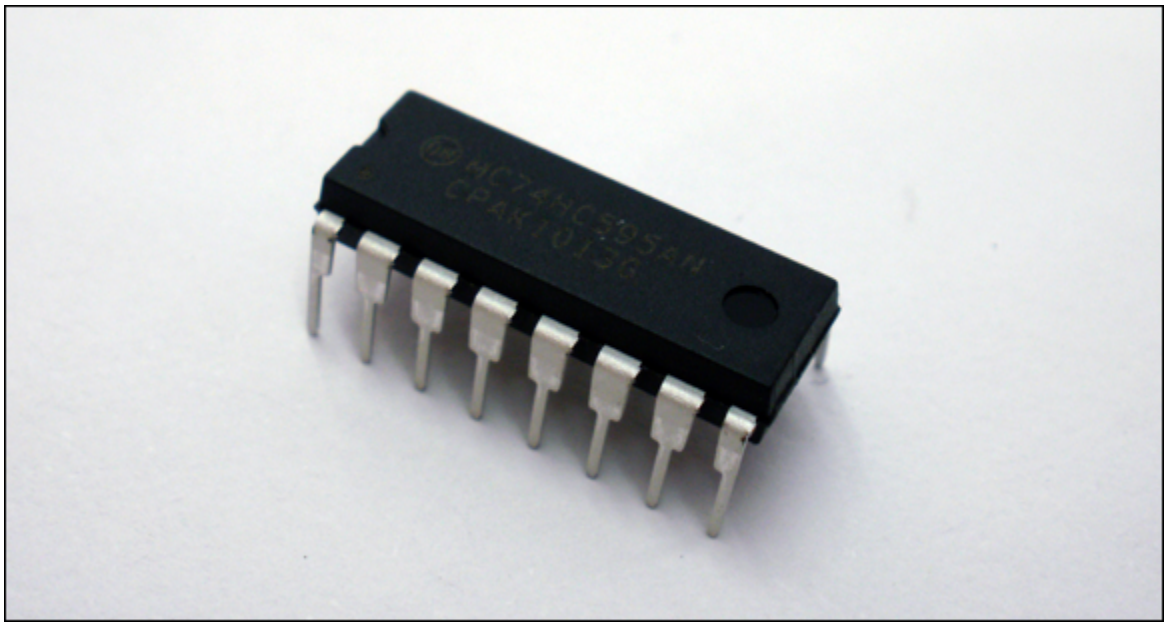

FIGURE I-10 A shift register

Piezos are used to detect vibrations and can also make sound, like a speaker. You need one piezo for Adventure 5 and six for Adventure 9. They sometimes come inside black plastic housing, which is okay for the one in Adventure 5 but you need at least five without housing (like the one in Figure I-11) for Adventure 9.

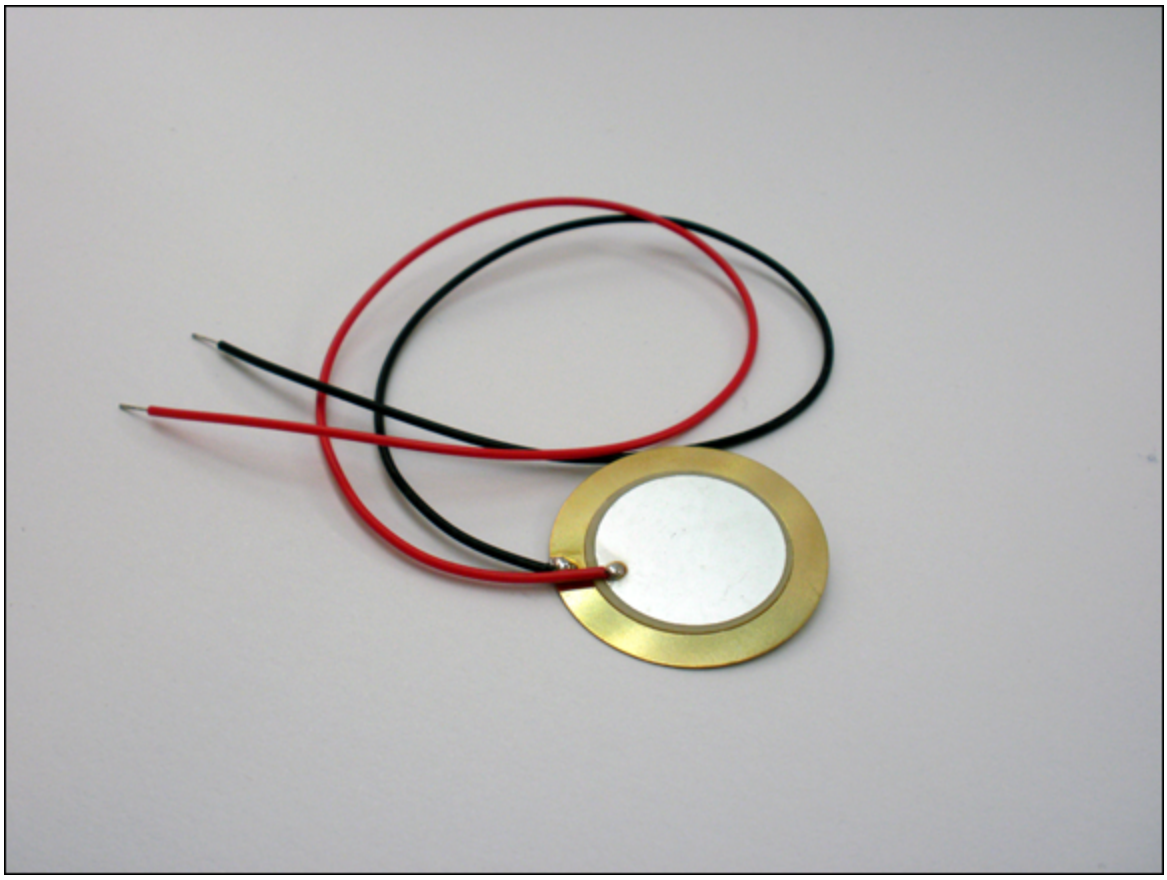

FIGURE I-11 A piezo

A light-dependent resistor can tell an Arduino board how bright or dark it is. These look like the one in Figure I-12 or can be a little bigger.

