
Introduction

Robots are getting simpler all the time.

If that statement sounds backwards, consider this: as we continue to cram ever-more-powerful electronics into tinier and tinier containers, the number of things we can do at home, ourselves, with our everyday appliances and devices is growing exponentially. The same technology that makes it possible to squeeze a GPS, tilt sensor, camera, and wireless Internet connection into your cell phone also lets researchers design miniaturized robots that really pack a punch.

For scientists, knowing that a robot brain doesn't need to take up more room than a postage stamp means they can design robot bodies out of the most unexpected materials: soft polymers, folded paper, fabric that can bend and stretch instead of breaking. At one time building a robot out of such materials might have sounded nuts. But today even high schools and hobbyists, not to mention universities and commercial labs, have access to tools like 3D printers and laser cutters that can produce lightweight robot bodies able to survive falls from the tops of buildings—or from outer space. These new robots are more resilient and yet easily replaceable. If one prototype doesn't work, it's easy to tweak the design and cobble together another.

It's not just robot bodies that are getting simpler, though. Roboticists are taking a look around them at the natural world, especially lower-order animals that exhibit complex behavior without a lot of what we would traditionally think of as "smarts." Where once the goal was to create a humanoid device that could do what people do, now the trend is to make something small yet effective. Instead of a giant laser-eyed Gort clomping across the landscape or Data with his positronic brain, we're getting the skittering mechanical spiders of *Minority Report*.

Roboticists are also asking whether a robot needs to be able to avoid every misstep and obstacle if it can easily pick itself up and keep going. A robot that can travel along through pretty much anything using only simple rhythmic motions can make do with a lot less computing power than one that needs to decide where to place every footstep based on sensory readings of the surrounding terrain. This frees up processing capability that can be devoted to higher-level tasks. It can also lead to pared-down, interdependent swarms of micro bots that do more as a

team than they could do alone. The hive mind is real. And modular robots that can assemble and repair themselves are already on the horizon.

For people who like to learn about robots, but who don't have a background in science or technology, this is all great news. We watch in fascination as researchers turn old bicycle tires and PVC pipes into robotic arms and autonomous rovers. And as robots get simpler, we can begin to build our own designs that share many of the traits of "real" robots without a fancy lab or an engineering degree. When constructing a robot body takes nothing more advanced than zipties and a sewing machine, you're now in a place where even rank beginners can get into the act.

That's where this book comes in. *Making Simple Robots* will show you how to use standard crafting techniques and skills to build designs that are only a few degrees away from the real thing. Don't worry about getting in over your head. Many of the projects in *Making Simple Robots* will introduce you to some aspect of robotics without requiring you to build an entire machine. Some can be done in one session. Others can easily be broken down into steps that can be completed over a few afternoons.

If you've ever felt intimidated by a beginning robotics book, *Making Simple Robots* is for you. None of the projects in this book assume any background in electronics. Unfamiliar tools and techniques will be described in detail.

However, this book is also aimed at getting you out of your comfort zone. Curious about 3D printing? You'll find a project to help you ease into it. Wondering how an Arduino microcontroller (a miniature "computer on a board" designed to run lights, motors and other electronics) works? You'll get a chance to find out.

What Is a Simple Robot?

The traditional definition of a robot is a machine that can sense, think, and act. That means it can:

- Tell what's happening in its physical environment
- Analyze that information and make a decision based on its programming
- Move around, flash lights, sound alarms, or otherwise do something that affects the physical world

Think of it this way: your standard upright vacuum turns on when you flip a switch, but it will sit in one spot forever unless you grab the handle and start pushing it over the carpet. Banging it into a chair leg (or a dog's tail) doesn't affect its operation at all—although you may change your actions accordingly. A Roomba, on the other hand, is a vacuum with a brain. It can be programmed to turn itself on at certain times. And when it bumps into something, it backs up on its own and goes around it. You may think of a Roomba as a glorified appliance, but it's

actually a full-fledged robot. In fact, the iRobot company that makes the Roomba also supplies combat-ready, autonomous search-and-rescue robots to the military.

The “sense, think, act” definition is useful when you’re trying to explain the difference between an appliance and a robot. But what is considered a robot has been changing in recent years, along with advancements in technology. For one thing, embedded sensors and processors are turning practically every device we use into a type of robot. The automatic garage door with the safety sensor that stops the door from closing if something or someone is in the way—that’s a robot. So is the dryer that stops tumbling when its moisture-sensing electrodes tell it the towels are done.

But more importantly, a new way of approaching the field of robotics is considering how to build “dumb” machines and structures that still behave in sophisticated ways. Primitive robots that use switches as sensors—such as the push button that reverses the motor on a bump-and-turn robot—have been around for a while. The area of BEAM robotics (an acronym for Biology, Electronics, Aesthetics, and Mechanics) makes use of the fluctuating power from solar panels to create lifelike unpredictability. But new research is looking at whether the design of a robot body that determines a machine’s behavior itself, separate from any electrical controls, can be considered a form of programming.

This book uses the word “robot” in its broadest sense. That includes robotic bodies and parts that are not necessarily electronic or even motorized. Some projects are conceptual, and don’t necessarily involve any building at all. But all are based on actual robotics research being done today.

What’s in This Book?

Making Simple Robots is divided into chapters, each focusing on an interesting topic in robotics. You’ll get a look at new developments, and the surprising ways simple robots are being used in applications from sheer fun and entertainment to some of the most advanced research being done today. And you get to make related projects of your own. Here’s how they’re broken down:

Chapter 1, Robots Made from Interesting Materials

This is a look at some of the state-of-the-art materials and manufacturing processes that are opening up new possibilities in robot construction.

Chapter 2, Robots That Get Around

One of the most interesting challenges in robot design is figuring out how to get from place to place. Learn about some of the unusual ways researchers are solving the problem of robot locomotion.

Chapter 3, Unevolved Robots

Take a look at vibrating robots, BEAM robots, and other primitive creations that stretch the definition of “intelligence.”

Chapter 4, *Robot Friends and Helpers*

Social robots just want to be loved. This chapter looks at the challenges involved in making helper robots look and act friendly, not threatening.

Chapter 5, *Fun, Artsy Robots*

Robots are useful, but they're playful, too. Discover some of the ways that artists, toymakers, and educators are using robotics to add life and excitement to their designs.

How Are Projects Laid Out?

The projects in this book are intended to enhance your understanding of robots and robot-building techniques. The descriptions introduce you to the type of working robot or robotics research that inspired the project. The directions cover the things you need and the things you'll do in great detail. By following them closely, you should be able to successfully complete the project as described. But the best way to learn something is to make it your own. So many of the projects go further, offering suggestions for adapting the project for different abilities and settings. They may also include ideas for extending the project to dive more deeply into the topic, or to increase the complexity for those looking for more of a challenge. There's even advice for making some projects the basis of an exhibit at a science fair—or a Maker Faire.

Developing any Maker project, from the simplest craft to the most complex electronics, involves planning, preparation, and documentation. So to give you a peek into the process of creating a project from scratch, woven in and around the directions for building each project you'll find explanations of the behind-the-scenes steps involved in creating it. This format was inspired by a joint talk given at World Maker Faire New York 2013 by Tech Valley Center of Gravity member Steve Nordhauser and the author. This added information will help you understand the project in greater depth, and be useful if you decide to create your own variations.

The project descriptions format is as follows:

- What Is a ____?
- What It Does
- Where It Came From
- How It Works
- Making the Project
 - Project Parameters
 - Time Needed
 - Cost
 - Difficulty
 - Safety Issues

- What You Need to Know
 - Skills You Already Have
 - Skills You Will Learn
- Gather Your Materials
- Directions



Don't forget to document your work!

This reminder can save you from repeating the same mistakes the next time you try a similar project. Keep a record of your materials and what you do so you can refer to them whenever you need to. In high school and college science classes and in research laboratories at universities and businesses, a permanently bound lab notebook in your own handwriting, with no erasures or torn-out pages, can provide proof that your invention or discovery is really your own. For that purpose, a hardbound notebook like the Maker's Notebook from [Maker Shed](#) is ideal. Some tips:

- Start each work session on a fresh page. Cross out any blank spaces.
- Write neatly so you can decipher your notes later.
- Write down every detail as it happens. Don't trust to memory.
- Write down names and contact information for anyone you consult with. Make note of any books or websites you consult.

While cultivating the habit of keeping a standard laboratory notebook is a worthwhile goal, beginners and die-hard hobbyists have other options for documenting their work. One quick and easy way is to take photos or videos as you go along. Be sure to jot down enough notes to help you remember what the pictures are showing. If your project is new and different and your documentation is clear and easy to understand, you can share your process with others on a site like [Instructables](#). For additional ways to show off your creations with other *Making Simple Robots* readers, visit [Crafts for Learning](#).

Documentation Linkbox

[Science Buddies Lab Notebooks](#)

[Skill Builder: Photographing Small Objects](#) by Charles Platt

[10 Tips for Making Great Build Videos](#) by Becky Stern

[The Illustrated Guide to Home Chemistry Experiments](#) by Robert Bruce Thompson (2008, Maker Media)

[Maker's Notebook](#)

The directions for each project are organized into the following steps: