About the Author
Dr. Simon Monk (Preston, UK) has a degree in Cybernetics and Computer Science and a PhD in Software Engineering. Monk spent several years as an academic before he returned to industry, co-founding the mobile software company Momote Ltd. He has been an active electronics hobbyist since his early teens and is a full-time writer on hobby electronics and open-source hardware. Dr. Monk is the author of numerous electronics books, specializing in open-source hardware platforms, especially Arduino and Raspberry Pi. He is also co-author with Paul Scherz of *Practical Electronics for Inventors*, 3rd edition. You can follow Simon on Twitter, where he is @simonmonk2.

**Hacking Electronics**

*An Illustrated DIY Guide for Makers and Hobbyists*

Simon Monk
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Acknowledgments
Many thanks to all those at McGraw-Hill Education who have done such a great job in producing this book. In particular, thanks to my editor Roger Stewart and to Vastavikta Sharma, Jody McKenzie, Mike McGee, and Claire Splan.

Special thanks are due to Duncan Amos, John Heath, and John Hutchinson for their technical review of the material and encouragement.

And last but not least, thanks once again to Linda, for her patience and generosity in giving me space to do this.

Introduction
This is a book about “hacking” electronics. It is not a formal, theory-based book about electronics. Its sole aim is to equip the reader with the skills he or she needs to use electronics to make something, whether it’s starting from scratch, connecting together modules, or adapting existing electronic devices for some new use.

You will learn how to experiment and get your ideas into some kind of order, so that what you make will work. Along the way, you’ll gain an appreciation for why things work and the limits of what they can do, and learn how to make prototypes on solderless breadboard, how to solder components directly to each other, and how to use stripboard.
You will also learn how to use the popular Arduino microcontroller board, which has become one of the most important tools available to the electronics hacker. There are over 20 examples of how to use an Arduino with electronics in this book.

Electronics has changed. This is a modern book that avoids theory you will likely never use and instead concentrates on how you can build things using readymade modules when they are available. There is, after all, no point in reinventing the wheel.

Some of the things explained and described in the book include

- Using LEDs, including high-power Lumileds
- Using LiPo battery packs and buck-boost power supply modules
- Using sensors to measure light, temperature, vibration, acceleration, sound level, and color
- Interfacing with Arduino microcontroller boards, including using Arduino shields such as the Ethernet and LCD display shields
- Using servo and stepper motors

Some of the things described in the book that you can make along the way include

- A noxious gas detector
- An Internet-controlled hacked electric toy
- A device for measuring color
- An ultrasonic rangefinder
- A remote control robotic rover
- An accelerometer-based version of the “egg and spoon” race
- A one-watt audio amplifier
- A bug made from a hacked MP3 FM transmitter
- Working brakes and head lights that can be added to a slot car

**You Will Need**

This is a very practical, hands-on type of book. You will therefore need some tools and components to get the most out of it.

As far as tools go, you will need little more than a multimeter and soldering equipment.

When it comes to areas of electronics where a microcontroller would be useful, an Arduino Uno board is best. So you may wish to buy one of these microcontroller boards before attempting some of the projects.

Every component used in this book is listed in the Appendix, along with sources where it can be obtained. The majority of the components can be found in a starter kit from SparkFun, but most electronic starter kits will provide a lot of what you will need.

In many of the “how-tos,” there will be a You Will Need section. This will refer to a code in the Appendix that explains where to get the component.
How to Use This Book
The book is organized into chapters, each of which has a theme. Within each chapter, most of the numbered sections contain a “how-to” on some topic of electronics.

The book contains the following chapters:

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Getting Started</td>
<td>The book starts off by telling you where you can buy equipment and components, as well as things to hack. This chapter also deals with the basics of soldering and focuses on a project to hack an old computer fan to make a fume extractor for use while soldering.</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Theory and Practice</td>
<td>This chapter introduces electronic components—or at least the ones you are likely to use—and explains how to identify them and describes what they do. It also introduces a small amount of essential theory, which you will use over and over again.</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>Basic Hacks</td>
<td>This chapter contains a set of fairly basic “hacking” how-tos, introducing concepts like using transistors with example projects. It includes hacking a “push light” to make it automatically turn on when it gets dark and how to control a motor using power MOSFETs.</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>LEDs</td>
<td>In addition to discussing regular LEDs and how to use them and make them flash and so on, this chapter also looks at using constant current drivers for LEDs and how to power large numbers of LEDs and laser diode modules.</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>Batteries and Power</td>
<td>This chapter discusses the various types of battery, both single use and rechargeable. It also covers how to charge batteries including LiPos. Automatic battery backup, voltage regulation, and solar charging are also explained.</td>
</tr>
<tr>
<td>Chapter 6</td>
<td>Hacking Arduino</td>
<td>The Arduino has become the microcontroller board of choice for electronics hackers. Its open-source hardware design makes using a complex device like a microcontroller very straightforward. The chapter gets you started with the Arduino and includes a few simple how-tos, like controlling a relay, playing sounds, and controlling servo motors from an Arduino. It also covers the use of Arduino expansion shields.</td>
</tr>
</tbody>
</table>
1

Getting Started

In this first chapter, we will investigate some of the tools and techniques needed to hack electronics. We will start with a little soldering, and wire up an old computer fan to help keep the solder fumes out of our lungs.

As it says in the title, this book is all about “hacking electronics.” The word “hacking” has come to mean many things. But in this book, “hacking” means “just do it!” You don’t need a degree in electronic engineering to create or modify something electronic. The best way to learn is by having a go at it. You will learn as much from your mistakes as from your successes.

As you start to make things and experiment, you will likely want to understand more of the theory behind it all. Traditional electronics textbooks are pretty terrifying unless you have a good grasp of complex mathematics. This book strives to, above all else, enable you to do things first and worry about the theory later.

To get started, you will need some tools, and also find out where to get components and parts to use in your projects.

Getting Stuff

In addition to buying components and tools, there are lots of low-cost and interesting electronic consumer items that can be hacked and used for new purposes, or that can act as donors of interesting components.

Buying Components

Most component purchases happen on the Internet, although there are local electronic stores like RadioShack (in the U.S.) and Maplin (in the UK) where you can buy...
components. At traditional brick-and-mortar stores like those, the product range is often limited and the prices can be on the high side. They do, after all, have a shop to pay for. These stores are invaluable, however, on the odd occasion where you need something in a hurry. Perhaps you need an LED because you accidentally destroyed one, or maybe you want to look at the enclosures they sell for projects. Sometimes it’s just nice to hold a box or look at tools for real, rather than trying to size them up from pictures on a web site.

As you get into electronics, you will likely gradually accumulate a set of components and tools that you can draw from when you start a new project. Components are relatively cheap, so when I need one of something, I generally order two or three or even five if they are cheap, enough that I have extras on hand that can be used another time. This way, you will often find that when you start to work on something, you actually have pretty much everything you need already.

Component buying really depends on where you are in the world. In the U.S., Mouser and DigiKey are the largest suppliers of electronic components to the hobby electronics market. In fact, both of these suppliers sell worldwide. Farnell also supplies pretty much anything you could want, anywhere in the world.

When it comes to buying ready-made electronics modules for your projects, the SparkFun, Seeed Studio, Adafruit, and ITead Studio web sites can help. All have a wide range of modules, and much enjoyment can be had simply from browsing their online catalogs.

Nearly all the components used in this book have part codes for one or more of the suppliers I just mentioned. The only exceptions are for a few unusual modules that are better to buy from eBay.

There is also no end to the electronic components available on online auction sites, many coming direct from countries in the far east and often at extremely low prices. This is frequently the place to go for unusual components and things like laser modules and high-power LEDs that can be expensive in regular component suppliers. They are also very good for buying components in bulk. Sometimes these components are not grade A, however, so read the descriptions carefully and don’t be disappointed if some of the items in the batch are dead-on-arrival.

**Where to Buy Things to Hack**

The first thing to consider, now that you are into hacking electronics, is an effect that your household and friends will have on you. You will become the recipient of dead electronics. But keep an eye open in your new role as refuse collector. Sometimes these “dead” items may actually be candidates for straightforward resurrection.

Another major source of useful bits is the dollar/pound/euro (delete as appropriate) store. Find the aisle with the electronic stuff: flashlights, fans, solar toys, illuminated cooling laptop bases, and so on. It’s amazing what can be bought for a single unit of
currency. Often you will find motors and arrays of LEDs for a lower price than you would the raw components from a conventional supplier.

Supermarkets are another source of cheap electronics that can be hacked. Good examples of useful gadgets are cheap powered computer speakers, mice, power supplies, radio receivers, LED flashlights, and computer keyboards.

**A Basic Toolkit**

Don’t think you are going to get through this chapter without doing some soldering. Given this, you will need some basic tools. These do not have to be expensive. In fact, when you are starting out on something new, it’s a good idea to learn to use things that are inexpensive, so it doesn’t matter if you spoil them. After all, you wouldn’t learn the violin on a Stradivarius. Plus, what will you have to look forward to if you buy all your high-end tools now!

Many starter toolkits are available. For our purposes, you will need a basic soldering iron, solder, a soldering iron stand, some pliers, snips, and a screwdriver or two. SparkFun sells just such a kit (SKU TOL-09465), so buy that one or look for something similar.

You will also need a multimeter ([Figure 1-1](#)). I would suggest a low-cost digital multimeter (don’t even think of going above USD 20). Even if you end up buying a better one, you will still end up using the other one since it’s often useful to measure more than one thing at a time. The key things you need are DC Volts, DC current, resistance, and a continuity test. Everything else is fluff that you will only need once in a blue moon. Again, look for something similar to this model from SparkFun (SKU TOL-09141) or the slightly higher specification meter shown in [Figure 1-1](#).
Solderless breadboards (Figure 1-2) are very useful for quickly trying out designs before you commit them to solder. You poke the leads of components into the sockets, and metal clips behind the holes connect all the holes on a row together. They are not expensive (see T5 in the Appendix).
You will also need some solid core wire in different colors (T6) to make bridging connections on the breadboard. Another good idea is to buy special-purpose jumper wires with little plugs on the end—although these are useful, they are by no means essential.

Breadboard comes in all shapes and sizes, but a big one is probably most useful. Where I use solderless breadboard in the book, I use the one specified in T5 in the Appendix. This has 63 rows by 2 columns with two supply strips down each side (Figure 1-2a). It is also mounted on an aluminum base with rubber feet to stop it moving about on the table. This is a very common size of breadboard and most suppliers will have something similar.

Figure 1-2b shows how the conductive strips are arranged underneath the plastic top surface of the board. All the holes that share a common gray area beneath are connected together in rows of five connectors. The long strips down each side are used for the
power supply to the components. One positive and one negative. They are color-coded red and green.

**How to Strip a Wire**
Let’s start with some basic techniques you need to know when hacking electronics. Perhaps the most basic of these is stripping wire.

**You Will Need**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Appendix Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wire to be stripped</td>
<td>T9 or scrap</td>
</tr>
<tr>
<td>1</td>
<td>Pliers</td>
<td>T1</td>
</tr>
<tr>
<td>1</td>
<td>Snips</td>
<td>T1</td>
</tr>
</tbody>
</table>

Whenever you hack electronics, there is likely to be some wire involved, so you need to know how to use it. Figure 1-3 shows a selection of commonly used types of wire, set beside a matchstick to give them perspective.

![Common types of wire](image)

On the left, next to the matchstick, are three lengths of solid-core wire, sometimes called hookup wire. This is mostly used with solderless breadboard, because being made of a single core of wire inside plastic insulation, it will eventually break if it is bent. Being made of a single strand of wire does mean it is much easier to push into sockets when prototyping since it doesn’t bunch up like multi-core wire.

When using it with breadboard, you can either buy already-striped lengths of wire in various colors as a kit (see Appendix, T6) or reels of wire that you can cut to the lengths you want yourself (see Appendix, T7, T8, T9). It is useful to have at least three colors: red, yellow, and black are a good choice. It makes it easier to see how a project is connected up if you use red for the positive power supply, black for negative, and yellow for any other wires needed.
The top right of Figure 1-3 shows a length of multi-core wire, as well as some twin-strand multi-core wire. Multi-core wire is used when connecting up modules of a project. For instance, the wires to a loudspeaker from an amplifier module might use some twin, multi-core wire. It’s useful to have some of this wire around. It is easily reclaimed from broken electronic devices, and relatively cheap to buy new (see Appendix, T10 and T11).