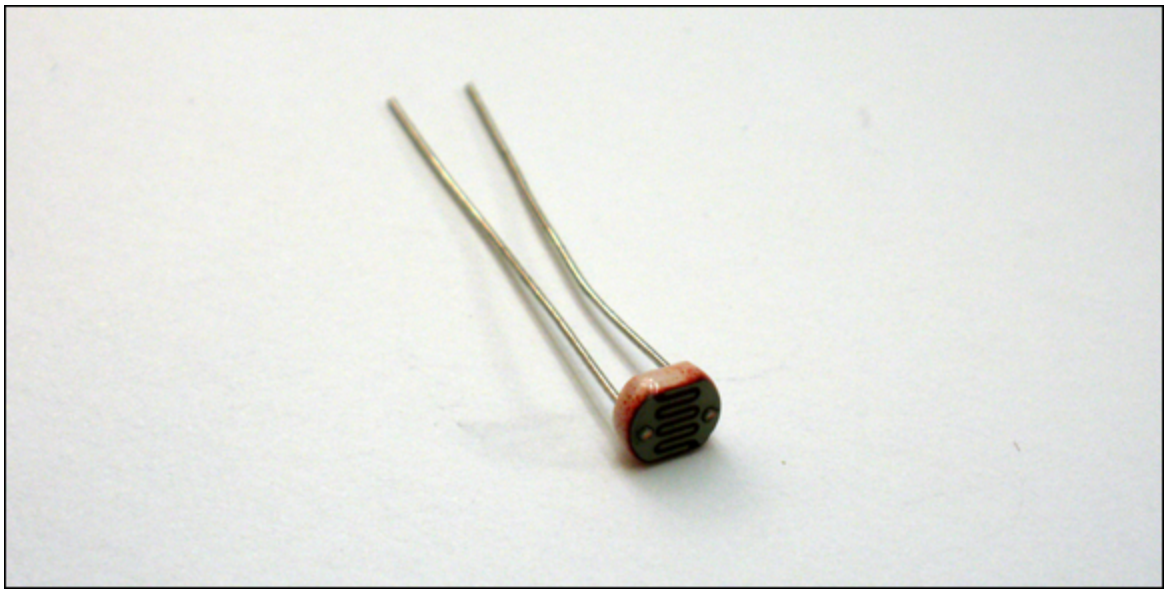

FIGURE I-12 A light-dependent resistor

Header pins are small strips of metal that are separated by plastic so that they fit perfectly into the holes on the Arduino Uno. They come in different spacings (called pitches), so you should make sure you get 2.54 mm male header pins, like the ones in Figure I-13. You need a strip of five for Adventure 5, but you can buy them in longer strips and easily break them apart into smaller sections with pliers.

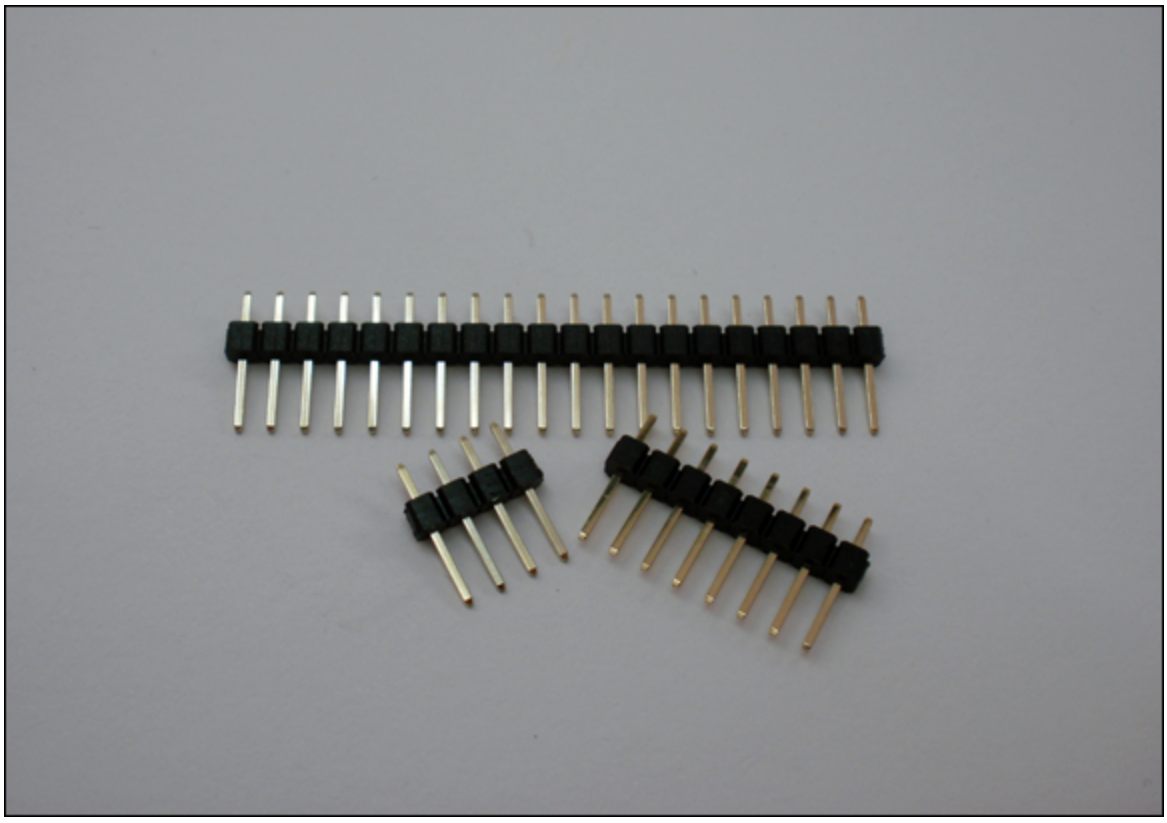

FIGURE I-13 Male header pins

When you think about circuits and electricity, one of the first things you picture is probably wire. But wire isn't a single item; there are many different kinds. Wire can be made of a single piece of metal (called solid core) or a lot of smaller pieces of metal twisted together (called stranded). Figure I-14 shows solid core and stranded wire. Solid core can be useful for breadboards but it's very stiff. Stranded is easier to bend, but you need to solder the end of it in order to get it to fit in a breadboard. You can decide for each project which sort you want to work with—there isn't a right or wrong type to use.

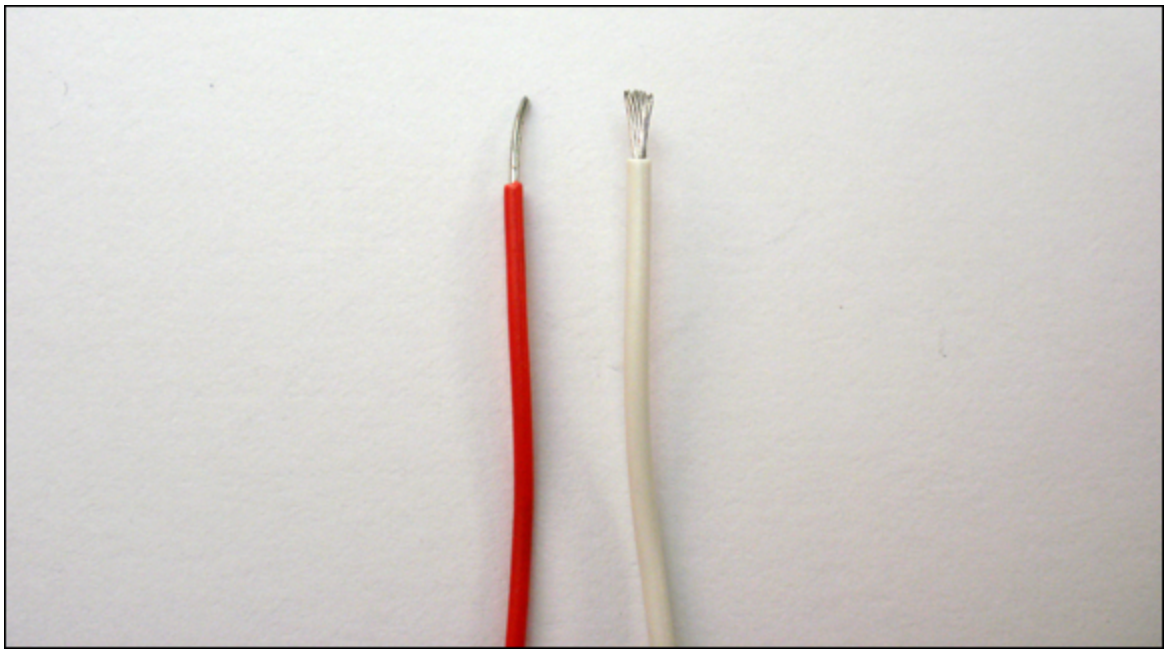

FIGURE I-14 Solid core wire (left) and stranded wire (right)

Wire usually comes with some kind of coating that doesn't conduct electricity. It may be coloured plastic like the wire on the right in Figure I-15, or it may be enamelled like the wire on the left. You can decide which wire works best in your projects. The enamelled wire works well in the augmented wind chime in Adventure 5 because it's very thin and lets the chimes swing easily. However, you could build the wind chime using a different thin wire.

