Getting Started with Arduino
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Printed in U.S.A.

Published by Make:Books, an imprint of Maker Media,
a division of O'Reilly Media, Inc.
1005 Gravenstein Highway North, Sebastopol, CA 95472

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Print History: October 2008: First Edition

Publisher: Dale Dougherty
Associate Publisher: Dan Woods
Executive Editor: Brian Jepson
Creative Director: Daniel Carter
Designer: Brian Scott
Production Manager: Terry Bronson
Copy Editor: Nancy Kotary
Indexer: Patti Schiendelman
Illustrations: Elisa Canducci

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ISBN: 978-0-596-15551-3

What Is Electricity?

If you have done any plumbing at home, electronics won't be a problem for you to understand. To understand how electricity and electric circuits work, the best way is to use something called the "water analogy". Let's take a simple device, like the battery-powered portable fan shown in Figure 4-4.

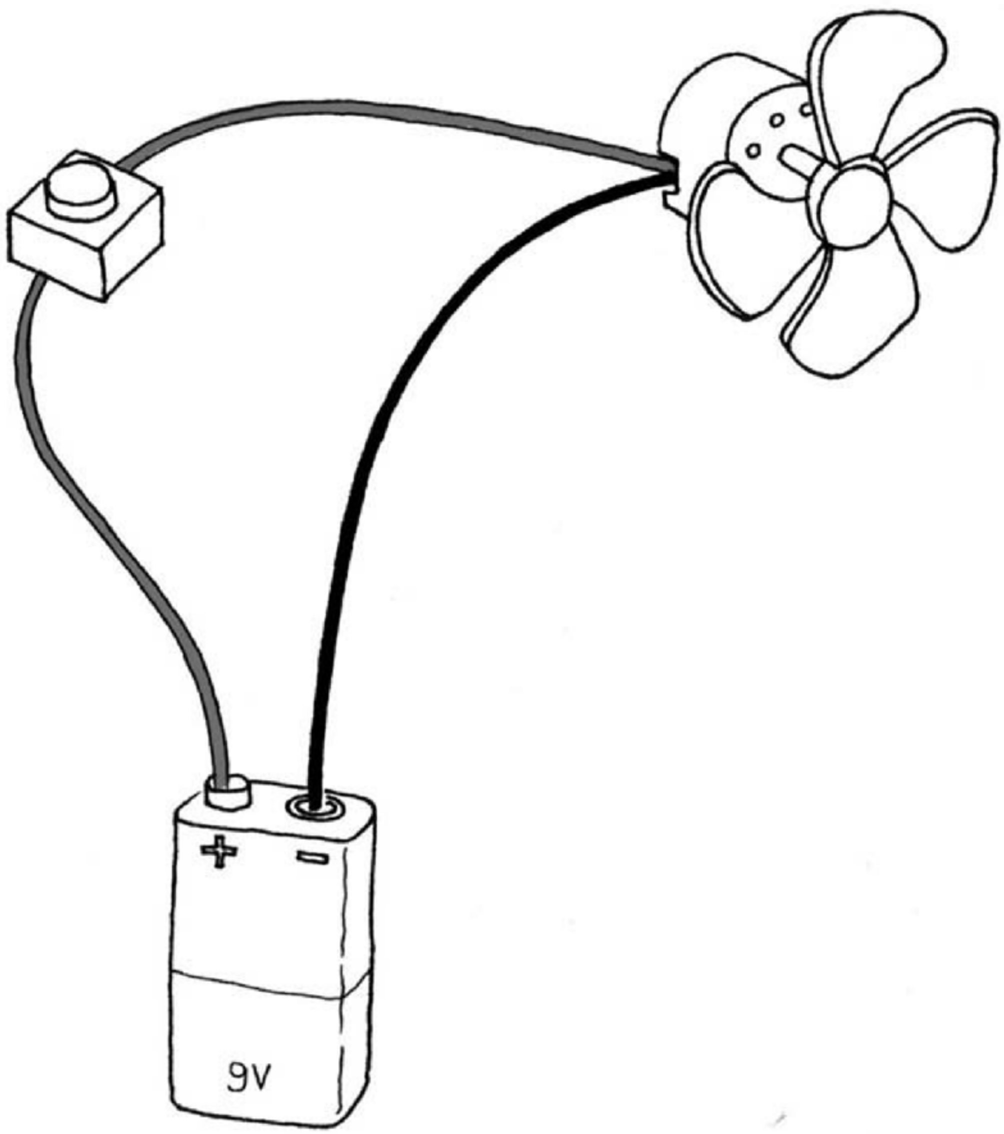

Figure 4-4.
A portable fan

If you take a fan apart, you will see that it contains a small battery, a couple of wires, and an electric motor, and that one of the wires going to the motor is interrupted by a switch. If you have a fresh battery in it and turn the switch on, the motor will start to spin, providing the necessary chill. How does this work? Well, imagine that the battery is both a water reservoir and a pump, the switch is a tap, and the motor is one of those wheels that you see in watermills. When you open the tap, water flows from the pump and pushes the wheel into motion.

In this simple hydraulic system, shown in Figure 4-5, two factors are important: the pressure of the water (this is determined by the power of pump) and the amount of water that will flow in the pipes (this depends on the size of the pipes and the resistance that the wheel will provide to the stream of water hitting it).

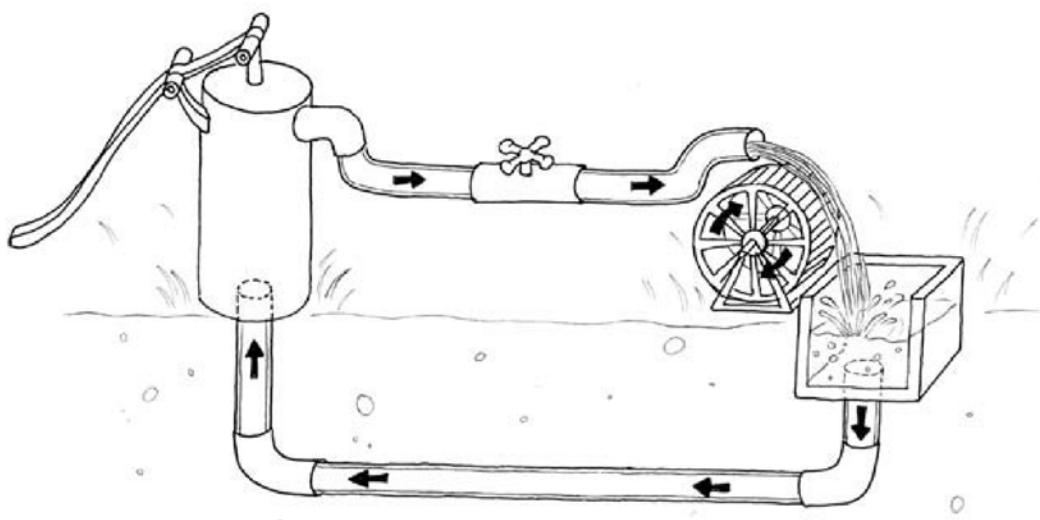

Figure 4-5.
A hydraulic system

You'll quickly realise that if you want the wheel to spin faster, you need to increase the size of the pipes (but this works only up to a point) and increase the pressure that the pump can achieve. Increasing the size of the pipes allows a greater flow of water to go through them; by making them bigger, we have effectively reduced the pipes' resistance to the flow of water. This approach works up to a certain point, at which the wheel won't spin any faster, because the pressure of the water is not strong enough. When we reach this point, we need the pump to be stronger. This method of speeding up the watermill can go on until the point when the wheel falls apart because the water flow is too strong for it and it is destroyed. Another thing you will notice is that as the wheel spins, the axle will heat up a little bit, because no matter how well we have mounted the wheel, the friction between the axle and the holes in which it is mounted in will generate heat. It is important to understand that in a system like this, not all the energy you pump into the system will be converted into movement; some will be lost in a number of inefficiencies and will generally show up as heat emanating from some parts of the system.

So what are the important parts of the system? The pressure produced by the pump is one; the resistance that the pipes and wheel offer to the flow of water, and the actual flow of water (let's say that this is represented by the number of litres of water that flow in one second) are the others. Electricity works a bit like water. You have a kind of pump (any source of electricity, like a battery or a wall plug) that pushes electric charges (imagine them as "drops" of electricity) down pipes, which are represented by the wires—some devices are able to use these to produce heat (your grandma's thermal blanket), light (your bedroom lamp), sound (your stereo), movement (your fan), and much more.

So when you read that a battery's voltage is 9 V, think of this voltage like the water pressure that can potentially be produced by this little "pump". Voltage is measured in volts, named after Alessandro Volta, the inventor of the first battery.

Just as water pressure has an electric equivalent, the flow rate of water does, too. This is called current, and is measured in amperes (after André-Marie Ampère, electromagnetism pioneer). The relationship between voltage and current can be illustrated by returning to the water wheel: a higher voltage (pressure) lets you spin a wheel faster; a higher flow rate (current) lets you spin a larger wheel.

Finally, the resistance opposing the flow of current over any path that it travels is called—you guessed it—resistance, and is measured in ohms (after the German physicist Georg Ohm). Herr Ohm was also responsible for formulating the most important law in electricity—and the only formula that you really need to remember. He was able to demonstrate that in a circuit the voltage, the current, and the resistance are all related to each other, and in particular that the resistance of a circuit determines the amount of current that will flow through it, given a certain voltage supply.

It's very intuitive, if you think about it. Take a 9 V battery and plug it into a simple circuit. While measuring current, you will find that the more resistors you add to the circuit, the less current will travel through it. Going back to the analogy of water flowing in pipes, given a certain pump, if I install a valve (which we can relate to a **variable resistor** in electricity), the more

I close the valve—increasing resistance to water flow—the less water will flow through the pipes. Ohm summarised his law in these formulae:

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R (resistance) = V (voltage) / I (current)
V = R * I
I = V / R
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This is the only rule that you really have to memorise and learn to use, because in most of your work, this is the only one that you will really need.

Using a Pushbutton to Control the LED

Blinking an LED was easy, but I don't think you would stay sane if your desk lamp were to continuously blink while you were trying to read a book. Therefore, you need to learn how to control it. In our previous example, the LED was our actuator, and our Arduino was controlling it. What is missing to complete the picture is a sensor.

In this case, we're going to use the simplest form of sensor available: a pushbutton.

If you were to take apart a pushbutton, you would see that it is a very simple device: two bits of metal kept apart by a spring, and a plastic cap that when pressed brings the two bits of metal into contact. When the bits of metal are apart, there is no circulation of current in the pushbutton (a bit like when a water valve is closed); when we press it, we make a connection.

To monitor the state of a switch, there's a new Arduino instruction that you're going to learn: the *digitalRead()* function.

digitalRead() checks to see whether there is any voltage applied to the pin that you specify between parentheses, and returns a value of HIGH or LOW, depending on its findings. The other instructions that we've used so far haven't returned any information—they just executed what we asked them to do. But that kind of function is a bit limited, because it will force us to stick with very predictable sequences of instructions, with no input from the outside world. With *digitalRead()*, we can "ask a question" of Arduino and receive an answer that can be stored in memory somewhere and used to make decisions immediately or later.

Build the circuit shown in Figure 4-6. To build this, you'll need to obtain some parts (these will come in handy as you work on other projects as well):