The wire at the bottom right of Figure 1-3 is screened wire. This is the type of wire you find in audio and headphone leads. It has an inner core of multi-core insulated wire surrounded by a screened wire on the outside. This type of wire is used where you don’t want electrical noise from the environment such as mains hum (60 Hz electrical noise from 110V equipment) to influence the signal running through the central wire. The outer wire screens the inner wire from any stray signals and noise. There are variations of this where there is more than one core surrounded by the screening—for example, in a stereo audio lead.

Insulated wire is of no use to us unless we have a way of taking some of the insulation off it at the end, as this is where we will connect it to something. This is called “stripping” the wire. You can buy special-purpose wire strippers for this, which you can adjust to the diameter of the wire you want to strip. This implies that you know the width of the wire, however. If you are using some wire that you scavenged from a dead electronic appliance, you won’t know the width. Having said that, with a bit of practice you will find you can strip wire just as well using a pair of pliers and some wire snips.

Both of these are essential tools for the electronics hacker. Neither tool needs to be expensive. In fact, snips tend to get notches in them that make them annoying to use, so a cheap pair (I usually pay about USD 2) that can be replaced regularly is a good idea.

Figures 1-4a and 1-4b show how to strip a wire with pliers and snips. The pliers are used to hold things still with a firm grip, while the snips do the actual stripping.

Grip the wire in the pliers, about an inch away from the end (Figure 1-4a). Use the snips to grip the insulation where you want to take it off. Sometimes it helps to just nip
the insulation all the way around before gripping it tightly with the snips, and then pull the insulation off (Figure 1-4b).

For longer lengths of wire, you can just wrap the wire around your finger a few times instead of using pliers.

This takes a bit of practice. Sometimes you will have the snips grip it too tightly and accidentally cut the wire all the way through, while other times you won’t grip it hard enough with the snips and the insulation will stay in place or stretch. Before attempting anything important, practice with an old length of wire.

**How to Join Wires Together by Twisting**

It is possible to join wires without soldering. Soldering is more permanent, but sometimes this technique is good enough.

One of the simplest ways of joining wires is to simply twist the bare ends together. This works much better for multi-core wire than the single-core variety, but if done properly with the single-core, it will still make a reliable connection.

**You Will Need**
To try out joining two wires by twisting (there is slightly more to it than you might expect), you will need the following.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Appendix Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Wires to be joined</td>
<td>T10</td>
</tr>
<tr>
<td>1</td>
<td>Roll of PVC insulating tape</td>
<td>T3</td>
</tr>
</tbody>
</table>

If you need to strip the wires first to get at the copper, refer back to the section “How to Strip a Wire.”

Figures 1-5a thru 1-5d show the sequence of events in joining two wires by twisting them.
First, twist the strands of each wire up clockwise (Figure 1-5a). This just tidies up any straggling strands of the multi-core wire. Then, twist together the two pre-twisted wires (Figure 1-5b) so they are both twisting around each other. Try to avoid the situation where one of the wires twists around the second, while the second remains straight. If it does this, it is very easy for the first wire to just slip off the second. Next, twist the joined wires up into a neat little knot (Figure 1-5c). Note that a pair of pliers may be easier to use when making the knot, especially if the wire is on the thick side. Lastly, cover the joint with four or five turns of PVC insulating tape (Figure 1-5d).

**How to Join Wires by Soldering**

Soldering is the main skill necessary for hacking electronics.

**Safety**

I don’t want to put you off, but … be aware that soldering involves melting metal at very high temperatures. Not only that, but melting metal that’s coupled with noxious fumes. It is a law of nature that anyone who has a motorbike eventually falls off it, and anyone who solders will burn their fingers. So be careful and follow these safety tips:

- Always put the iron back in its stand when you are not actually soldering something. If you leave it resting on the bench, sooner or later it will roll off. Or you could catch the wires with your elbow and if it falls to the floor, your natural reflex will be to try and
catch it—and chances are you will catch the hot end. If you try and juggle it in one hand, while looking for something or arranging some components ready to solder, sooner or later you will either solder your fingers or burn something precious.

- Wear safety glasses. Blobs of molten solder will sometimes flick up, especially when soldering a wire or component that is under tension. You do not want a blob of molten solder in your eye. If you are long-sighted, magnifying goggles may not look cool, but they will serve the dual purpose of protecting your eyes and letting you see properly.

- If you do burn yourself, run cold water over the burned skin for at least a minute. If the burn is bad, seek medical attention.

- Solder in a ventilated room, and ideally set up a little fan to draw the fumes away from you and the soldering iron. Preferably have it blowing out of a window. A fun little project to practice your wire joining skills on is making a fan using an old computer (see the section “How to Hack a Computer Fan to Keep Soldering Fumes Away”).

**You Will Need**

To practice joining some wires with solder, you will need the following items.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
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</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Wires to be joined</td>
<td>T10</td>
</tr>
<tr>
<td>1</td>
<td>Roll of PVC insulating tape</td>
<td>T3</td>
</tr>
<tr>
<td>1</td>
<td>Soldering kit</td>
<td>T1</td>
</tr>
<tr>
<td>1</td>
<td>Magic hands (optional)</td>
<td>T4</td>
</tr>
<tr>
<td>1</td>
<td>Coffee mug (essential)</td>
<td></td>
</tr>
</tbody>
</table>

Magic hands are a great help during soldering because they solve the problem that, when soldering, you really need three hands: one to hold the iron, one to hold the solder, and one to hold the thing or things you are trying to solder. You generally use the magic hands to hold the thing or things you are trying to solder. Magic hands are comprised of a small weighted bracket with crocodile clips that can be used to hold things in place and off the work surface.

An alternative that works well for wires is to bend them a little so that the end you are soldering will stick up from the workbench. It usually helps to place something heavy like a coffee mug on the wire to keep it from moving.

**Soldering**

Before we get onto the business of joining these two wires, let’s have a look at soldering. If you haven’t soldered before, Figures 1-6a thru 1-6c show you how it’s done.

1. Make sure your soldering iron has fully heated up.
2. Clean the tip by wiping it on the damp (not sopping wet) sponge on the soldering iron stand.
3. Touch a bit of solder onto the tip of the iron to “tin” it (see Figure 1-6a). After you have done this, the tip should be bright and shiny. If the solder doesn’t melt, then your iron probably isn’t hot enough yet. If the solder forms into a ball and doesn’t coat the tip of the iron, the tip of it may be dirty, so wipe it on the sponge and try again.

4. Hold the soldering iron to the wire and leave it there for a second or two (Figure 1-6b).
5. Touch the solder to the wire near the soldering iron. It should flow into the wire (Figure 1-6c).

Soldering is something of an art. Some people are naturally very neat at soldering. So do not worry if your results are a bit blobby at first. You will get better. The main thing to remember is that you heat up the item you want to solder and only apply the solder when that thing is hot enough for the solder to melt onto it. If you are struggling, it sometimes helps to apply the solder to the spot where the soldering iron meets the thing being soldered.

The following section offers a bit more soldering practice for you—in this case, by soldering wires together.

**Joining Wires**

To join two wires with solder, you can use the same approach described in the section “How to Join Wires Together by Twisting” and then flow solder into the little knot. An
alternative way— that makes for a less lumpy joined wire—is illustrated in Figures 1-7a thru 1-7d.

1. The first step is to twist each end. If it is multi-core wire (a), tin it with solder as shown in Figure 1-7a.

2. Hold the wires side by side and heat them with the iron (see Figure 1-7b). Note the chopstick technique of holding both the second wire and the solder in one hand.

3. Introduce the solder to the wires so they join together into one wire and look something like that shown Figure 1-7c.

4. Wrap the joint in three or four turns of insulating tape— half an inch is probably enough (see Figure 1-7d).

**How to Test a Connection**

For the joints that we have made in the section “How to Join Wires by Soldering,” it is fairly obvious that they are connected. However, especially with solid-core wire, it is not uncommon for the wire core to break somewhere under the insulation. If you own an electric guitar, you will probably be familiar with the problem of a broken guitar lead.

**You Will Need**
Nearly all multimeters have a “Continuity” mode. When set in this useful mode, the multimeter will beep when the leads are connected to each other.

Set your multimeter to “Continuity mode,” and then try touching the leads together. Now take a length of wire and try touching the multimeter leads to each end of the wire (Figure 1-8). The buzzer should sound if the wire is okay.

![Figure 1-8 A multimeter in Continuity mode](image)

You can use this technique on circuit boards. If you have an old bit of circuit board from something, try testing between the soldered connections on the same track (Figure 1-9).
If there is no connection where you would expect there to be a connection, then there may be a “dry joint,” where the solder hasn’t flowed properly or there is a crack in the track on the circuit board (this sometimes happens if the board gets flexed).

A dry joint is easily fixed by just applying a bit of solder and making sure it flows properly. Cracks on a circuit board can be fixed by scraping away some of the protective lacquer over the track and then soldering up the split in the track.

**How to Hack a Computer Fan to Keep Soldering Fumes Away**

Solder fumes are unpleasant and bad for you. If you can sit by an open window while you solder, then great. If not, then this is a good little construction project to enhance your electronics hacking skills (Figure 1-10).
Okay, so it’s not going to win any awards for style, but attached to my work light (which is always close to whatever I am soldering), the fumes will at least be directed away from my face.

**You Will Need**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Appendix Code</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Soldering equipment</td>
<td>T1</td>
</tr>
<tr>
<td>1</td>
<td>An old computer fan (two-lead)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>12V power supply</td>
<td>M1</td>
</tr>
<tr>
<td>1</td>
<td>SPST switch</td>
<td>K1</td>
</tr>
</tbody>
</table>

**Construction**

*Figure 1-11* shows the schematic diagram for this mini-project.

\[ +12V \]

![Schematic Diagram](image)

*Figure 1-11* The schematic diagram for the fume extractor
Newcomers to electronics often view schematic diagrams like this with suspicion, thinking it better just to show the components as they actually are, with wires where wires need to be—just like in Figure 1-12. It is worth learning how to read a schematic diagram. It really isn’t that hard and in the long term it will pay dividends. Not least because of the vast number of useful circuit diagrams published on the Internet. It’s a bit like being able to read music. You can get so far playing by ear, but there are more options if you can read and write musical notation.

![Figure 1-12 The wiring diagram for the fume extractor](image)

So, let’s examine our schematic diagram. Over on the left we have two labels that say “+12V” and “GND.” The first is the 12V positive supply from the 12V power supply. GND actually refers to the negative connection of the power supply. GND is short for “ground” and just means zero volts. Voltage is relative, so the 12V connection of the power supply is 12V above the other connection (the GND connection). We will learn more about voltage in the next chapter.

Moving toward the right, we have a switch. This is labeled “S1,” and if we had more than one switch in a schematic, they would be labeled “S2,” “S3,” and so on. The symbol for a switch shows how it operates. When the switch is turned to the on position, its two connections are connected together, and when it is in the off position, they aren’t. It’s as simple as that.

The switch is just controlling the supply of electricity to the motor of the fan (M) as if it were a faucet.

**Step 1. Strip the Power Supply Leads**
We have a power supply and we are going to cut the plug off the end of it and strip the wires (see the section “How to Strip a Wire”). Before you cut off the plug, make sure the power supply is NOT plugged in. Otherwise, if you snip both wires at the same time, the cutters will probably short the two connections together, which may damage the power supply.

**Step 2. Identify the Power Supply Lead Polarity**
Having cut the wires, we need to know which one is the positive one. To do this, let’s use a multimeter. Set the multimeter to its 20V DC range. Your multimeter will probably have two voltage ranges, one for AC and one for DC. You need to use the DC
range. This is often marked by a solid line above a dotted line. The AC range will either be marked as AC or have a picture of a little sine wave next to it. If you select AC instead of DC, it will not damage the meter, but you will not get a meaningful reading. (See Chapter 11 if you need more information on multimeters.)

First making sure that the stripped leads from the power supply are not touching, plug the power supply in and turn it on.

Now touch the two test leads from the multimeter to the leads from the power supply (Figure 1-13). If the number on the multimeter is not negative, then the red test lead of the multimeter is connected to the positive lead. Mark the lead in some way (I tied a knot in it). If the multimeter shows a negative voltage, then the leads are swapped over, so tie a knot in the power supply lead connected to the black test lead of the multimeter—in this case, this is the positive lead from the power supply.

Step 3. Connect the Negative Leads Together
Unplug your power supply. You should never solder anything that is powered up.

Cut any plug off the end of your computer fan and strip the two wires. Mine had one black (negative) and one yellow (positive) lead. Three lead fans are more complex and should be avoided. If you get the leads the wrong way around, no harm will befall you. The fan will just rotate in the opposite direction.

We are now going to join the negative lead of the fan to the negative lead (no knot) of the power supply (Figure 1-14).
Step 4. Connect the Positive Lead to the Switch
Solder the positive lead from the power supply to one of the outer connections on the switch (it doesn’t matter which). (See Figure 1-15.) It will help to tin the switch connection with a little solder before you start.

Finally, connect the remaining lead from the fan to the center connection of the switch (see Figure 1-16).
Step 5. Try It Out
Wrap the bare connections with insulating tape, plug it in, turn it on, and presto! When you flick the switch, the fan should come on.

Summary
Now that we have the basics and are confident about a bit of soldering and dealing with wires and switches, we can now move on to Chapter 2. There, we will start looking at a few electronic components, as well as some of the basic ideas you will need to understand to successfully hack electronics.

2

Theory and Practice
There are a few fundamentals that will help us get the most out of our electronics. I have no intention of overloading you with theory, so you may find you come back to this chapter as and when you need to. But before we start on any theory, let’s look at getting together some of the components we will use.

How to Assemble a Starter Kit of Components
In Chapter 1, we assembled a few tools and did some soldering. The only thing we made used a scavenged computer fan, an off-the-shelf power supply, and a switch.

Certain components you will find that you use over and over again. To get yourself a basic stock of components, I recommend you buy a starter kit. SparkFun sells such a kit (see the Appendix, K1), but it does not contain any resistors, so you will need to buy a resistor set, too (K2). Once you have these, you will have a useful collection of components that should cover 80 percent of what you need.
Other suppliers sell starter kits, and although none of them will contain everything you need for this book, most will give you a very good starting point.

**You Will Need**
The SparkFun Starter Kit contains the following items, and the items used directly in this book are marked with a *, so if buying an alternative kit, look for one that has the majority of these components. Also see the Appendix for a list of other components used in the book.

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<th>Item</th>
<th>Quantity</th>
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<td>20-pin male header *</td>
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<td>100μF capacitor *</td>
<td>3</td>
<td>Mini power switch *</td>
</tr>
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<tr>
<td>3</td>
<td>20-pin female header</td>
<td>1</td>
<td>Mini photocell *</td>
</tr>
</tbody>
</table>

The separate SparkFun resistor kit (K2) contains resistors of the following values:
- 0Ω, 1.5Ω, 4.7Ω, 10Ω, 47Ω
- 110Ω, 220Ω, 330Ω, 470Ω, 680Ω
- 1kΩ, 2.2kΩ, 3.3kΩ, 4.7kΩ, 10kΩ
- 22kΩ, 47kΩ, 100kΩ, 330kΩ, 1MΩ

**How to Identify Electronic Components**

So, what have we just bought here? Let’s go through the components in the SparkFun starter kits and explain what they do, starting with the resistors.

**Resistors**

Figure 2-1 shows an assortment of resistors. Resistors come in different sizes to be able to cope with different amounts of power. High-power resistors are physically big to cope with the heat they produce. Since “parts getting hot” is generally a bad thing in
electronics, we will mostly avoid that. Nearly all of the time we can use the 0.25-watt resistors as provided in the SparkFun kit, which are perfect for general use.

As well as having a maximum power rating, resistors also have a “resistance.” As the word suggests, resistance is actually resistance to the flow of current. So a high-resistance resistor will not allow much current to flow, while a low-value resistor will allow lots of current to flow.

Resistors are the most commonly used component you can find. Since we will be using them a lot, we will go into greater detail on the subject in the section “What Are Current, Resistance, and Voltage?” later in this chapter.

Resistors have little stripes on them that tell you their value. You can learn to read the stripes (more in a moment on that) or you can avoid all of this by storing them in a bag or in the drawer of a component box with the value written on the box or bag.

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