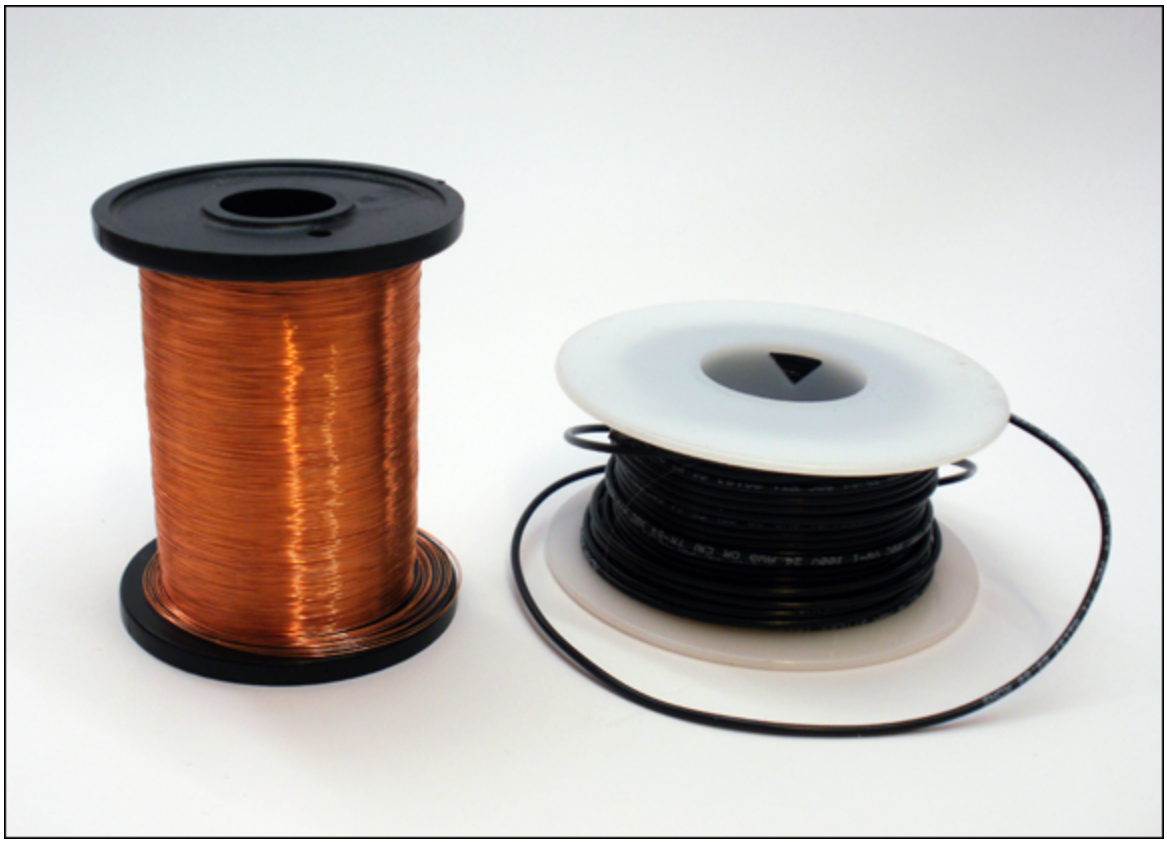

FIGURE I-15 Enamelled (left) and plastic coated (right) wire

Solder is like a conductive glue for electronics. It sometimes comes on spools in different thicknesses like in Figure I-16. The projects in this book don't require very sophisticated soldering, so you don't have to worry about which thickness to buy. Just about any thickness will work okay. The only important thing to watch out for is to make sure you buy solder for electronics—don't buy solder that's used for plumbing!

FIGURE I-16 Solder on spools

After you build your projects, you might want to run them without having to connect them to your computer for power. If so, you can either power your project from a power supply or from a battery. If you use a power supply, it's easiest to buy a USB wall adapter—a power supply that lets you connect a USB cable to a wall socket, with the other end of the USB cable plugged into your Arduino board. If you'd like to use a battery, the best option is to get a 9V battery connector with a DC barrel on the end. There is a black plug socket on your Arduino board where you can plug in the connector. Both options are shown in Figure I-17. For the Lilypad Arduino USB, you can use a LiPo battery, but you read more about that in Adventure 8.

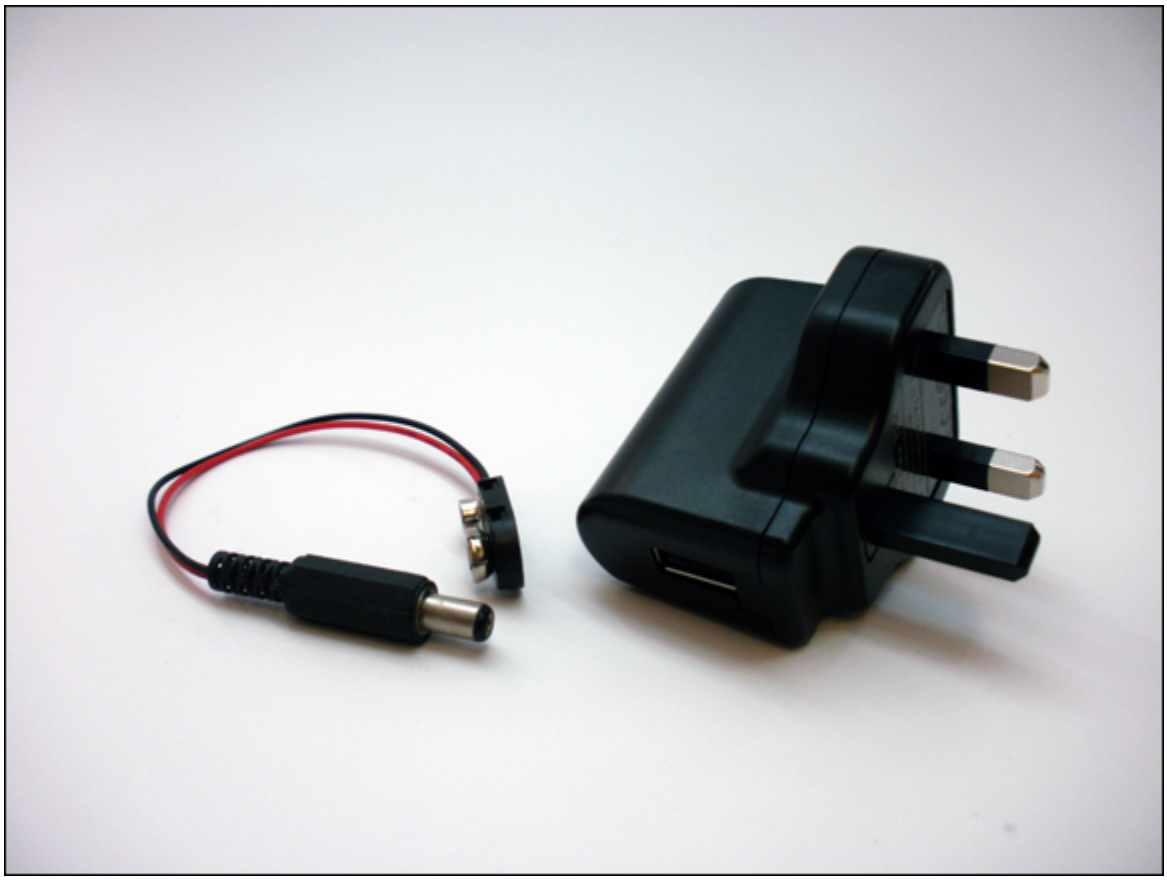

FIGURE I-17 A 9V battery-to-DC-barrel connector (left) and a UK plug for a USB cable (right)

When you work with soft circuits in Adventure 8, you need alligator clips like the ones in Figure I-18, which you use instead of jumper wires.

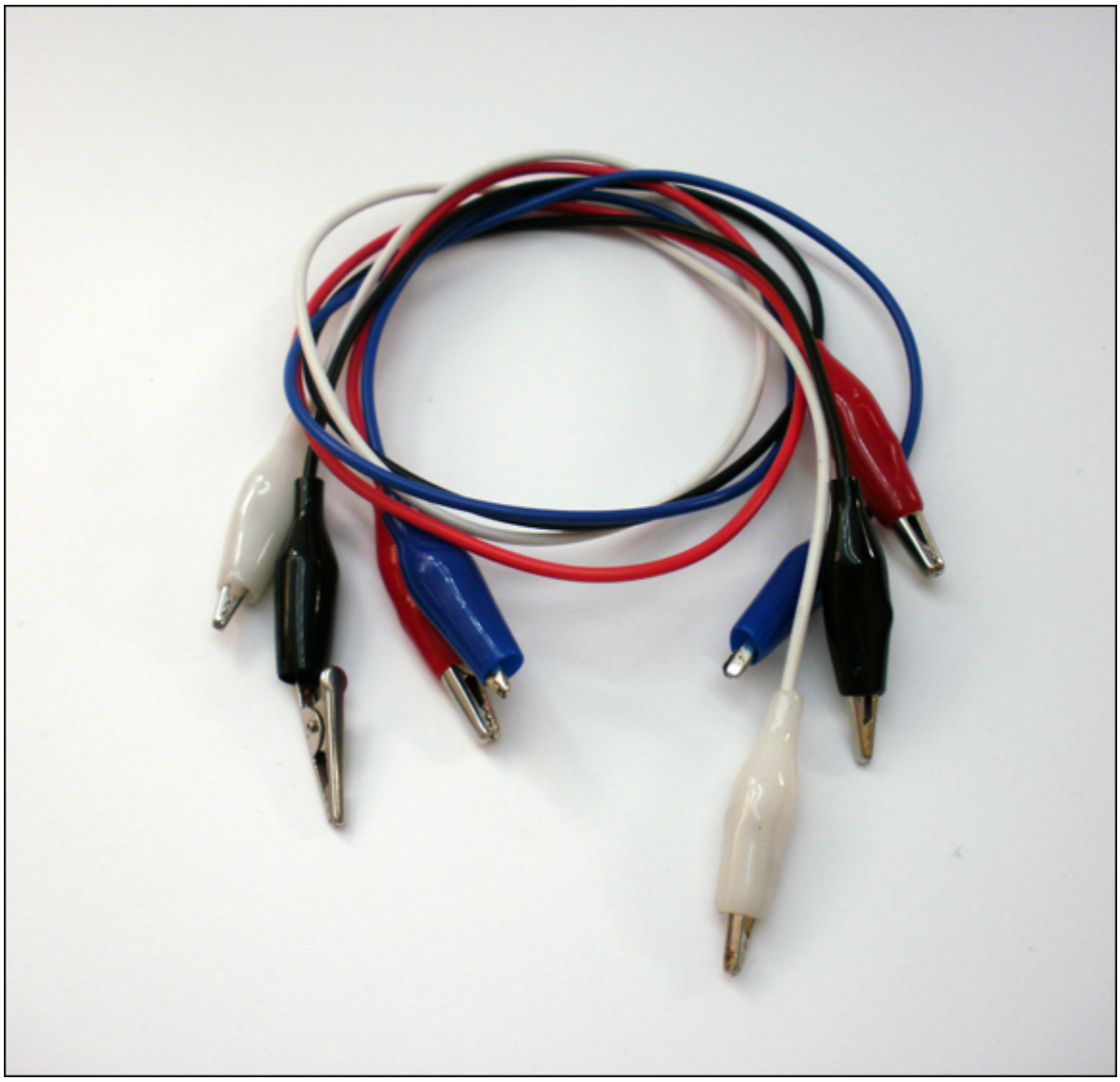

FIGURE I-18 Alligator clips

In Adventure 8, you also use conductive thread, which is thread spun with conductive fibres. There are different kinds available from different manufacturers, but all the options are a silver colour as shown in Figure I-19.

FIGURE I-19 Conductive thread

Tools You Will Need

Just as you need hammers and saws to build something with wood, you need special tools to work with electronics.

When you test your circuits you use a breadboard, but you eventually need to go beyond the breadboard. For example, you might need to add longer wires to a component so it fits inside your housing, or you might want to connect components together in a more permanent way that won't fall apart.

The first thing you need is a soldering iron. Solder is like glue for electronics, but it only works at high temperatures (think of it as a hot glue for electronics). A soldering iron is a tool that gets very hot (much hotter than an oven) so that

it can melt solder. Only use a soldering iron when an adult is nearby to help you.

A soldering iron may be a single hand-held tool that plugs into the wall, like the one in Figure I-20. Or it may plug into a box with a temperature dial that plugs into the wall. Either kind is okay. The important thing is to buy one that is meant for small electronics and not plumbing or any other activity.

FIGURE I-20 A soldering iron

Wire often comes with a plastic coating that is an insulator that doesn't conduct electricity. You sometimes need to remove this plastic coating from the ends of the wire so you can fit it into a breadboard or solder a component to it. You could always carefully use a knife or cutters to try and remove the plastic, but that can be a very frustrating method. It is well worth buying the right tool for the job. Enter the wire stripper!

Wire strippers come in lots of shapes and sizes, as you can see in Figure I-21. Choose whichever one you like best.

FIGURE I-21 Different kinds of wire stripper

Wire cutters do what you expect—they cut wires. Be sure to get smaller ones that easily fit in your hand as you will be working with small components and thin wires. Figure I-22 shows the kind of wire cutters you could get.

FIGURE I-22 Wire cutters

Pliers help you shape and bend wires. They come in different sizes and shapes, but a smaller general purpose pair of pliers is all you need for the projects in this book. Either of the pairs in Figure I-23 would work well.

FIGURE I-23 Pairs of pliers

The next tool may seem a bit daunting, but it can be your best friend when working with electronics. It's the multimeter! It measures multiple things (that's how it got its name), with resistance and voltage being the most useful to the beginner. They range from very cheap to extremely expensive. When you are choosing one for yourself, you don't need to spend a lot of money, especially if it is your first multimeter. You probably want one that auto-ranges, though that's not essential, but you definitely need one with a continuity test. (When you look at multimeters in a store, auto-ranging and continuity testing will be listed in their features.) Auto-ranging means that you don't need to know the approximate value of whatever you are testing before you test it. A continuity test is when the multimeter beeps when an electrical connection is

made between the probes. Figure I-24 shows a less expensive multimeter, which isn’t auto-ranging but does have a continuity test.

FIGURE I-24 A multimeter

The final tools are not specifically used with electronics but are be essential for constructing the housing for your projects: scissors and a utility knife (Figure I-25). Always take care when using either!

FIGURE I-25 A pair of scissors and a utility knife

Software You Will Need

When we talk about Arduino, it is easy to think about the board and nothing else. After all, that's the part you physically place into your project. However, the Arduino needs code in order to do anything. You write that code on

another computer first and then upload the code to the Arduino board.

The company that makes the Arduino board also makes the software that helps you write and upload the code. It's free to download from http://arduino.cc/en/Main/Software.

Adventure 1 takes you through the steps to setting up the software on your computer.

The circuit schematics and diagrams of circuits on breadboards in this book are made with a program called Fritzing, which is also free online at http://fritzing.org/download. You can even use Fritzing to start designing your own projects!

Other Useful Materials

Writing code and building a circuit is only one half of completing a project. Your project doesn't come alive until it is surrounded by some kind of housing. Whether it's a game or an interactive light, when it is just a circuit on a breadboard it hasn't yet reached its full potential.

So, to make the projects in this book, you use many low-tech techniques alongside your newly acquired high-tech skills. Scissors, paper and glue form the basis of many of your projects. It's good to have the following items to hand, but it's never a bad decision to add decorative items like glitter that allow you to let your imagination run riot! In particular, you need the following things:

- Small cardboard boxes or shoeboxes
- Card, cardboard and paper
- Paint for decorating
- String or yarn
- White craft glue, glue-stick or a hot glue gun

- Paintbrush
- A balloon (for Adventure 6)
- A marble (for Adventure 9)

What I Assume You Already Know

Because you've started reading this book, I'm going to assume you're already interested in technology! You don't need to have done any computer programming previously or built any circuits (that's what this book is explaining!), but I do assume that you have used a computer before.

You need a computer to work with the Arduino but it doesn't really matter what operating system your computer uses—Mac OS X, Windows or many different Linux distributions (see http://playground.arduino.cc/Learning/Linux for guidance on which Linux distributions you can use). I assume that you are comfortable going online and downloading files and that you know how to find and open applications on your computer.

You may need an administrator password to install some of the software, so if you don't know the password for your computer it will help if someone who does know the password is nearby when you install it.