

## BUILD A ROVERBOT

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Imagine a robot that can vacuum the floor for you, relieving you of that time-consuming household drudgery and freeing you to do other, more dignified tasks. Imagine a robot that patrols your house, inside or out, listening and watching for the slightest trouble and sounding the alarm if anything goes amiss. Imagine a robot that knows how to look for fire, and when it finds one, puts it out. Impossible? A dream?

Think again. The compact and versatile Roverbot introduced in this chapter can serve as the foundation for building any of these more advanced robots. You can easily add a small DC-operated vacuum cleaner to the robot, then set it free in your living room. Only the sophistication of the control circuit or computer running the robot limits its effectiveness at actually cleaning the rug.

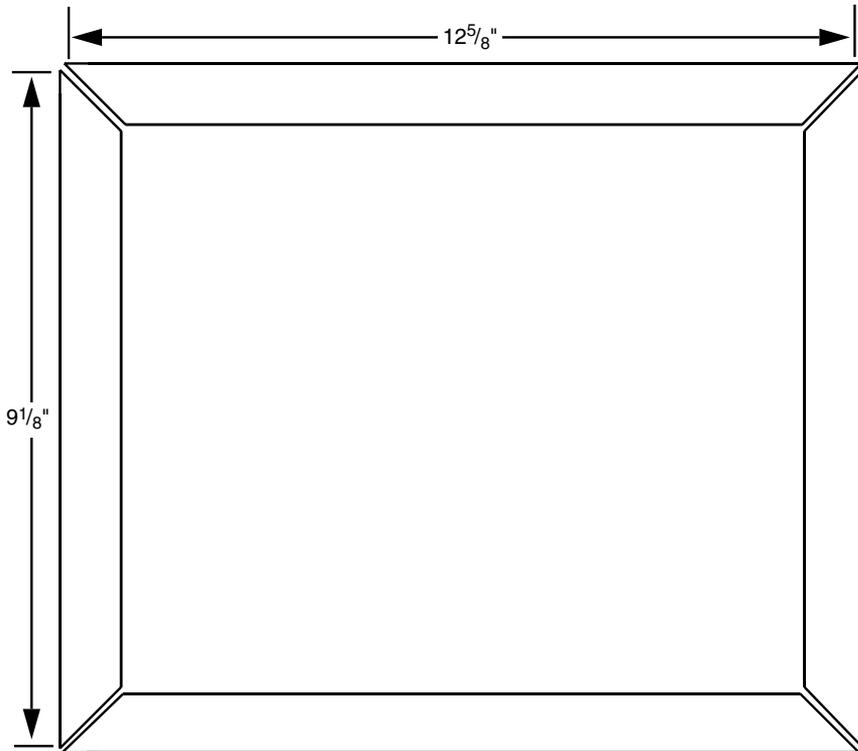
You can attach light and sound sensors to the robot, providing it with eyes that help it detect potential problems. These sensors, as it turns out, can be the same kind used in household burglar alarm systems. Your only job is to connect them to the robot's other circuits. Similar sensors can be added so your Roverbot actively roams the house, barn, office, or other enclosed area looking for the heat, light, and smoke of fire. An electronically actuated fire extinguisher containing Halon is used to put out the fire.

The Roverbot described on the following pages represents the base model only. The other chapters in this book will show you how to add onto the basic framework to create a more sophisticated automaton. The Roverbot borrows from techniques described in Chapter 10, "Building a Metal Platform." If you haven't yet read that chapter, do so now. It will help you get more out of this one.

## Building the Base

Construct the base of the Roverbot using shelving standards or extruded aluminum channel stock. The prototype Roverbot for this book used aluminum shelving standards because aluminum minimized the weight of the robot. The size of the machine didn't require the heavier-duty steel shelving standards.

The base measures  $12 \frac{5}{8}$  inches by  $9 \frac{1}{8}$  inches. These unusual dimensions make it possible to accommodate the galvanized nailing (mending) plates, which are discussed later in this chapter. Cut two pieces each of  $12 \frac{5}{8}$ -inch stock, with  $45^\circ$  miter edges on both sides, as shown in Fig. 21.1 (refer to the parts list in Table 21.1). Do the same with the  $9 \frac{1}{8}$ -inch stock. Assemble the pieces using  $1 \frac{1}{4}$ -by- $\frac{3}{8}$ -inch flat corner irons and  $\frac{8}{32}$  by  $\frac{1}{2}$ -inch nuts and bolts. Be sure the dimensions are as precise as possible and that the cuts are straight and even. Because you are using the mending plates as a platform, it's doubly important with this design that you have a perfectly square frame. Don't bother to tighten the nuts and bolts at this point.



**FIGURE 21.1** Cutting diagram for the Roverbot.

**TABLE 21.1 PARTS LIST FOR ROVERBOT.****FRAME**

2	12 5/8-inch length aluminum or steel shelving standard
2	9 1/8-inch length aluminum or steel shelving standard
3	4 3/16- by 9-inch galvanized nailing (mending) plate
4	1 1/4- by 3/8-inch flat corner iron

**RISER**

4	15-inch length aluminum or steel shelving standard
2	7-inch length aluminum or steel shelving standard
2	10 1/2-inch length aluminum or steel shelving standard
4	1- by 3/8-inch corner angle iron

**MOTORS AND CASTER**

2	Gear reduced output 6 or 12 volt DC motors
4	2 1/2- by 3/8-inch corner angle iron
2	5- to 7-inch diameter rubber wheels
2	1 1/4-inch swivel caster
Misc	Nuts, bolts, fender washers, tooth lock washers, etc. (see text)

**POWER**

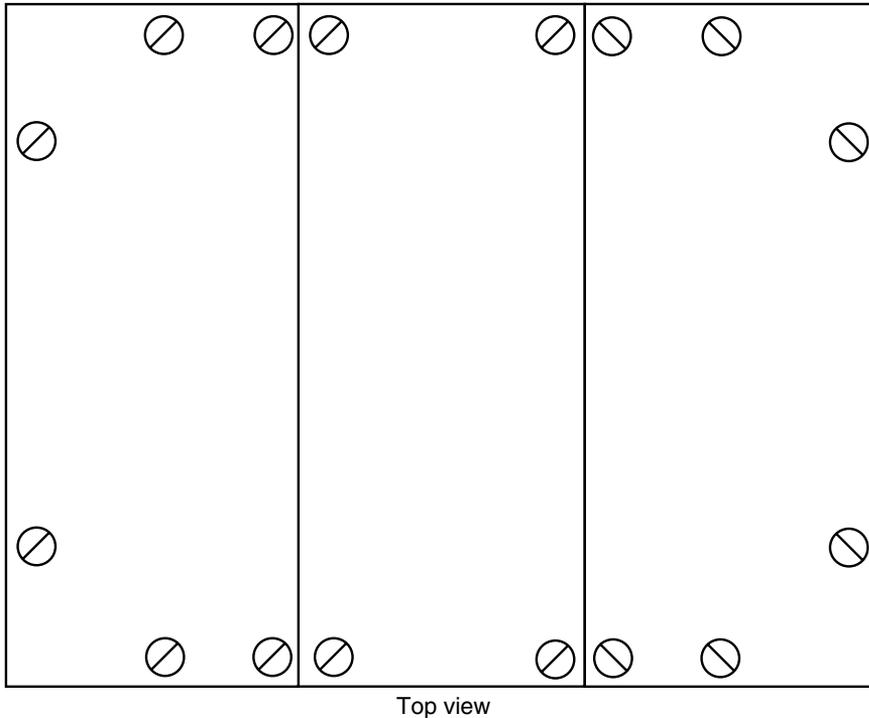
2	6 or 12 volt, 1 or 2 amp hour batteries (voltage depending on motor)
2	Battery clamps

Attach one 4 3/16-inch-by-9-inch mending plate to the left third of the base. Temporarily undo the nuts and bolts on the corners to accommodate the plate. Drill new holes for the bolts in the plate if necessary. Repeat the process for the center and left mending plate. When the three plates are in place, tighten all the hardware. Make sure the plates are secure on the frame by drilling additional holes near the inside corners (don't bother if the corner already has a bolt securing it to the frame). Use 8/32 by 1/2-inch bolts and nuts to attach the plates into place. The finished frame should look something like the one depicted in Fig. 21.2. The underside should look like Fig. 21.3.

## Motors

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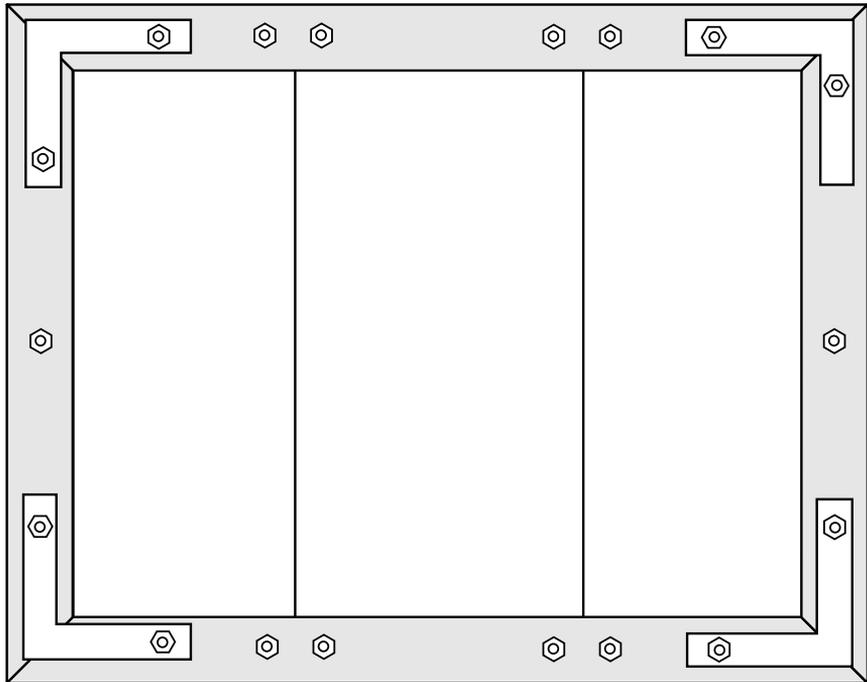
The Roverbot uses two drive motors for propulsion and steering. These motors, shown in Fig. 21.4, are attached in the center of the frame. The center of the robot was chosen to help distribute the weight evenly across the platform. The robot is less likely to tip over if you keep the center of gravity as close as possible to the center column of the robot.



**FIGURE 21.2** The top view of the Roverbot, with three galvanized mending plates added (holes in the plates not shown).

The 12-volt motors used in the prototype were found surplus, and you can use just about any other motor you find as a substitute. The motors used in the prototype Roverbot come with a built-in gearbox that reduces the speed to about 38 rpm. The shafts are 1/4 inch. Each shaft was threaded using a 1/4-inch 20 die to secure the 6-inch-diameter lawn mower wheels in place. You can skip the threading if the wheels you use have a setscrew or can be drilled to accept a setscrew. Either way, make sure that the wheels aren't too thick for the shaft. The wheels used in the prototype were 1 1/2 inches wide, perfect for the 2-inch-long motor shafts.

Mount the motors using two 2 1/2-inch-by-3/8-inch corner irons, as illustrated in Fig. 21.5. Cut about one inch off one leg of the iron so it will fit against the frame of the motor. Secure the irons to the motor using 8/32 by 1/2-inch bolts (yes, these motors have pretapped mounting holes!). Finally, secure the motors in the center of the platform using 8/32 by 1/2-inch bolts and matching nuts. Be sure that the shafts of the motors are perpendicular to the side of the frame. If either motor is on crooked, the robot will crab to one side when it rolls on the floor. There is generally enough play in the mounting holes on the frame to adjust the motors for proper alignment.



Bottom view

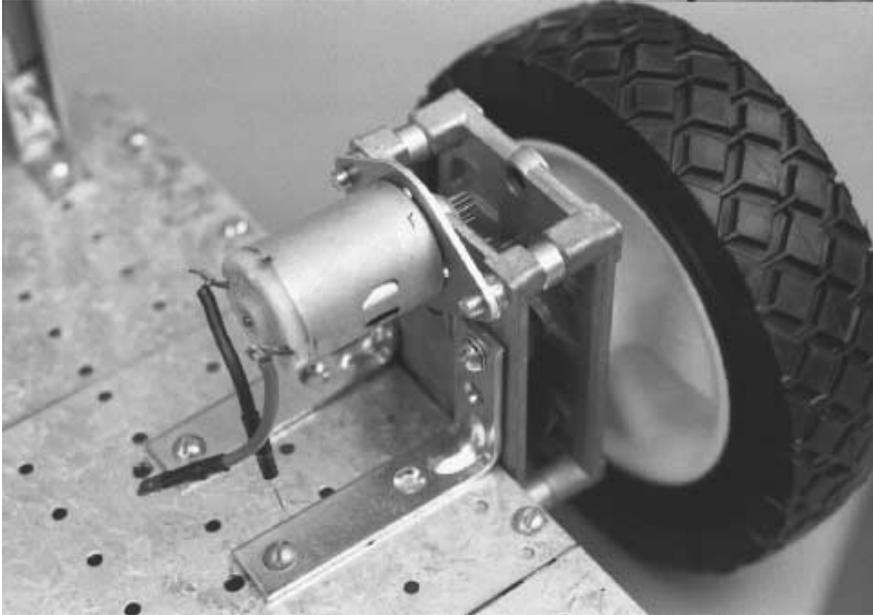
**FIGURE 21.3** Hardware detail for the frame of the Roverbot (bottom view).

Now attach the wheels. Use reducing bushings if the hub of the wheel is too large for the shaft. If the shaft has been threaded, twist a 1/4-inch 20 nut onto it, all the way to the base. Install the wheel using the hardware shown in Fig. 21.6. Be sure to use the tooth lock washer. The wheels may loosen and work themselves free otherwise. Repeat the process for the other motor.

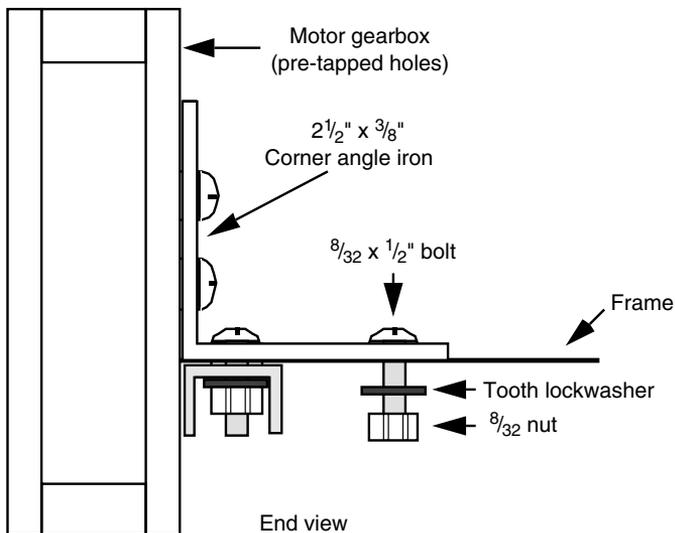
## Support Casters

The ends of the Roverbot must be supported by swivel casters. Use a two-inch-diameter ball-bearing swivel caster, available at the hardware store. Attach the caster by marking holes for drilling on the bottom of the left and right mending plate. You can use the baseplate of the caster as a drilling guide. Attach the casters using 8/32 by 1/2-inch bolts and 8/32 nuts (see Fig. 21.7). You may need to add a few washers between the caster baseplate and the mending plate to bring the caster level with the drive wheels (the prototype used a 5/16-inch spacer). Do the same for the opposite caster.

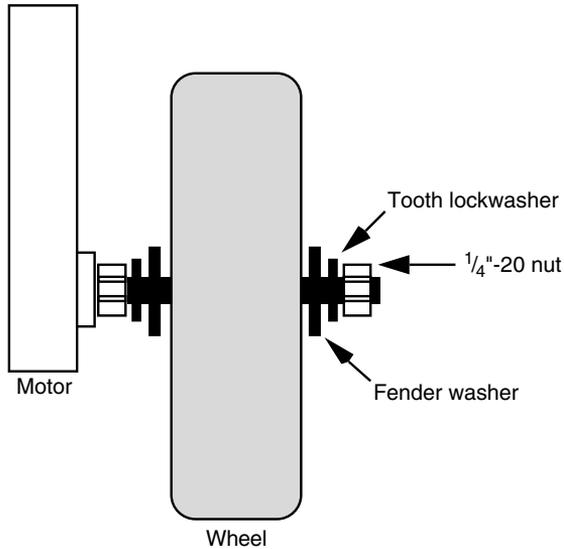
If you use different motors or drive wheels, you'll probably need to choose a different size caster to match. Otherwise, the four wheels may not touch the ground all at once as



**FIGURE 21.4** One of the drive motors, with wheel, attached to the base of the Roverbot.



**FIGURE 21.5** Hardware detail for the motor mount. Cut the angle iron, if necessary, to accommodate the motor.



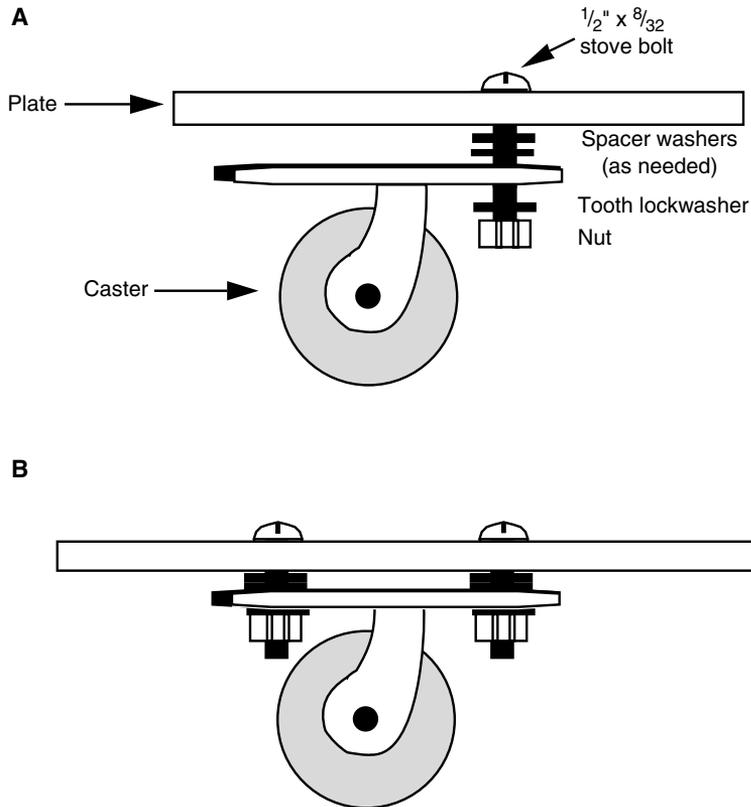
**FIGURE 21.6** Hardware detail for attaching the wheels to the motor shafts. The wheels can be secured by threading the shaft and using 1/4-inch 20 hardware, as shown, or secured to the shaft using a setscrew or collar.

they should. Before purchasing the casters, mount the motors and drive wheels, then measure the distance from the bottom of the mending plate to the ground. Buy casters to match. Again, add washers to increase the depth, if necessary.

## Batteries

Each of the drive motors in the Roverbot consumes one-half amp (500 mA) of continuous current with a moderate load. The batteries chosen for the robot, then, need to easily deliver two amps for a reasonable length of time, say one or two hours of continuous use of the motors. A set of high-capacity Ni-Cads would fit the bill. But the Roverbot is designed so that subsystems can be added to it. Those subsystems haven't been planned yet, so it's impossible to know how much current they will consume. The best approach to take is to overspecify the batteries, allowing for more current than is probably necessary.

Six- and eight-amp-hour lead-acid batteries are somewhat common on the surplus market. As it happens, six or eight amps are about the capacity that would handle intermittent use of the drive motors. (The various electronic subsystems, such as an on-board computer and alarm sensors, should use their own battery.) These heavy-duty batteries are typically

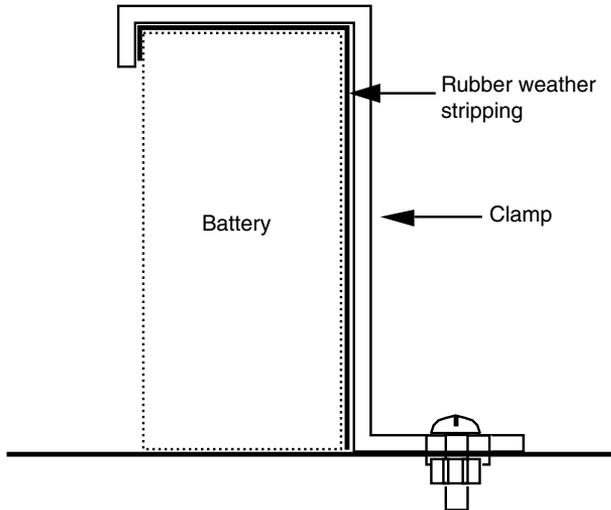


**FIGURE 21.7** Adding the casters to the Roverbot. There is one caster on each end, and both must match the depth of the drive wheels (a little short is even better). *a.* Hardware detail; *b.* Caster mounted on mending plate.

available in six-volt packs, so two are required to supply the 12 volts needed by the motors. Supplementary power, for some of the linear ICs, like op amps, can come from separate batteries, such as a Ni-Cad pack. A set of “C” Ni-Cads don’t take up much room, but it’s a good idea to leave space for them now, instead of redesigning the robot later on to accommodate them.

The main batteries are rechargeable, so they don’t need to be immediately accessible in order to be replaced. But you’ll want to use a mounting system that allows you to remove the batteries should the need arise. The clamps shown in Fig. 21.8 allow such accessibility. The clamps are made from 1 1/4-inch wide galvanized mending plate, bent to match the contours of the battery. Rubber weather strip is used on the inside of the clamp to hold the battery firmly in place.

The batteries are positioned off to either side of the drive wheel axis, as shown in Fig. 21.9. This arrangement maintains the center of gravity to the inside center of the robot.



**FIGURE 21.8** A battery clamp made from a strip of galvanized plate, bent to the contours of the battery. Line up the metal with weather stripping for a positive grip.

The gap also allows for the placement of one or two four-cell “C” battery packs, should they be necessary.

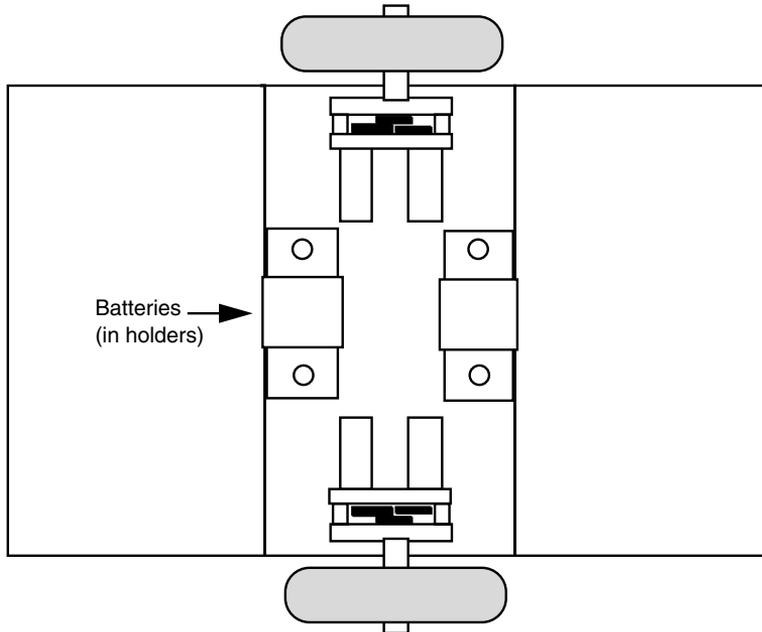
## Riser Frame

The riser frame extends the height of the robot by approximately 15 inches. Attached to this frame will be the sundry circuit boards and support electronics, sensors, fire extinguisher, vacuum cleaner motor, or anything else you care to add. The dimensions are large enough to assure easy placement of at least a couple of full-size circuit boards, a 2 1/2-pound fire extinguisher, and a Black & Decker DustBuster. You can alter the dimensions of the frame, if desired, to accommodate other add-ons.

Make the riser by cutting four 15-inch lengths of channel stock. One end of each length should be cut at 90°, the other end at 45°. Cut the mitered corners to make pairs, as shown in Fig. 21.10. Make the crosspiece by cutting a length of channel stock to exactly seven inches. Miter the ends as shown in the figure.

Connect the two sidepieces and crosspiece using a 1 1/2-inch-by-3/8-inch flat angle iron. Secure the angle iron by drilling matching holes in the channel stock. Attach the stock to the angle iron by using 8/32 by 1/2-inch bolts on the crosspieces and 8/32 by 1 1/2-inch bolts on the riser pieces. Don’t tighten the screws yet. Repeat the process for the other riser.

Construct two beams by cutting the angle stock to 10 1/2 inches, as illustrated in Fig. 21.11. Do not miter the ends. Secure the beams to the top corners of the risers by using



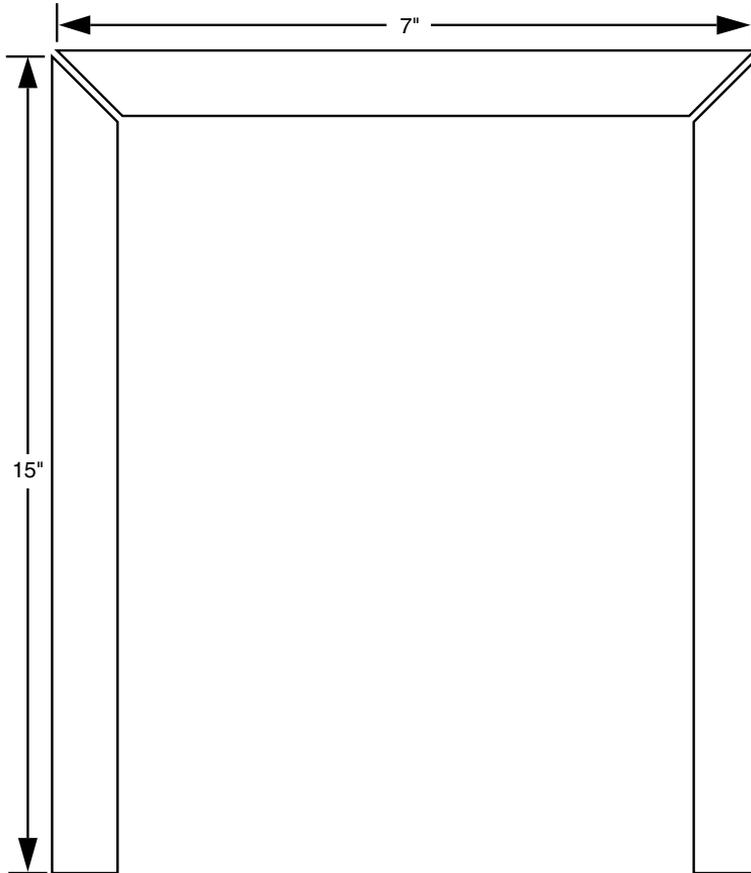
**FIGURE 21.9** Top view of the Roverbot, showing the mounted motors and batteries. Note the even distribution of weight across the drive axis. This promotes stability and keeps the robot from tipping over. The wide wheelbase also helps.

1-inch-by-3/8-inch corner angle irons. Use 8/32 by 1/2-inch bolts to attach the iron to the beam. Connect the angle irons to the risers using the 8/32 by 1 1/2-inch bolts installed earlier. Add a spacer between the inside of the channel stock and the angle iron if necessary, as shown in Fig. 21.12. Use 8/32 nuts to tighten everything in place.

Attach the riser to the baseplate of the robot using 1-inch-by-3/8-inch corner angle irons. As usual, use 8/32 by 1/2-inch bolts and nuts to secure the riser into place. The finished Roverbot body and frame should look at least something like the one in Fig. 21.13.

## Street Test

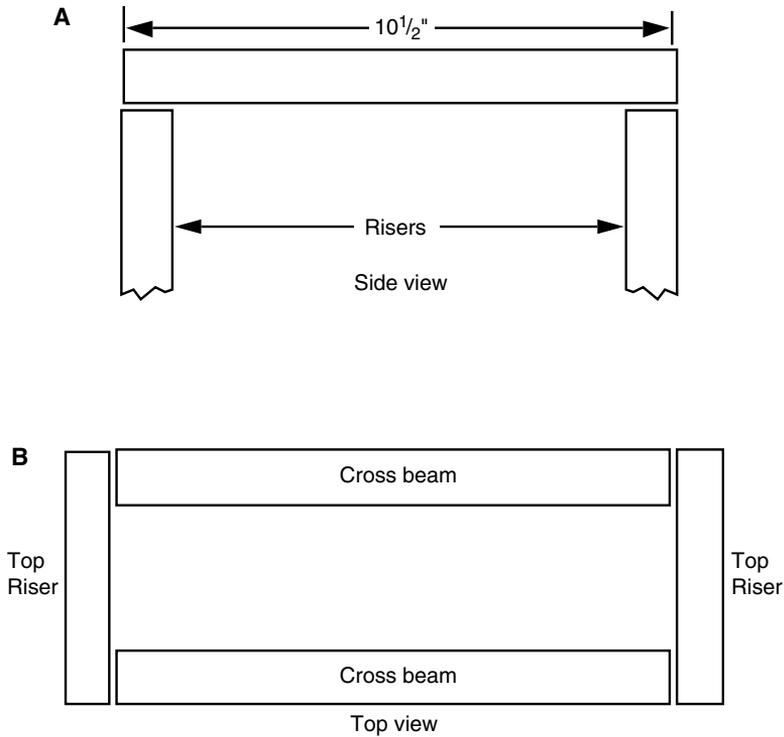
You can test the operation of the robot by connecting the motors and battery to a temporary control switch. See Chapter 8, “Building a Plastic Robot Platform,” for a wiring diagram. With the components listed in Table 21.1, the robot should travel at a speed of about one foot per second. The actual speed will probably be under that because of the weight of the robot. Fully loaded, the Roverbot will probably travel at a moderate speed of about



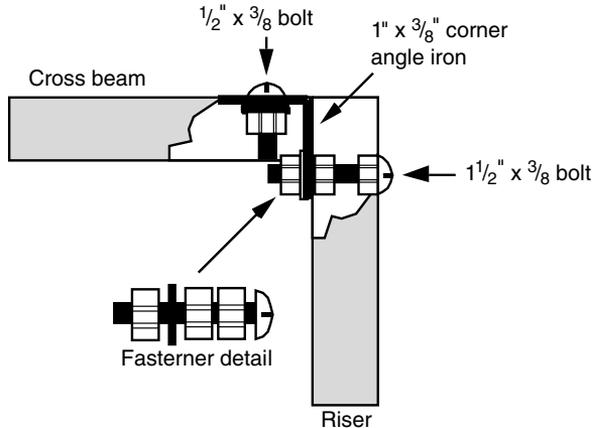
**FIGURE 21.10** Cutting diagram for the Roverbot riser pieces (two sets).

eight or nine inches per second. That's just right for a robot that vacuums the floor, roams the house for fires, and protects against burglaries. If you need your Roverbot to go a bit faster, the easiest (and cheapest) solution is to use larger wheels. Using eight-inch wheels will make the robot travel at a top speed of 15 inches per second.

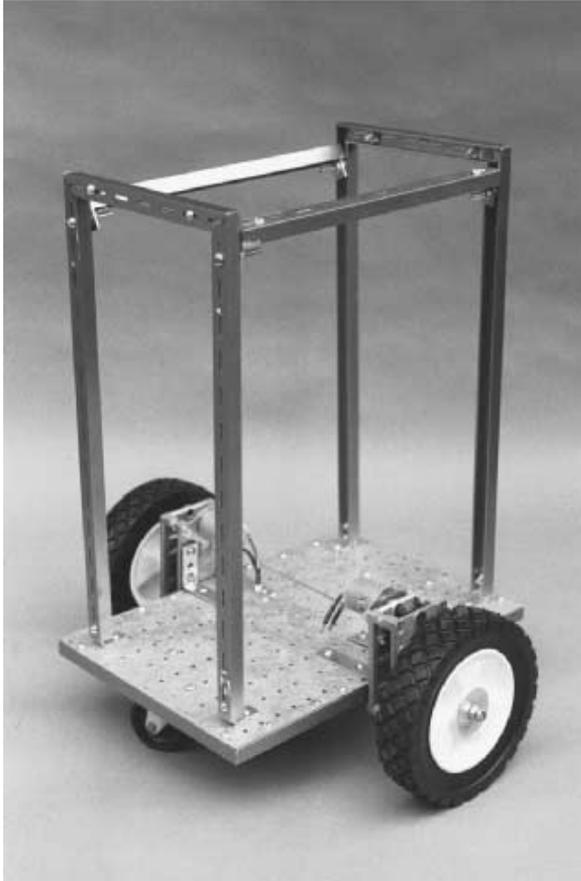
One problem with using larger wheels, however, is that they raise the center of gravity of the robot. Right now, the center of gravity is kept rather low, thanks to the low position of the two heaviest objects, the batteries and motors. Jacking up the robot using larger wheels puts the center of gravity higher, so there is a slightly greater chance of the robot tipping over. You can minimize any instability by making sure that subsystems are added to the robot from the bottom of the riser and that the heaviest parts are positioned closest to the base. You can also mount the motor on the bottom of the frame instead of on top.



**FIGURE 21.11** Construction details for the top of the riser. *a.* Side view showing the crosspiece joining the two riser sides; *b.* Top view showing the cross beams and the tops of the risers.



**FIGURE 21.12** Hardware detail for attaching the risers to the cross beams.



**FIGURE 21.13** The finished Roverbot (minus the batteries), ready for just about any enhancement you see fit.

## From Here

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### *To learn more about...*

Constructing robots using metal parts and pieces

Powering your robot using batteries

Selecting a motor for your robot

Operating your robot with a computer  
or microcontroller

### *Read*

Chapter 10, “Building a Metal Platform”

Chapter 15, “All about Batteries and Robot  
Power Supplies”

Chapter 17, “Choosing the Right Motor for  
the Job”

Chapter 28, “An Overview of Robot  
‘Brains’”