1

building your first robot

Want to make a robot car in five minutes? This chapter will show you how. You'll learn how to build simple vehicles with two motors, as well as how to make basic one-motor devices like fans and grabbers. You'll also learn how to run all of these creations just by pressing buttons on the Hub—no programming required.

building a quick car

Follow the steps in this section and you'll have a working robot car in no time. It won't be the sturdiest or most elegant robot, and it won't have any special features. But it will work just fine and can serve as a basis for fancier robots. Figure 1-1 shows two possible cars.

Both of the car designs, like all the robots you'll make, center around the *Hub*, which is like a LEGO brain. The Hub can be programmed to control motors and sensors, making your robots work. In this case, the Hub controls two motors to make the car go. The motors are attached either underneath or on the sides of the Hub. A wheel is attached to each motor, and a third, nonmotorized wheel attached to the Hub helps the car keep its balance.

Let's get building!

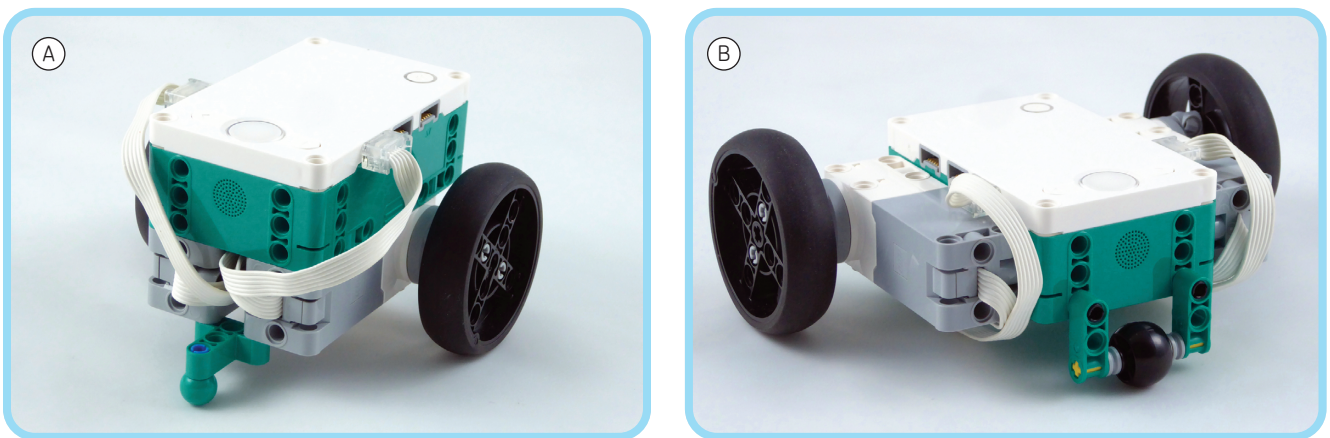


Figure 1-1: A simple car with the motors positioned underneath the Hub (a) and on the sides of the Hub (b)

step 1: attach two motors to the Hub

First you must attach two motors to the Hub, opposite each other. There are many ways to do this, since the Hub has so many connection points. Figures 1-2 and 1-3 show two possibilities.

In both cases, you use black connector pins to attach the motors. The motors face in opposite directions, with each motor shaft (the part that turns) facing out, away from the Hub.

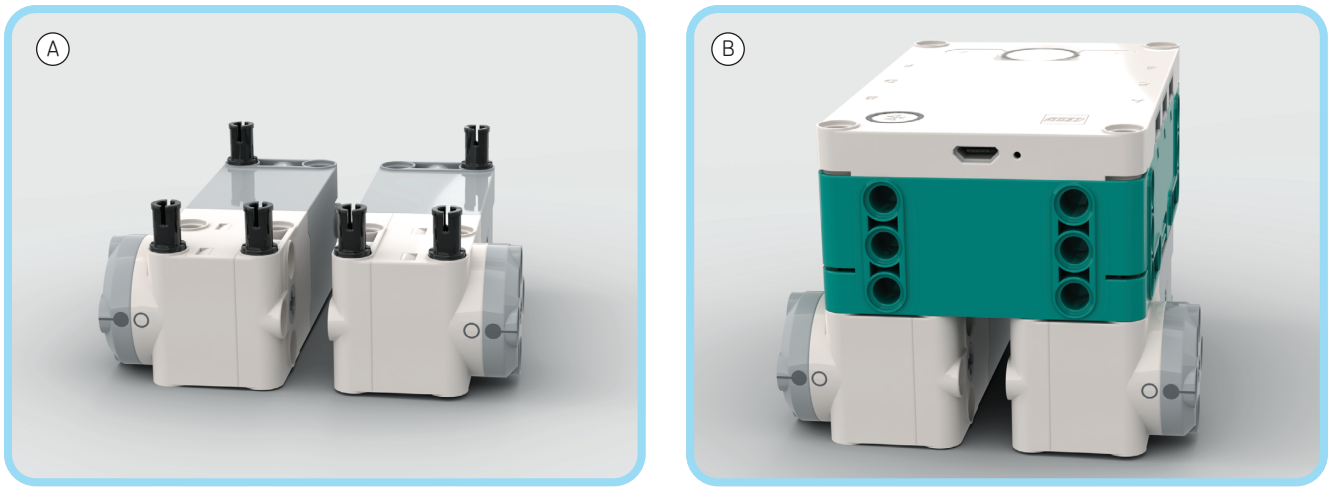


Figure 1-2: Use three black pins per motor (a) to attach the motors under the Hub (b).

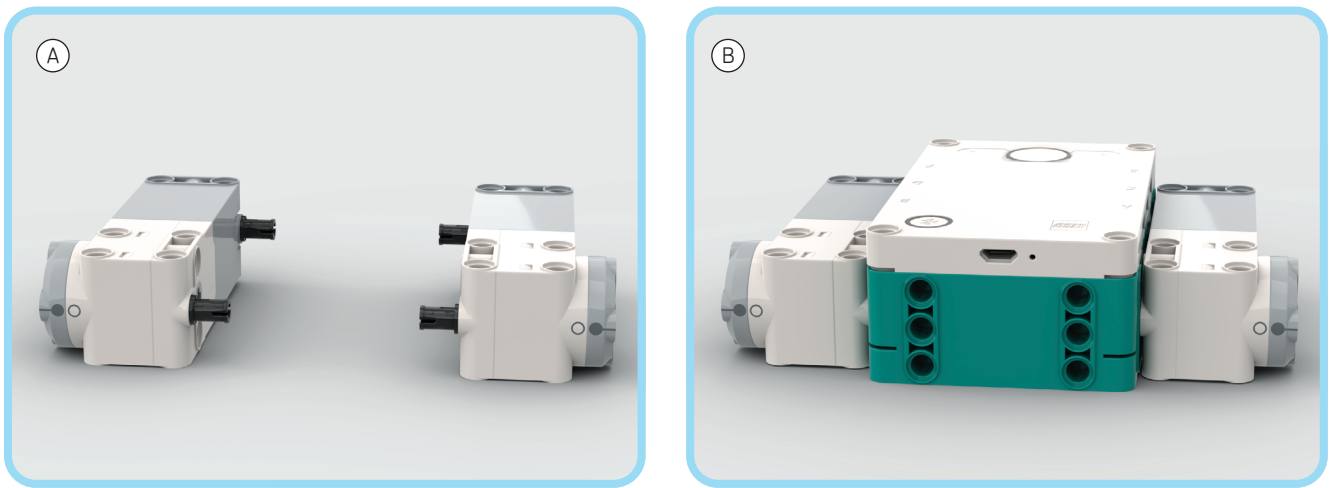


Figure 1-3: Use two black pins per motor (a) to attach the motors to the sides of the Hub (b).

step 2: attach wheels to the motors

Next, attach wheels to the motors by using black connector pins or gray H-shaped pin connectors, as shown in Figure 1-4.

Why use pins to attach a wheel to a motor rather than a single axle placed in the central hole of the motor shaft? Using two or more pins gives you two points of attachment rather than one. That way, two pins are doing the work of turning the wheels, rather than having the small ridges of the single axle do all the pushing.

step 3: attach more wheels for balance

Next, you need to add nonmotorized wheels or sliding pieces to the front of your car—or the back, if the motorized wheels are in the front. You can use a single wheel or another rounded LEGO piece to make a three-wheeled vehicle like a tricycle, or you can add two wheels to make a four-wheeled vehicle.

For example, Figure 1-5 shows the two attachments used on the three-wheeled cars from the beginning of the chapter, in Figure 1-1. The first attachment includes a rounded LEGO piece that will slide along the ground without rolling. The second attachment includes a rounded LEGO piece mounted on an axle so that it rolls like a wheel.

To make a four-wheeled vehicle instead, you can attach two other nonmotorized wheels. Figure 1-6 shows two possible ways.

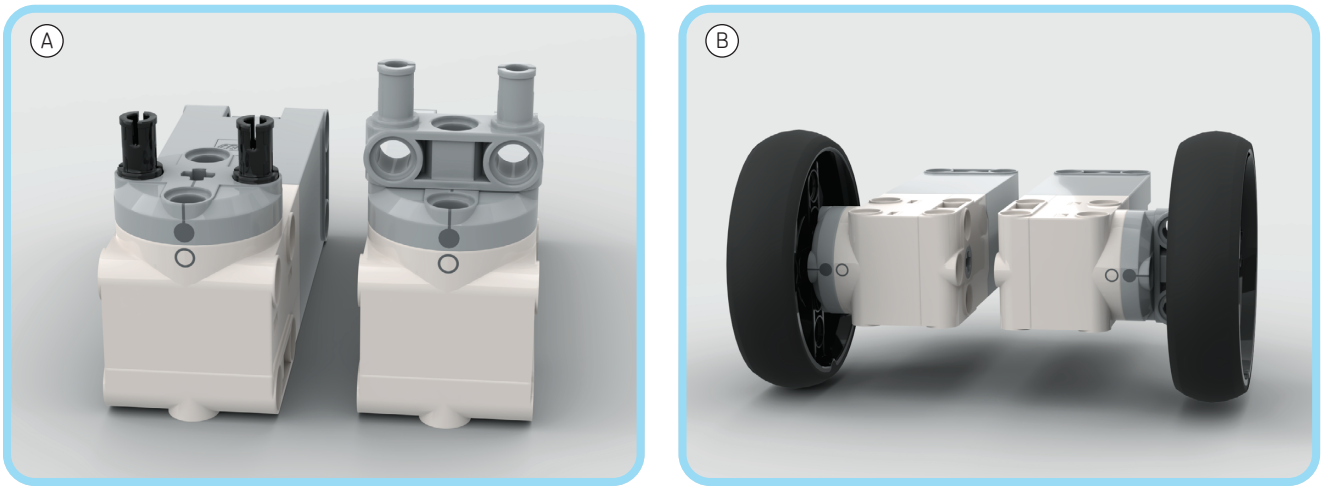


Figure 1-4: Use black connector pins or H-shaped pin connectors (a) to attach wheels to the motors (b).

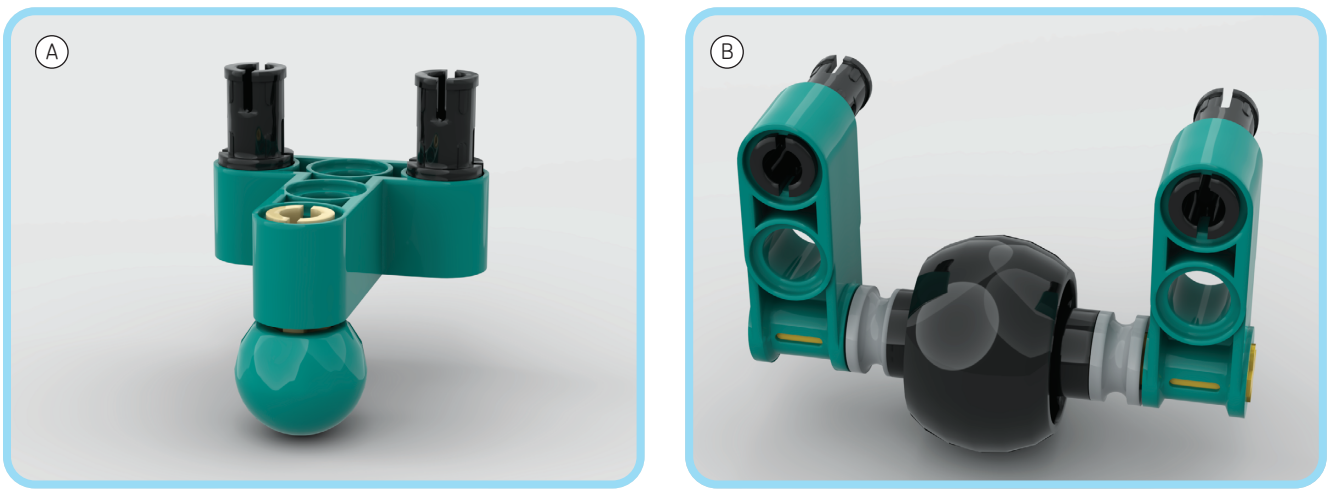


Figure 1-5: How to add a sliding or rolling piece underneath the motors (a) or to the front of the Hub (b)

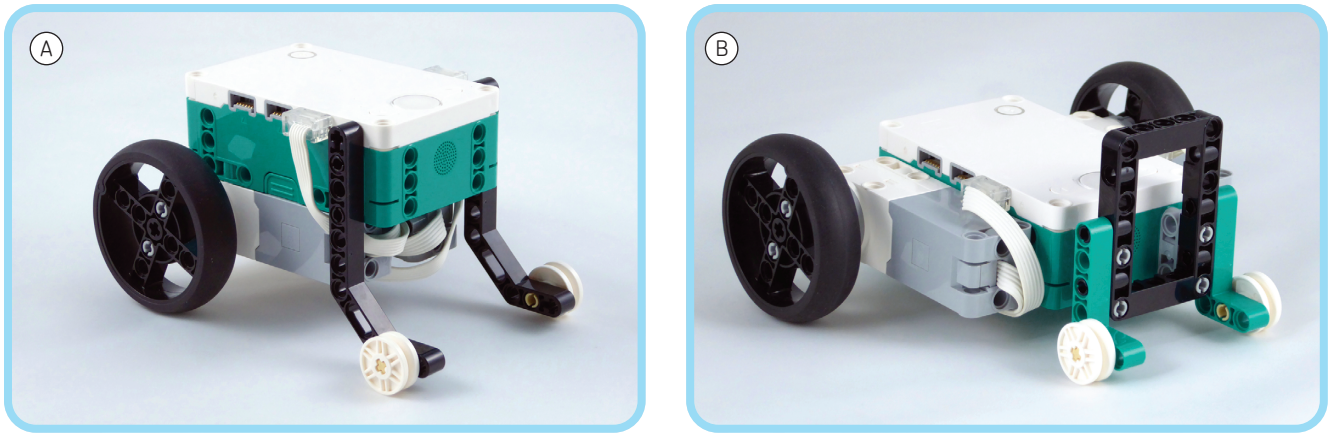


Figure 1-6: Two nonmotorized wheels added to a car with motors attached below (a) and alongside (b) the Hub

Notice that the two nonmotorized wheels are attached using separate axles. If both wheels were fixed to a single axle, the car wouldn't turn easily. The wheels need to move at different rates during a turn, which they can't do if they're on the same axle.

Notice also that the nonmotorized wheels don't have rubber tires. This, again, is to help with turning. Having rubber tires would increase the friction between the wheels and the driving surface. This would make the wheels jitter rather than turn smoothly.

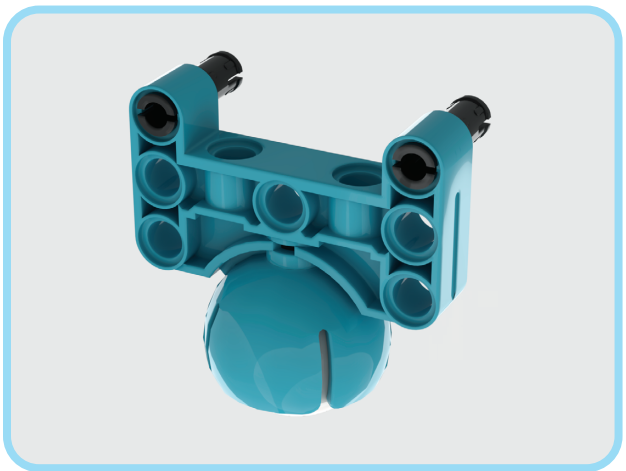
step 4: connect the cables

The last step is to connect the cables from the motors to the Hub. The Hub has six ports, labeled A through F. Plug one of the motors into a port on one side (A, C, or E). Plug the other motor into a port on the other side (B, D, or F). Any ports are fine, as long as they're on opposite sides of the Hub.

In Figure 1-7, for example, the cables are connected to ports A and B.

THE SPIKE PRIME CASTER WHEEL

The SPIKE Prime set comes with a caster wheel that you can use as the third, nonmotorized wheel of a robot vehicle. The caster wheel consists of a white plastic ball that sits inside a housing, which anchors it while allowing it to turn freely as it moves along the ground. Because the ball can rotate in any direction, the caster wheel easily handles turns and changes in direction.



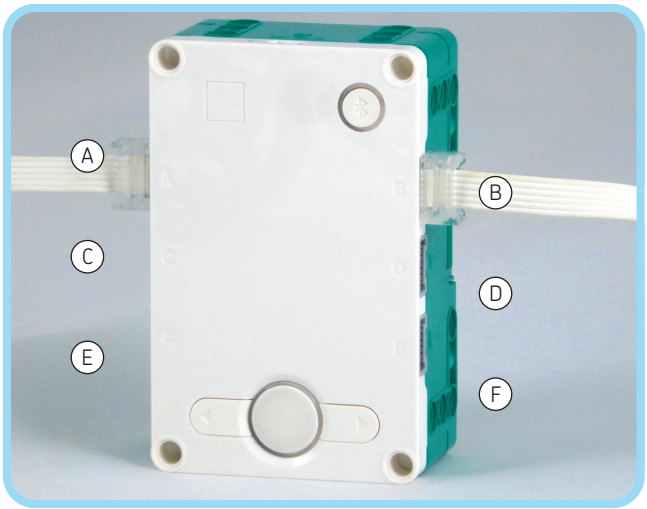


Figure 1-7: The Hub with cables in ports A and B

You've just built your first robot car—well done! Now it's time to take it for a test drive.

running your car

The Hub comes with a built-in program, the Play program, for running motors and sensors. You can use it to run your car without writing any code. To access the Play program, press the large round center button on the front of the Hub. The Hub will start up (it takes a few moments) and then display a *play arrow*, as in Figure 1-8.

NOTE With SPIKE Prime, the Hub will display a heart rather than an arrow when it powers up.

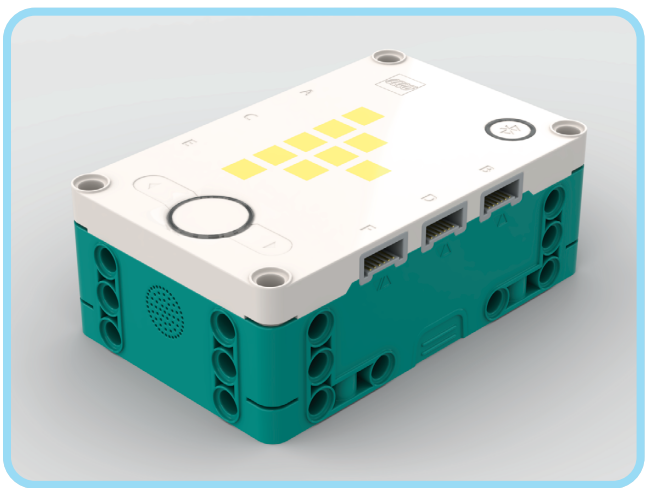
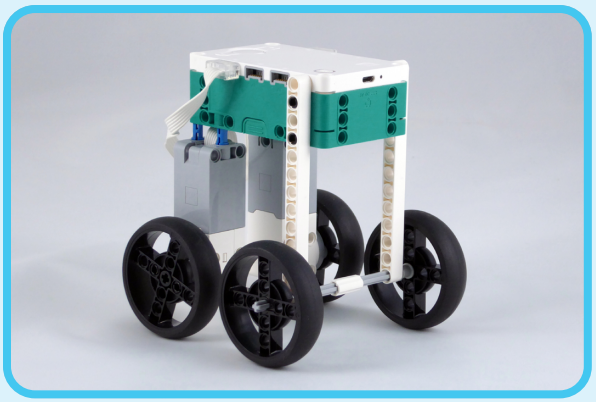


Figure 1-8: The play arrow on the Hub display

THINK ABOUT IT

Take a good look at this car. It has a number of design flaws. How many can you spot?



Answer: Here are some poorly designed features of the car:

- The center of gravity is very high because the heavy Hub is far off the ground. This makes the car more likely to tip over.
- The base is relatively small compared to the height of the car. This also makes the car likely to tip, especially when stopping suddenly or reversing direction.
- The motors aren't flush against the Hub and are attached with only two connector pins. This design creates flex between the Hub and the motors and makes the motors wobbly.
- The two nonmotorized wheels are connected by a single axle. As mentioned earlier, this makes turning difficult because the axle connection forces the wheels to rotate at the same rate.

Press the center button again after you see the arrow. In a few moments, lights will appear next to the two ports where you plugged in your motors. The Play program is ready to use.

You can now control your car by using the buttons on the Hub. Pressing the right or left buttons on either side of the round button will run the motors. The left button will make your car go in one direction; the right button will make it go in the opposite direction. (Which button makes your car go forward depends on how you built your car.) Pressing a button repeatedly will increase the speed of the motors. To stop the motors, press the center button.

The two sides of the Hub will run the motors in different directions by default, one clockwise and one counterclockwise. Since you built your car with the motors facing in opposite directions, running them this way will make the motors work together to send your car forward (or backward).

driving on a curve

You make a two-motor vehicle curve to the left or right by running its motors at different speeds. To do this, unplug one of the motors and use the right and left Hub buttons to adjust the speed of the second motor. Then plug the first motor back in. Now when you use the right and left buttons to adjust the speed, both motors will change up or down at the same rate. However, they will change from their different starting points: the second motor from whatever speed you set it to, and the first motor from a stop.

spinning in place

When you plugged your motors into ports on opposite sides of the Hub, they ran in different directions, causing your car to move forward and backward. If you plug in both motors on the same side of the Hub, they'll both run clockwise or counterclockwise. Since the motors are facing in opposite directions, however, this will cause your car to spin in a circle while remaining in place.

going further with robot vehicles

Want a more elegant car? Develop your own, using a basic two-motor design as a starting point. Or try building Tricky, one of the core Robot Inventor models. Tricky is sturdier than the quick cars shown in this chapter and is designed to accept sensors and other attachments.

If you have a SPIKE Prime set, the Build section of the SPIKE App contains plans for several different *driving bases*, platforms with two motorized wheels that can be used as the basis for more complicated robots with sensors and additional motors. Also, the SPIKE Prime unit "Competition Ready" from LEGO Education features basic and advanced driving bases.

creating single-motor builds

You can build so much more than cars with your Robot Inventor set! This section shows two examples of non-car projects that use only one motor. Both projects will work with the Play program, so you can use them right away. To control a single motor with the Play program, simply plug in the motor, and then use the right and left Hub buttons to set the motor's speed.

fast fan

A single spinning motor can be the basis for a fan or windmill. Try making a speedy fan with parts from your Robot Inventor set. The set comes with several winglike panels that can work as fan blades. Figure 1-9 shows one possibility.

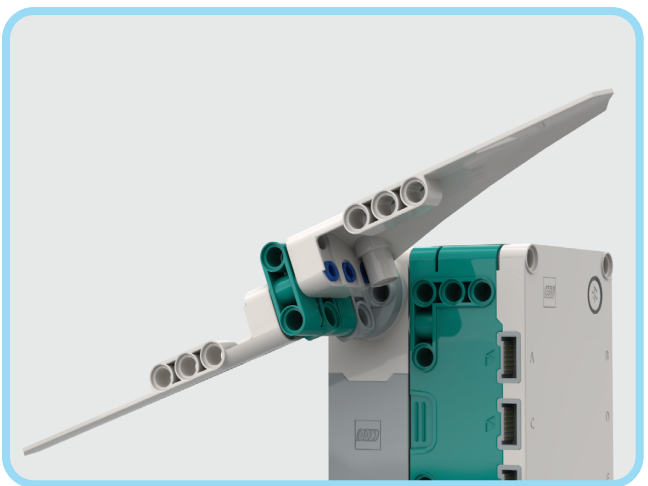


Figure 1-9: Fan blades made from white panels

Notice that the two fan blades are made from identical wings, not ones that are mirror images of each other. Using identical pieces means the blades will direct the flow of air in the same direction as they turn.

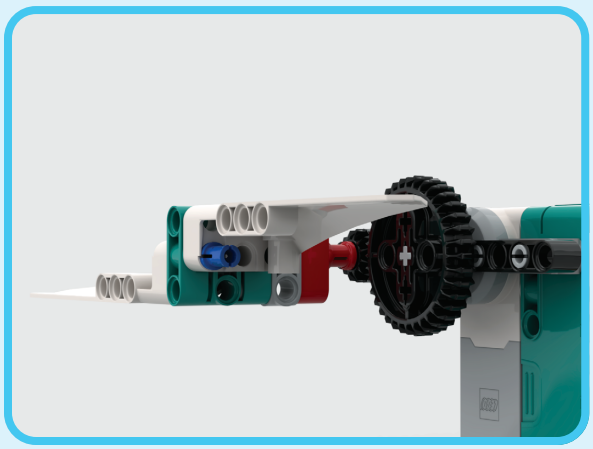
Use the Hub's Play program to change the speed and direction of your fan. Then plug a sensor into the port directly opposite the motor (the motor in port A and the sensor in port

B, for example). When you connect a motor and sensor like this, the Play program will use the sensor to control the motor. If you use the Distance Sensor, then the closer an object comes to the sensor, the faster the motor will go. If you use the Color Sensor, different colors will make the motor run at different speeds. You will learn more about sensors in Chapter 6.

TRY THIS

Want your fan to make a breeze you can feel? Try using gears to increase its speed. Attach a larger gear directly to the motor, and use it to turn a smaller gear attached to the fan blades. This is called gearing up.

Here's one possible design. This geared-up fan will turn three times as fast as the motor rotates:



motorized grabber

Motors can power devices that move in all sorts of ways besides simply spinning in a circle. For example, you can make a motorized grabber for picking up objects. The trick to building a grabber is to make "fingers" that will open when the motor runs in one direction and close when the motor runs in the opposite direction. One simple way of doing this uses two gears, as shown in Figure 1-10.

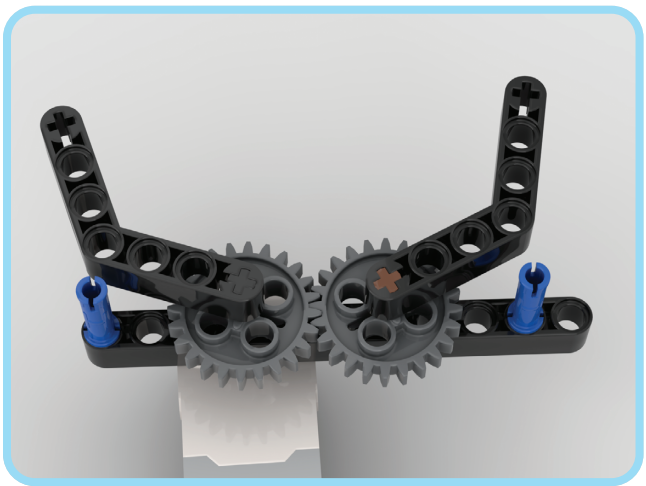


Figure 1-10: A grabber made with gears

The gears are *meshed*, meaning their teeth overlap. When the gear attached to the motor turns clockwise, the other gear turns counterclockwise, closing the grabber's "fingers." When the motor turns the other way, the grabber will open. Use the right and left Hub buttons with the Play program to operate the grabber.

NOTE For a more elegant and effective grabber, check out the Further Activity "Grab and Move" under the robot Blast in the MINDSTORMS App. Or if you have a SPIKE Prime set, look at "Grabbers" in the Build section of the SPIKE App.

summary

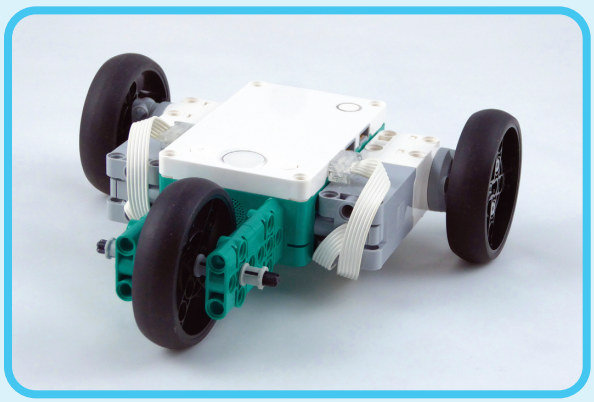
In this chapter, you've learned how to build simple motorized creations, including a basic two-motor vehicle, and you've seen how to run them using the Play program. In the next chapter, you'll explore the MINDSTORMS App so you can start writing your own code to control your creations.

PROJECTS

FLIPPED CAR

Build a car that can drive right side up (with the Hub facing up) or upside down (with the Hub facing down).

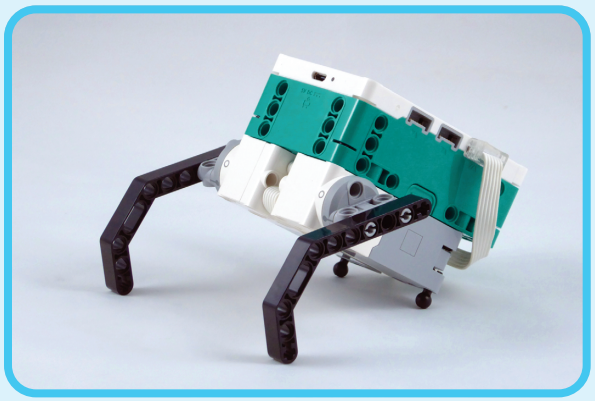
Here's one possible solution:



MOVING WITHOUT WHEELS

The basic two-motored vehicle designs you saw in this chapter can be adapted to make robots that move around without wheels that roll. Try making a walking or crawling robot by attaching pieces to the motors that will function as arms or legs. (You're welcome to still use wheels if you turn them on their side so they become feet, as in the second example shown here.)

Here's a simple solution. When the motors run, the curved beams will rotate. As they come in contact with the ground on each rotation, they will pull the robot forward:



Here's a more complex solution that uses a crank-slider mechanism for each of the motorized legs. This kind of mechanism converts the rotation of the motor into a back-and-forth motion that pushes the robot forward. Try building it yourself based on the picture and watch how it works: