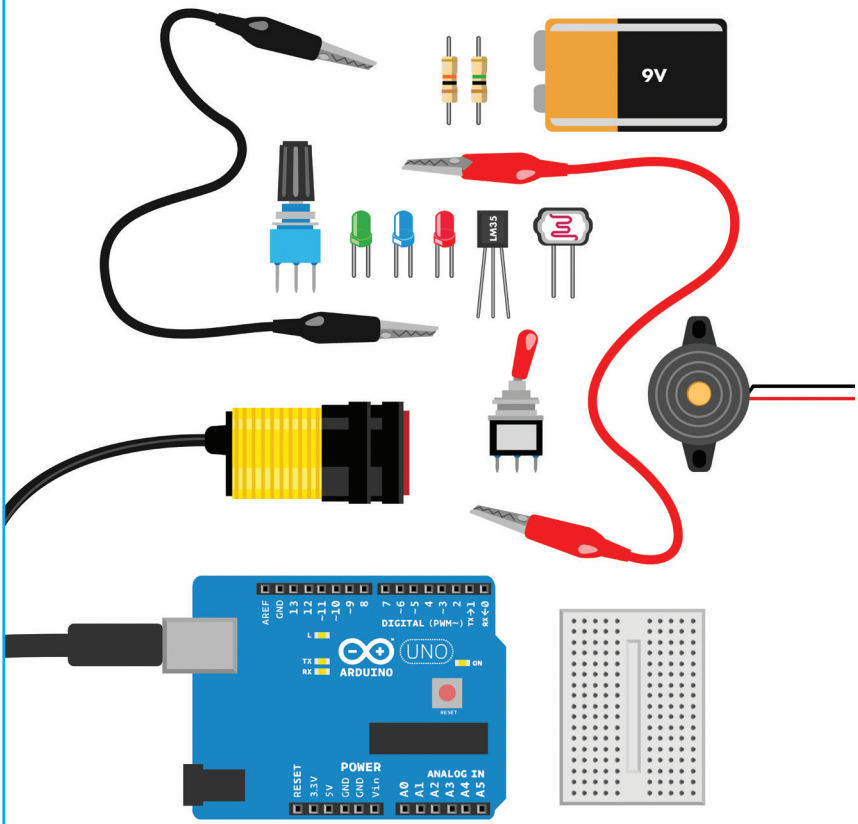
# Make: Getting Started with Sensors




## Measure the World with Electronics, Arduino, and Raspberry Pi

**Kimmo Karvinen & Tero Karvinen**

# Getting Started with Sensors

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MAKER MEDIA™
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# Getting Started with Sensors

by Kimmo Karvinen and Tero Karvinen



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# Contents

# Preface

There is a world of things happening around you, most of which become knowable to you thanks to one or more of your five senses. Sensory perception happens so quickly, and so often, that it's easy to overlook how impressive a system you actually are.

Take a moment and think how many sensory events happened to you from the time you woke up to the time you began reading this book. It's likely that you can't even list all the sensory occurrences. Not only do you constantly sense the environment, but your senses also work together to compile a picture of the universe. For example, events such as people passing by, warm sun shining on your face, or observing that a cool breeze in the morning is getting warmer in the afternoon are all fine examples of your senses at work and your mind processing sensations. But how can a robot or gadget have similar input? You probably already know what makes this possible (you did buy a book on the topic): sensors.

Adding sensors to a circuit expands its capabilities just as your own senses expand your awareness and inform you about the world. Sensors provide an input for information about an environment and work much like your own senses. But sensation isn't the only issue with sensors. A component doesn't necessarily have the ability to draw conclusions when a particular event occurs. Say, for instance, that it is –5 degrees outside and you want to go for a walk; what should you wear? You know, of course, that a coat and winter clothing are in order, but a temperature sensor does not know this. It can certainly provide you with a temperature reading, but it does not make judgments or inferences about what you should wear—at least not at the component level. For sensors to matter in the same way that your own sensations *and* your reflection on these sensations matter, a level of data processing needs to occur on the sensor data. Ultimately, sensors are components that you wire so that, either through hardware or software, their data is processed—and that's what this book is about: how to wire sensors and process their data.

In the first part of this book, you'll learn how to wire up sensors to other components. The level of data processing isn't too robust at the component

level, and the focus is really on just getting a sensor safely wired and teaching some of the basics. The second part of the book deals with how to process sensor data. You will learn how to easily and quickly write programs with Arduino to process sensor data, as well as how to wire and program a Raspberry Pi to support analog sensors.

In this book, you'll gain hands-on experience with some of the most useful and instructive sensors available. Among the sensors and applications in this book, you'll learn how to detect and respond to:

- Clicks and rotation with a potentiometer
- Distance with ultrasound
- Proximity with infrared sensors
- Light and dark with a photoresistor
- Temperature with a thermometer
- Magnetic fields with a Hall effect sensor

## What Sensors to Buy?

This book covers a number of specific sensors and components (a few are illustrated in Figure P-1). To make sourcing parts easier, we've included Appendix D, which lists a complete bill of materials for all the projects in this book.

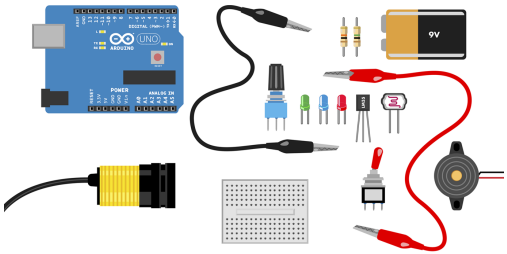


**Figure P-1.** *Arduino, sensors, and components*

Some well-known sellers of Arduino boards and related parts include Maker Shed, SparkFun Electronics, Parallax, and Adafruit. All four of these shops should stock most of the individual sensors used in this book, and all sell original, high-quality parts. Start with these shops.

Global electronics distributors, like Element14 and RS Components, are great places to order parts from, too. However, their product lists can be daunting for beginners to navigate. These global suppliers stock parts that differ from each other only in the pin format or voltage tolerances, which can

be quite exhaustive. The parts sold from both of these global suppliers are high quality parts and very well documented.

Some online shops are very cheap, but these places typically do not sell official Arduino boards—they will say the product is "compatible." The sensors they sell may differ slightly in their pin configuration or even general appearance. At the time of writing, DealExtreme is one of the most popular shops of this sort. Even though they are based in Hong Kong and Shenzhen and offer free worldwide shipping, the quality of their parts varies a lot and delivery time can be slow. AliExpress is another popular Asian shop.

If you're ordering from abroad, research your local laws regarding custom fees. In some countries, small orders may be exempt from customs and taxes.

## 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 element signifies a tip, suggestion, or general note.

This element indicates a warning or caution.

## Using Code Examples

You can download all the source code for this book from *http://getstarted.botbook.com*.

You can extract the zip package by double-clicking it, or by right-clicking and selecting Extract from the pop-up menu.

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We have a web page for this book, where we list errata, examples, and any additional information. You can access this page at: *http://bit.ly/get-start-sensors*.

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

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# 1/Sensors

Sensors surround you in daily life. The world is full of them: from passive infrared sensors in motion detectors, to $CO_2$ detectors in air conditioning systems, and even tiny accelerometers, GPS modules, and cameras inside your smartphone and tablet—sensors are everywhere! The variety of sensor applications is remarkable.

It's safe to assume that if an electronic device is considered "smart," it's full of sensors (Figure 1-1). In fact, thanks to the proliferation of smart devices, especially phones, the price of sensors has been driven to affordability. Not only is it economically viable to add advanced sensors to your projects, but they vastly expand the kinds of projects you can make.

You'll learn about sensors in this book by making small projects and reflecting on the experience. It's more fun to build first and discuss later, but both are equally important. It's best to avoid the temptation to only build projects and skip the conceptual sections.

Getting started with sensors is easy, and only the sky is the limit. Electronics challenge some of the best brains daily and produce new innovations and dissertations. On the other hand, even a child can get started with some guidance.

If you don't know much about sensors yet, try to remember what it feels like now. After you've tackled some challenges and built a couple of gadgets, many dark mysteries of sensors will probably seem like common sense to you.

This book is suitable for anyone with an interest in sensors (see Figure 1-2). After you've built the gadgets and have read this book, you can get ideas for bigger projects from our book *Make: Arduino Bots and Gadgets* or learn more advanced sensors in *Make: Sensors*. For a wider view of the basics, see *Getting Started with Arduino, 2nd Edition* by Massimo Banzi, *Getting Started with Raspberry Pi* by Matt Richardson and Shawn Wallace, or *Make: Electronics* by Charles Platt.

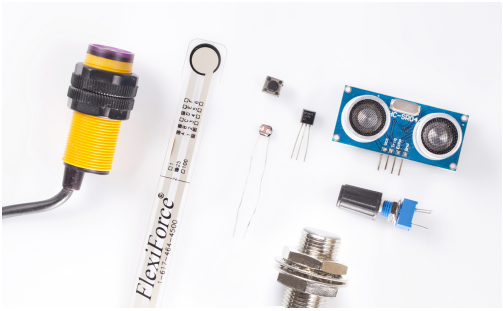


**Figure 1-1.** *Various sensors: infrared proximity, rotation, brightness, button, temperature, and distance*

What are sensors? Sensors are electrical components that function as input devices. Not all inputs are explicitly sensors, but almost all inputs use sensors! Consider your computer mouse or trackpad, a keyboard, or even a webcam; these are not sensors, but they definitely use sensors in their design. More abstractly, you can frame sensors as a component to measure a stimulus that is external to the system it is in (its environment). The output data is based on the measurement. For example, when you type at a keyboard, the letter that appears on your screen (the output) is based on the measurement (which switch, or key, you pressed on the keyboard). How many letters appear on screen is based on another measurement (how long you keep the key pressed).

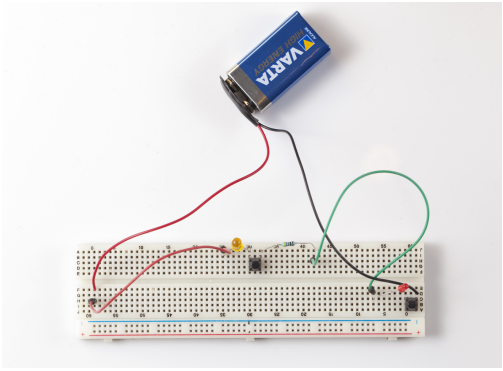


**Figure 1-2.** *Simple AND connection with buttons, built and designed by a four-year-old with help from an adult*

The first project uses a photoresistor to measure light. Without the photoresistor (or similar sensor), there is no way the circuit can know how bright