

2

building ROV3R

Now that you're familiar with the pieces that come in the EV3 set, it's time to build your first robot: ROV3R, a mobile robot that is built with just a few parts. Thanks to its modular design, reconfiguring it for various missions is a snap. In this chapter, I'll show you how to combine the wheeled version of ROV3R with different sensors and tools (see Figures 2-1 and 2-2), but you can easily swap out ROV3R's wheels for treads. In the chapters that follow, you'll learn how the added sensors and tools work and then program these ROV3Rs to accomplish various tasks.

Along with the building instructions that follow, you'll find many tips and tricks. As you read through the instructions, you'll learn various building techniques, tips for making good design choices, and some rules of thumb for building robots with studless LEGO Technic pieces.

Although this book is printed in grayscale, the contrast and readability of the images have been maximized. Almost all of the parts in the 31313 set are white, black, or red. When knowing the color of a certain element is important—for example, to distinguish pins with friction from pins without friction (or axle pins)—I've added labels to indicate the color (see Table 2-1).

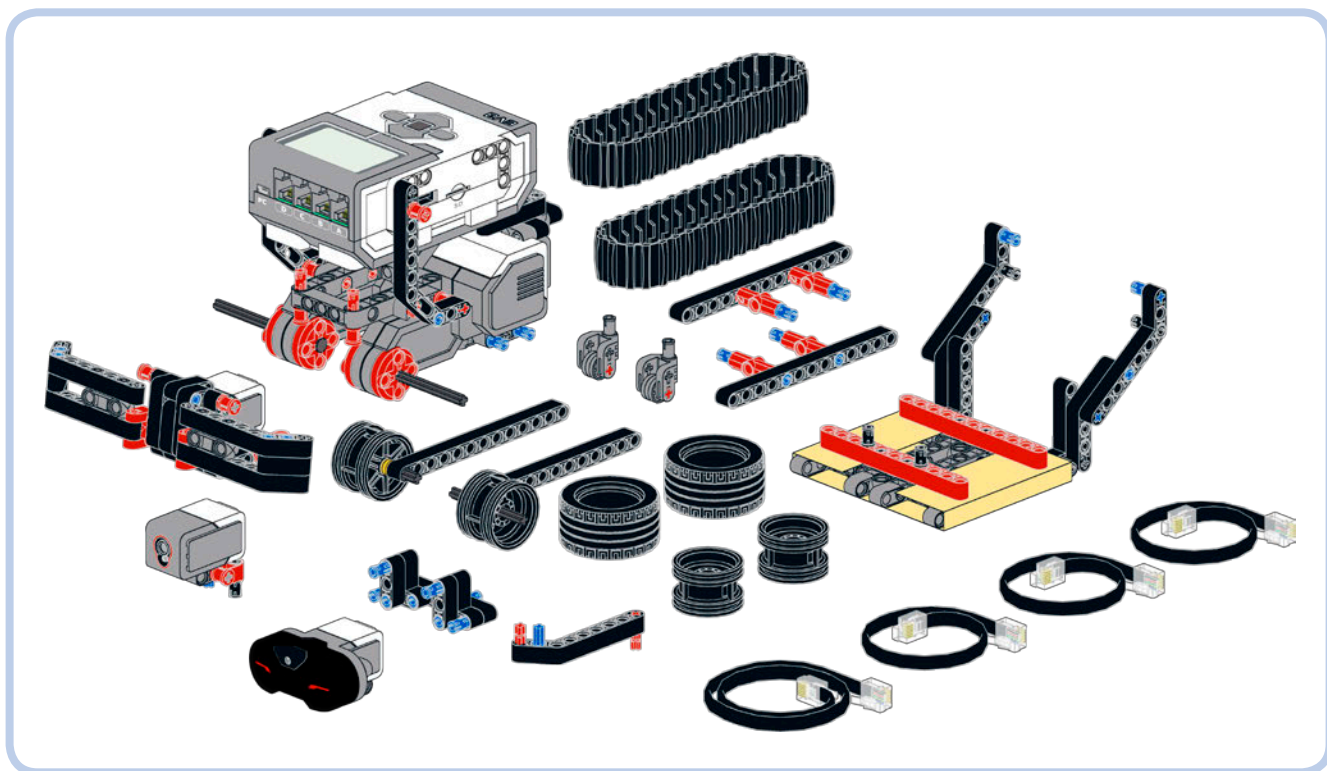
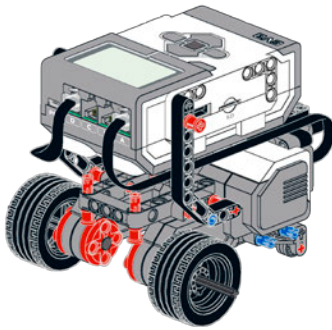
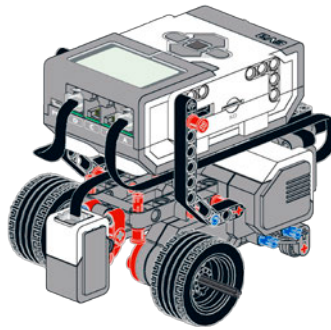


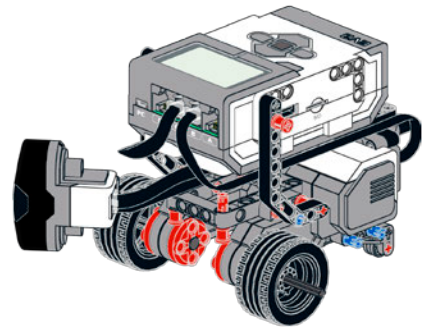
Figure 2-1: An overview of ROV3R's modules



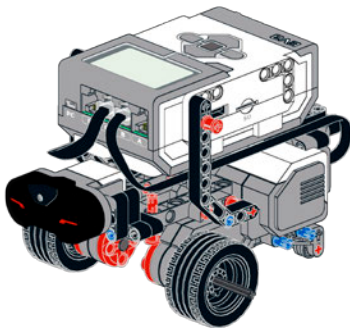
with wheels
(page 23)



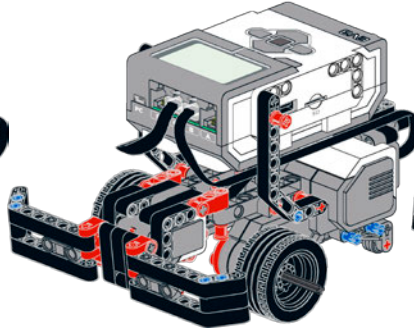
line follower
(page 28)



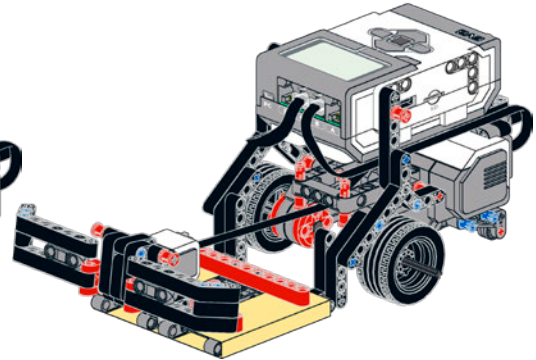
wall follower
(page 32)



with Front IR Sensor
(page 30)



with Touch Sensor Bumper
(page 25)



floor sweeper
(page 34)

Figure 2-2: ROV3R can be reconfigured in many ways, thanks to its modular design. These are just a few of the possible combinations.

When not otherwise specified, pins are black pins with friction, axle pins are blue axle pins with friction, and 3M pins are long blue pins with friction. And remember that odd-length axles (3M, 5M, 7M, 9M) are light grey.

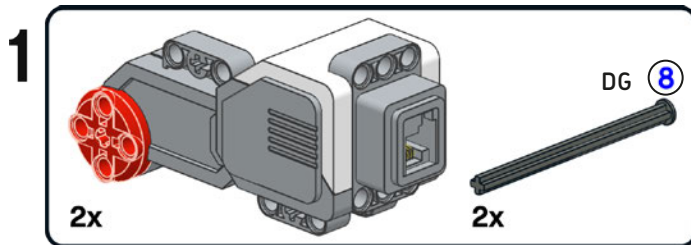
NOTE This color legend applies to all elements throughout this book.

table 2-1: labels used to designate colors in the building instructions

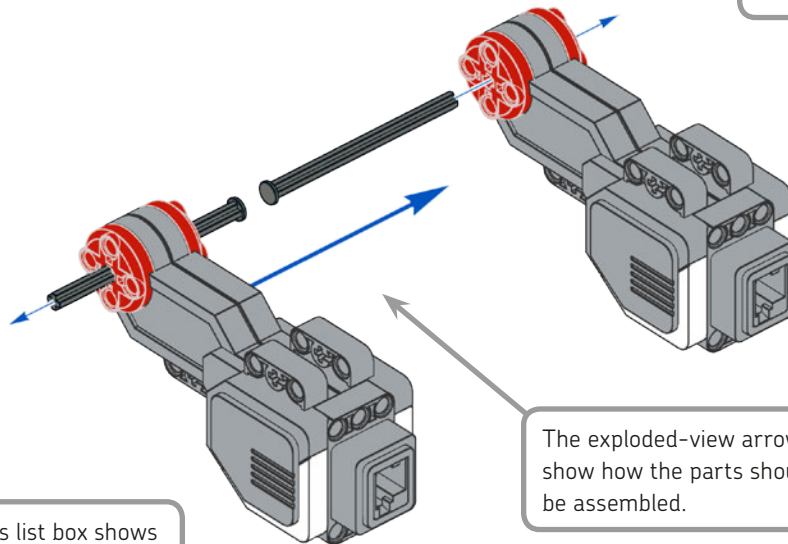
Color	Label
White	W
Grey	G
Dark grey	DG
Yellow	Y
Red	R
Blue	B
Tan	T

base module

First you'll need to build the Base Module, which can be used with wheels (see "ROV3R with Wheels" on page 23) or treads (see "ROV3R with Treads" on page 40).



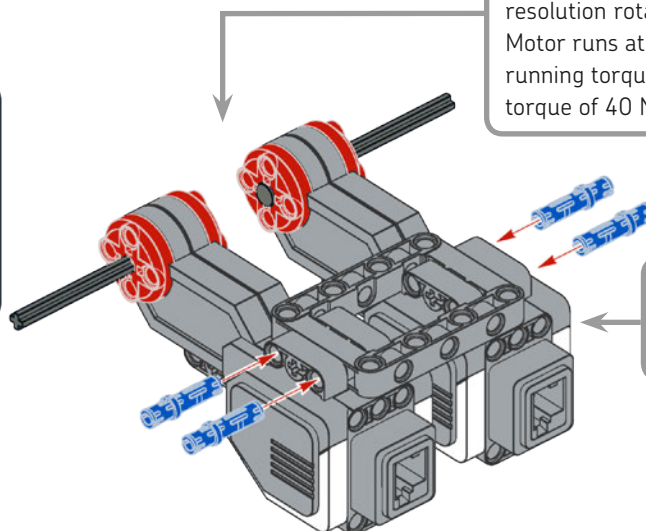
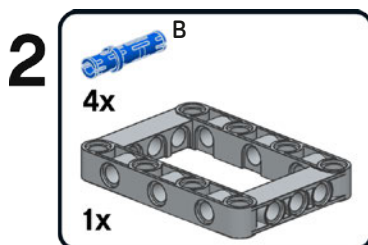
At the top of an axle, you will see a number indicating its length. To determine the length of an axle, first place it next to a long beam and then count the holes in the beam that lie alongside the axle. You can also use these real-scale pictures to measure axles.



The parts list box shows the elements you'll need for that particular step.

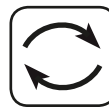
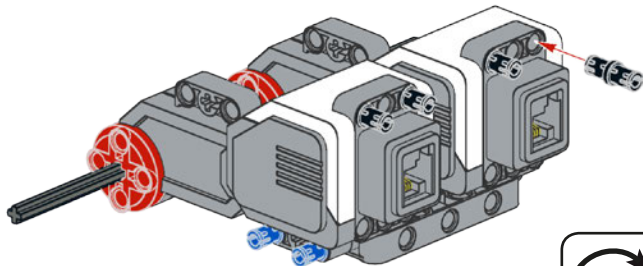
The exploded-view arrows show how the parts should be assembled.

The EV3 Large Servo Motor is internally geared down, with a built-in one-degree-resolution rotation sensor. The Large Motor runs at 160 to 170 rpm, with a running torque of 20 N·cm and a stall torque of 40 N·cm.



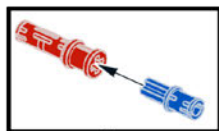
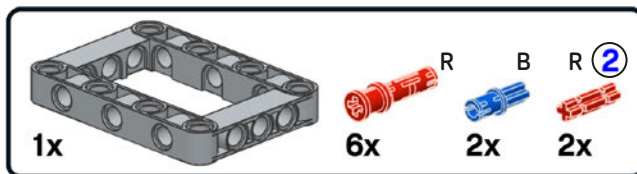
The O-frame holds the motors together. This technique is called *bracing*.

3

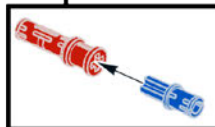
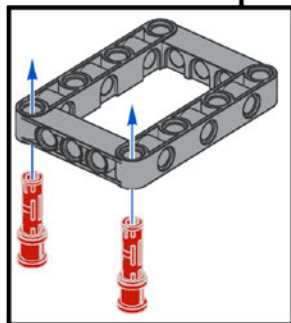
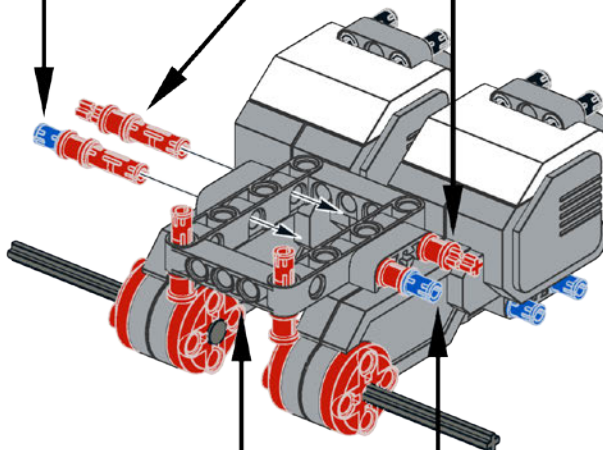


When you see this symbol, rotate the model to look like the picture.

4



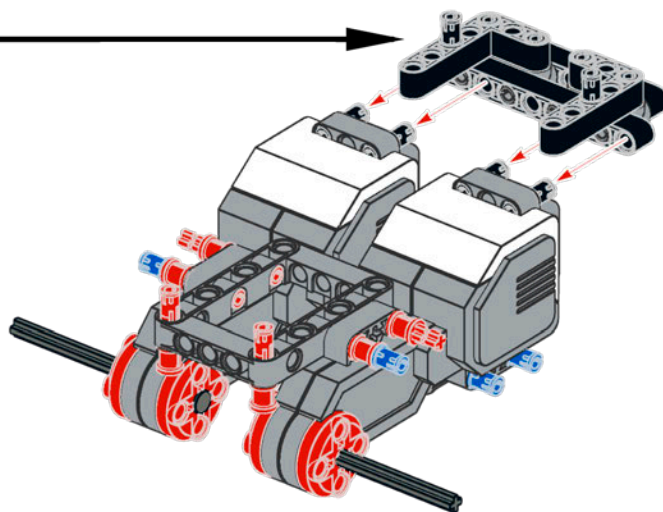
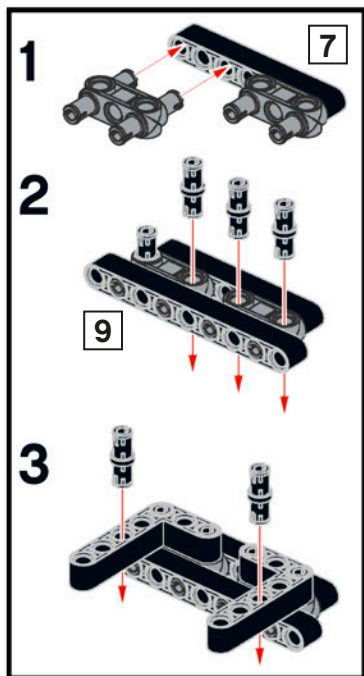
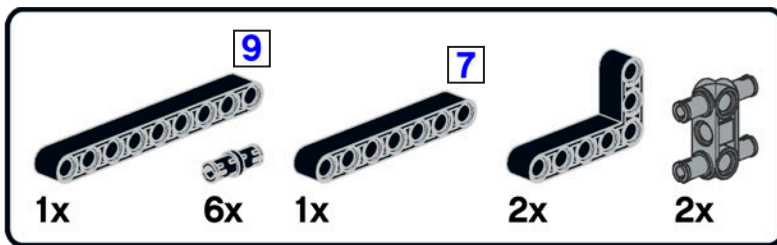
Always build the subassemblies shown in the callouts first. Then add them to the main model.



Inserting an axle pin into the cross hole of a 3M pin with stop bush gives you a sort of four-module-long pin.

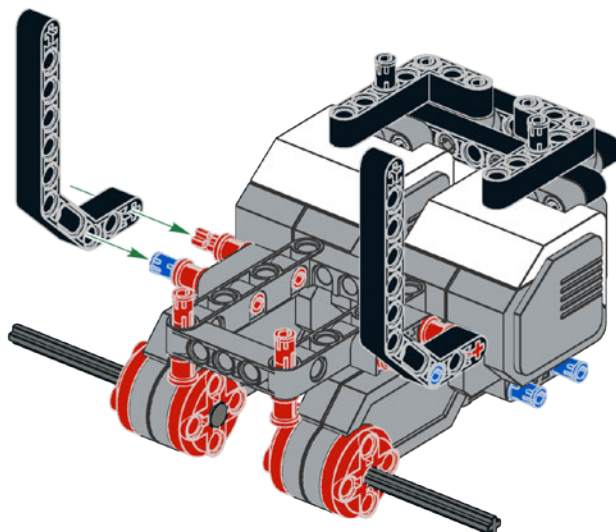


5



The 9M beam braces the motors so that you can no longer pull them apart. This is another example of bracing.

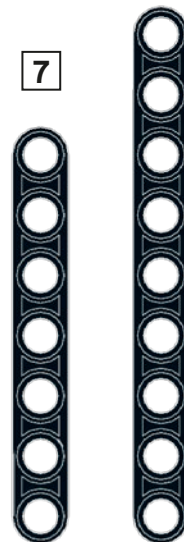
6



1:1

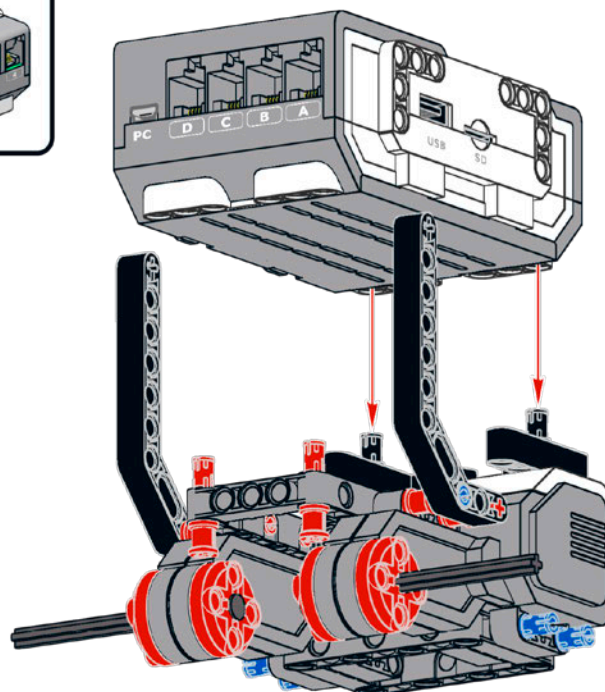
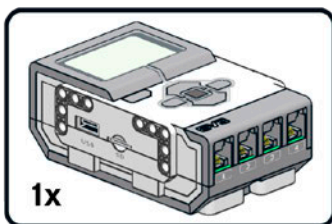
9

7

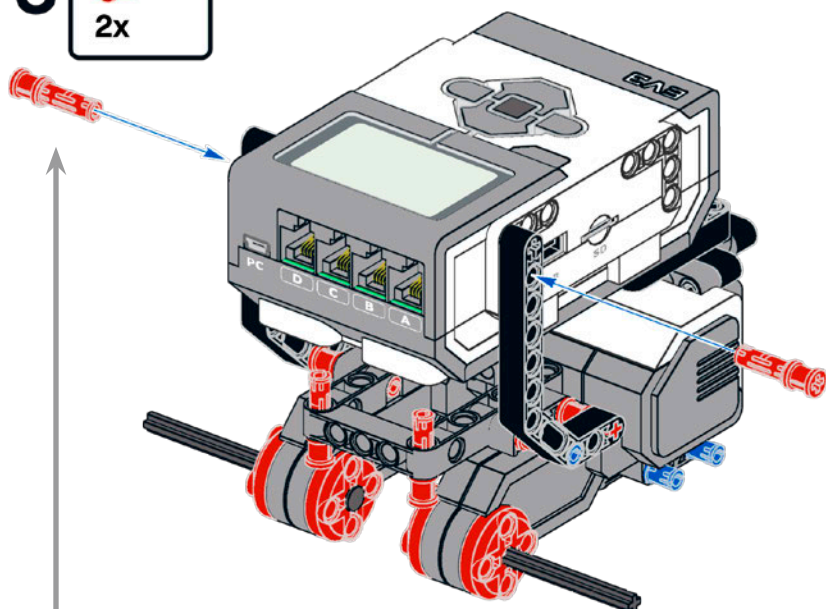


The double angular beam's ends form a right angle, since each bend is 45 degrees.

7



8



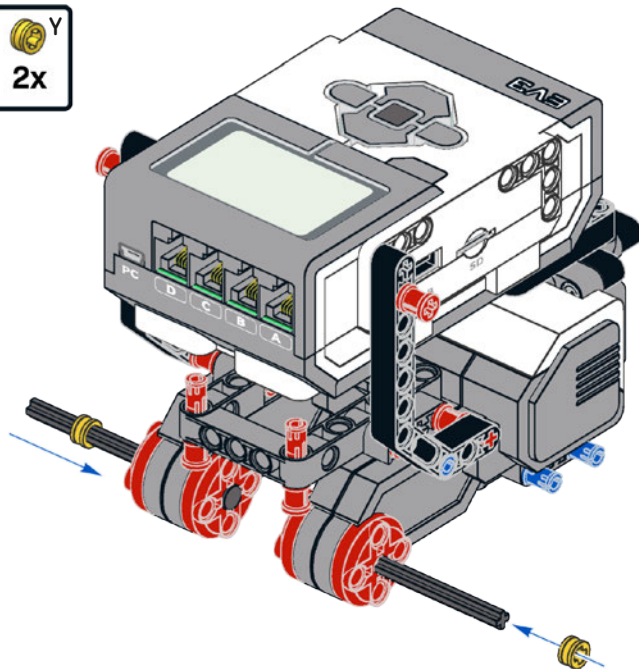
Lock the EV3 Brick with the 3M pins with stop bush. Thanks to the bush, these pins can be easily grabbed and pulled out with little force.



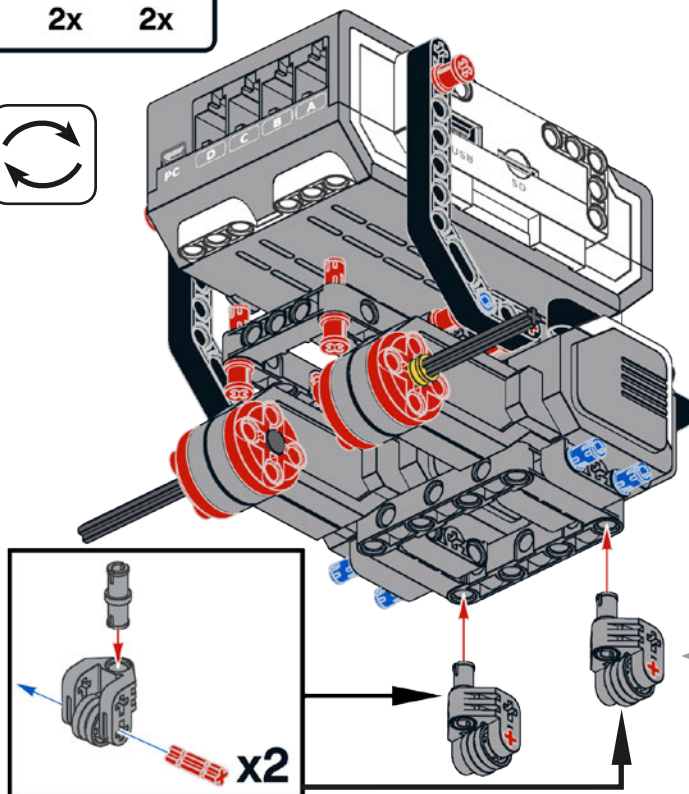
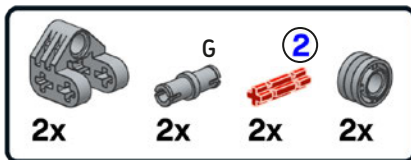
The Base Module is complete.

ROV3R with wheels

1  Y
2x

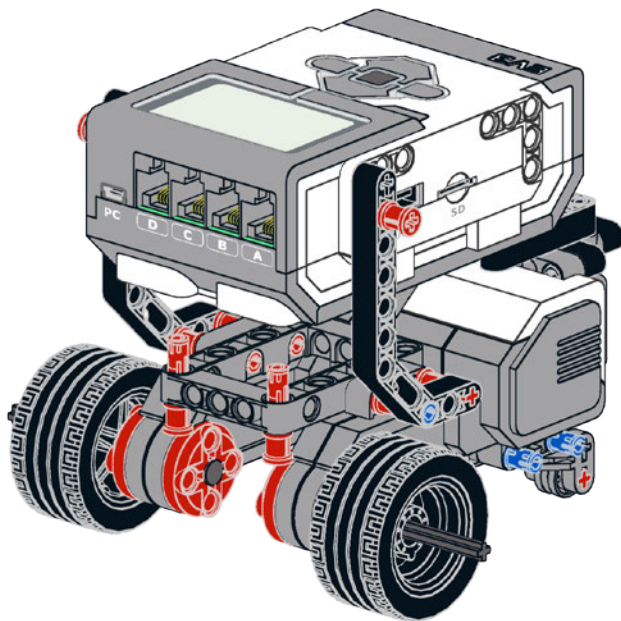
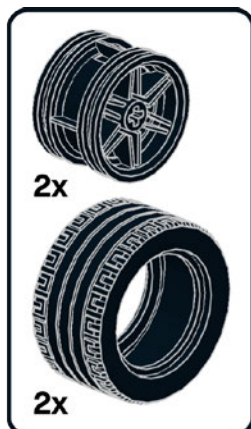


2

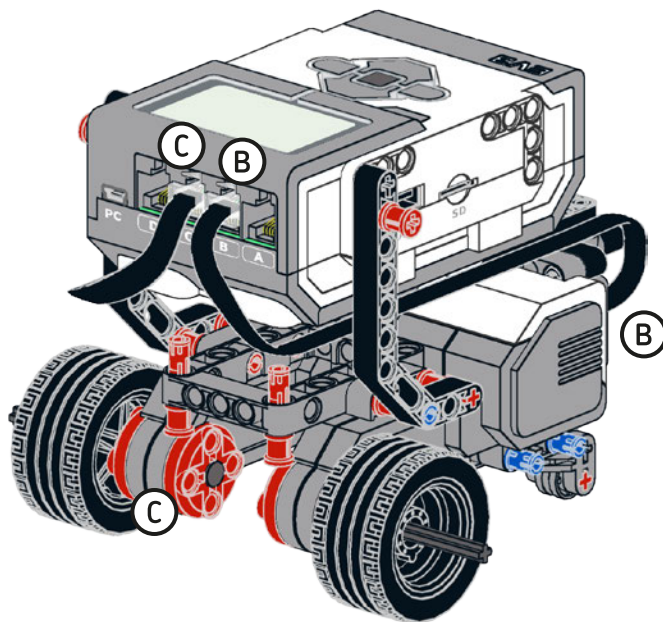
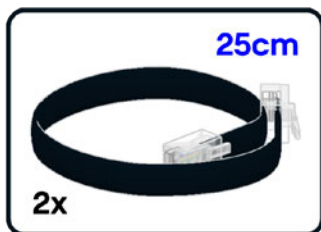


These small caster wheels support the robot. They are passive, meaning that they don't propel the robot but just follow the robot's motion. Like shopping cart wheels, these wheels sometimes swivel when the robot reverses direction, causing the robot to jiggle.

3



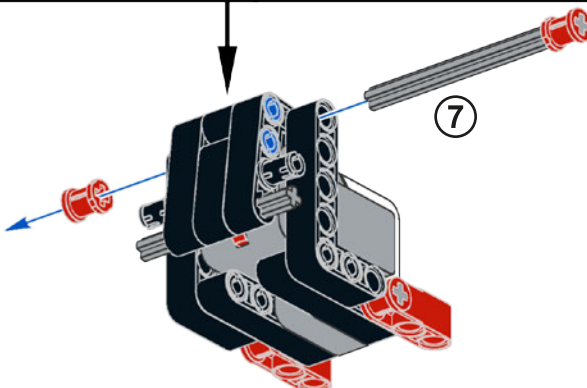
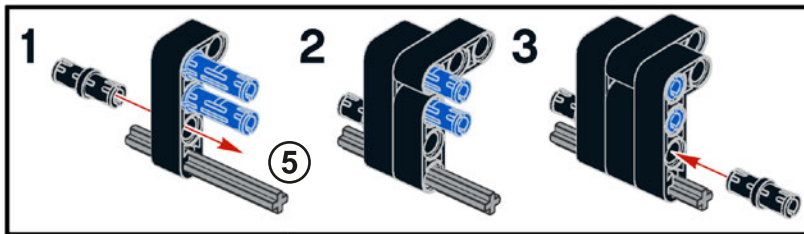
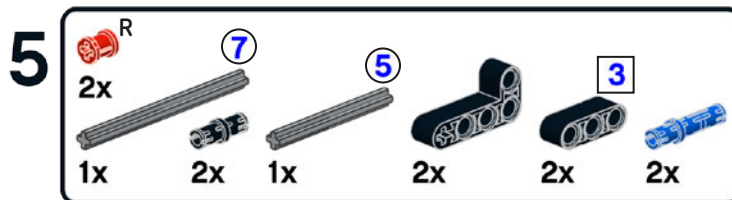
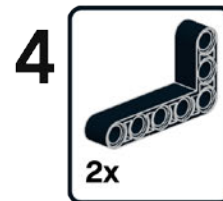
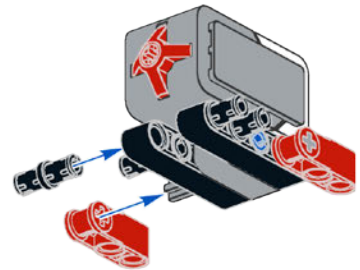
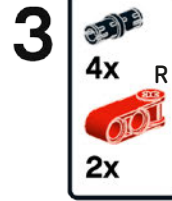
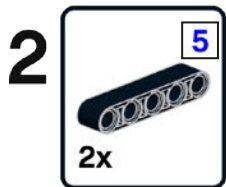
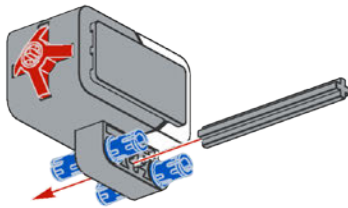
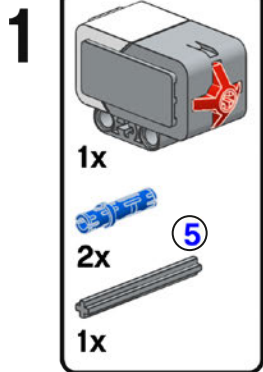
4



The EV3 Brick has four output ports, labeled A, B, C, and D. Use the short cables to connect the right driving motor to port C and the left driving motor to port B.

The ROV3R with Wheels is now complete. You can attach the modules in this chapter to this version of ROV3R *or* to the ROV3R with Treads.

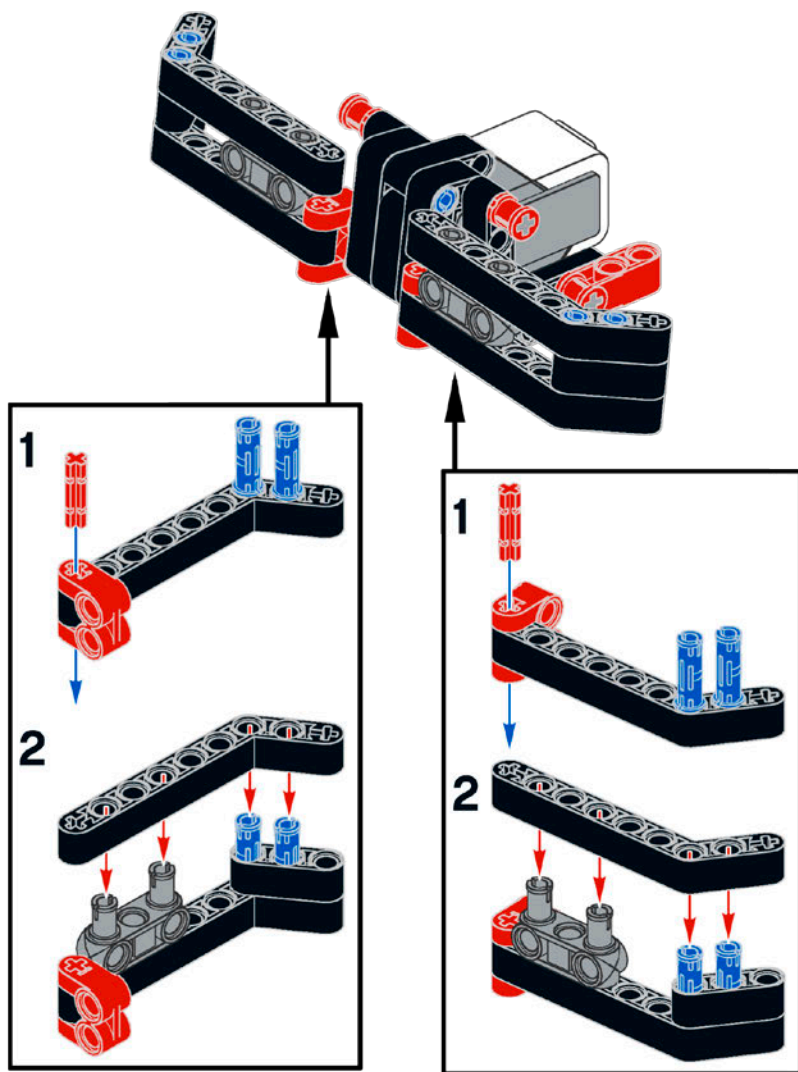
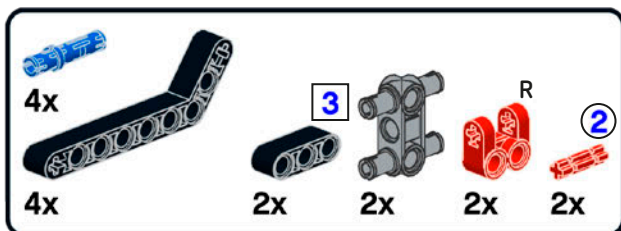
touch sensor bumper



The Touch Sensor is simply a switch that is normally open. It returns a value of 1 if pressed and 0 if released.



6

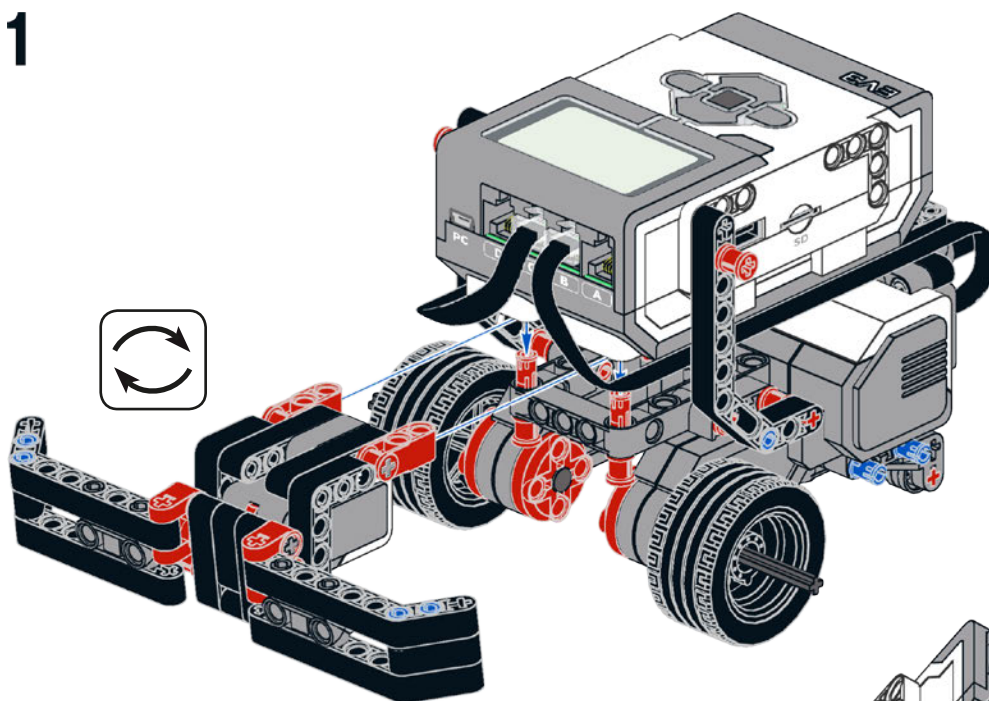


3 1:1

The Touch Sensor Bumper is now complete.

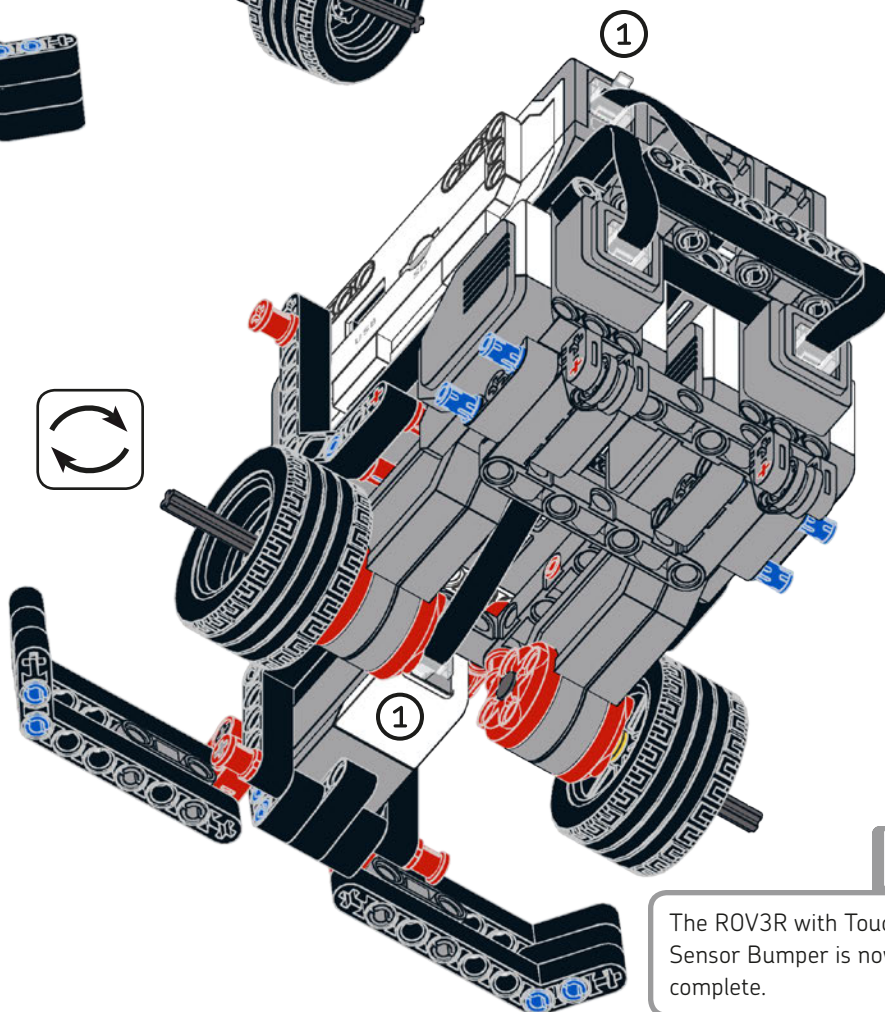
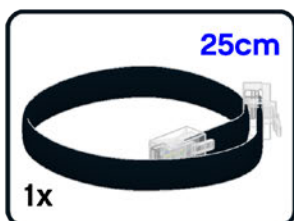
ROV3R with touch sensor bumper

1



You can add the Touch Sensor Bumper to the ROV3R with Wheels or the ROV3R with Treads. The ROV3R with Wheels is shown.

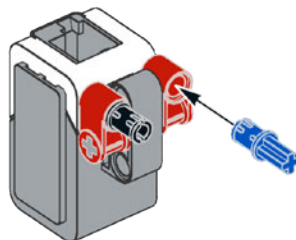
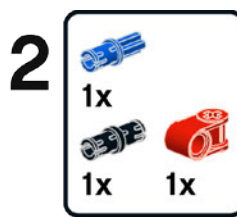
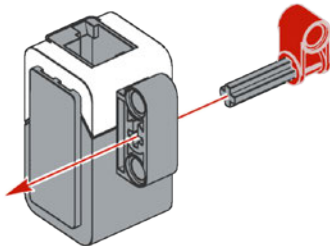
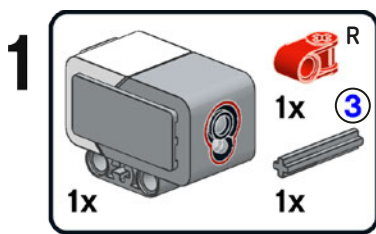
2



The Brick Program App allows you to program your robots without a computer by using the EV3 Brick menu. When using the Brick Program App, you must connect motors and sensors to the default ports. The Touch Sensor default port for the Brick Program App is 1. The EV3 system's Auto-ID feature allows the EV3 Brick to recognize the type of sensor attached to an input port. If you connect a motor to a sensor port, or vice versa, you'll see a warning.

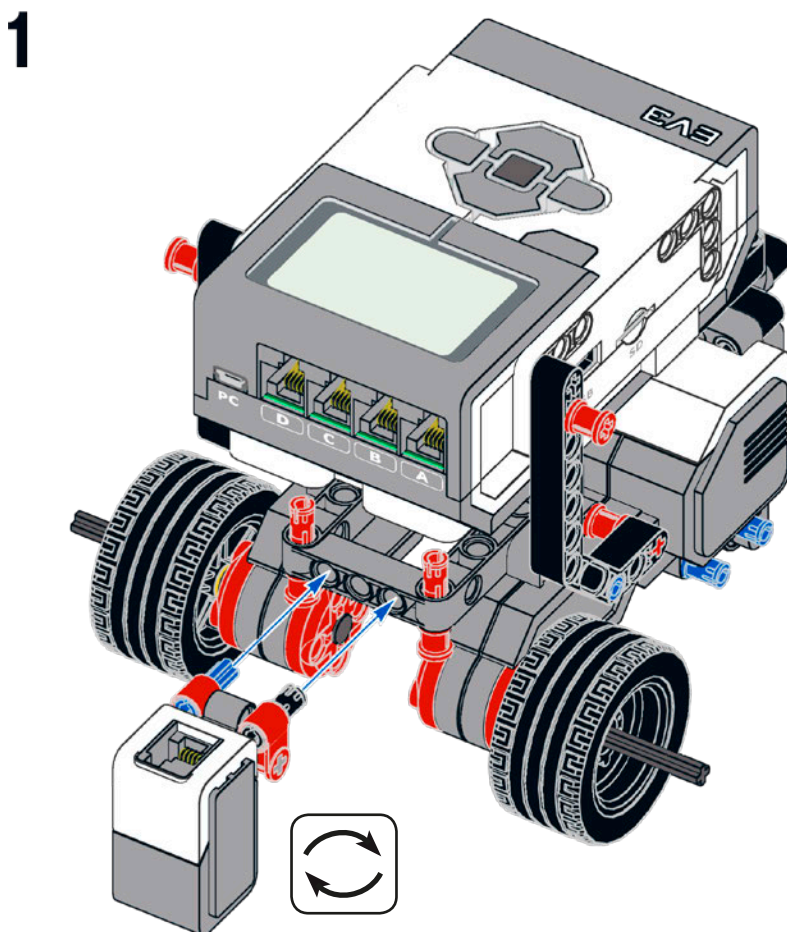
The ROV3R with Touch Sensor Bumper is now complete.

line-following module



Using an axle pin instead of another black pin makes it easier to attach or detach this module from ROV3R.

line-following ROV3R



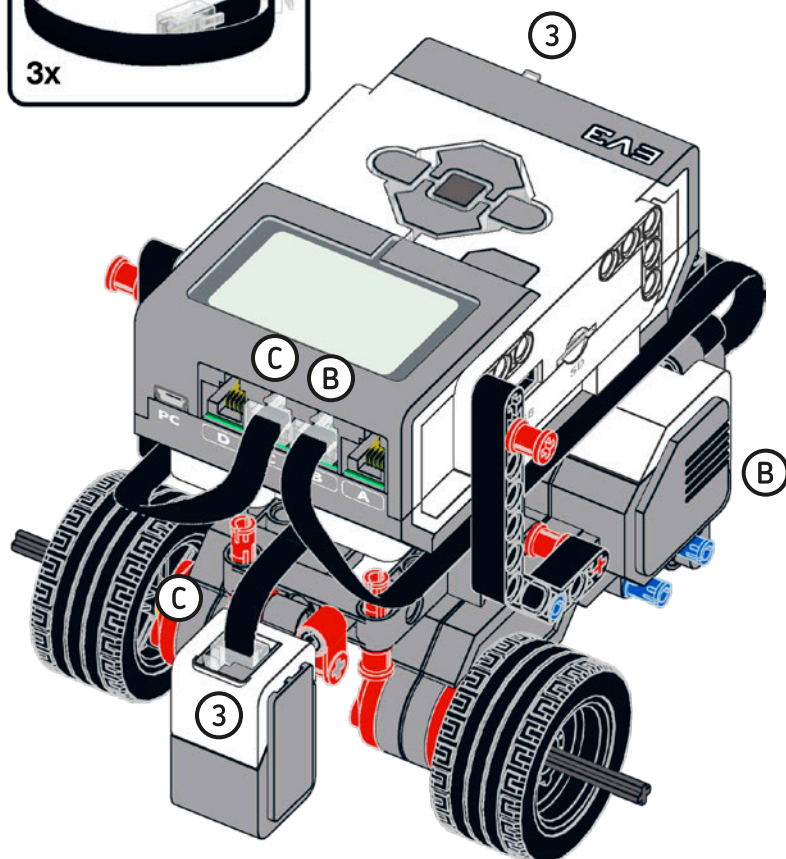
You can add the Line-Following Module to the ROV3R with Wheels or the ROV3R with Treads. The ROV3R with Wheels is shown.

The Color Sensor has a built-in RGB LED that can emit red, green, or blue light. The sensor detects different colors by flashing all three colors in a very fast loop and measuring the light returned by the surface being scanned. When the sensor is measuring the amount of reflected light, the LED glows red. You'll learn more about how ROV3R uses the Color Sensor to follow a line in Chapter 4.

2



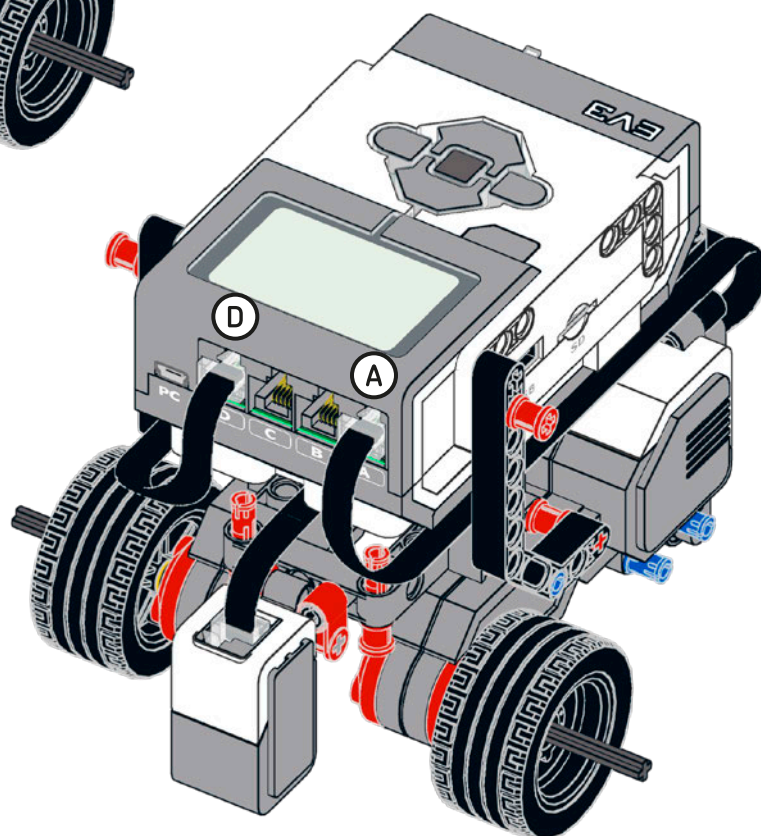
3x



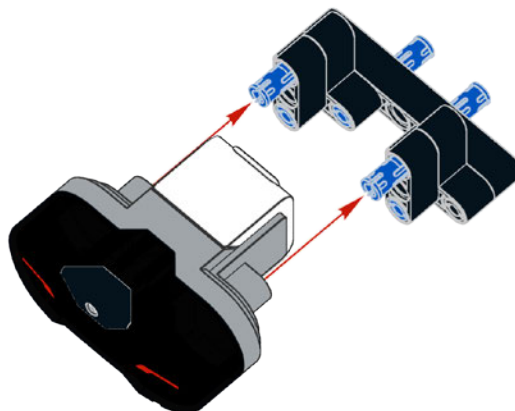
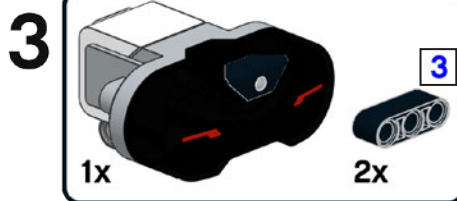
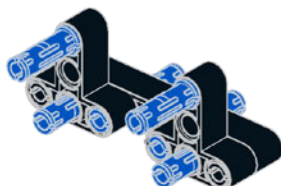
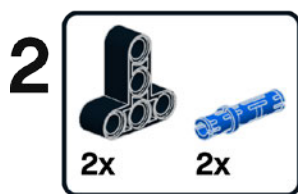
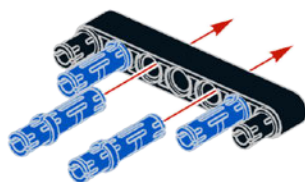
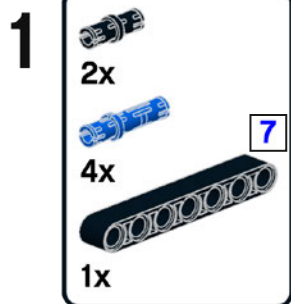
The Color Sensor default port for the Brick Program App is 3.

The Line-Following ROV3R is now complete.

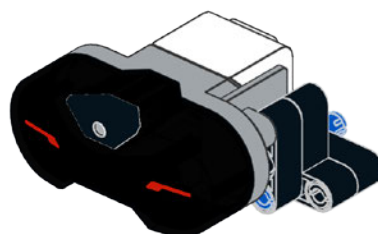
When using the Brick Program App, you must connect motors and sensors to their default ports. The app sends a fixed amount of power to the motors on ports B and C, while it allows you to control the level of power for the motors attached to ports A and D independently. This will come in handy when you try to fine-tune the Line-Following ROV3R's movements in Chapter 4.



front IR sensor



4



The Front IR Sensor is now complete.

The digital Infrared (IR) Sensor detects infrared light reflected from solid objects and receives commands from the Remote IR Beacon. The IR Sensor can be used in three modes: Proximity mode, Beacon mode, and Remote mode.

In *Proximity mode*, the IR Sensor emits bursts of infrared light and uses the amount of light reflected from an object to estimate that object's distance from the sensor. It reports the distance using percentage values between 0 (very close) and 100 (far away), but it does not give a specific number of centimeters or inches. In *Beacon mode*, the sensor can estimate the heading (values from -25 to 25) and proximity to the beacon (0-100 percent). In *Remote mode*, it receives the numeric commands sent by the Remote IR Beacon.

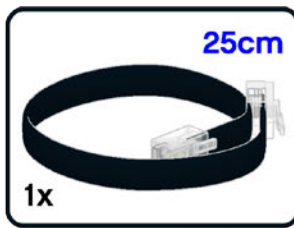


1:1

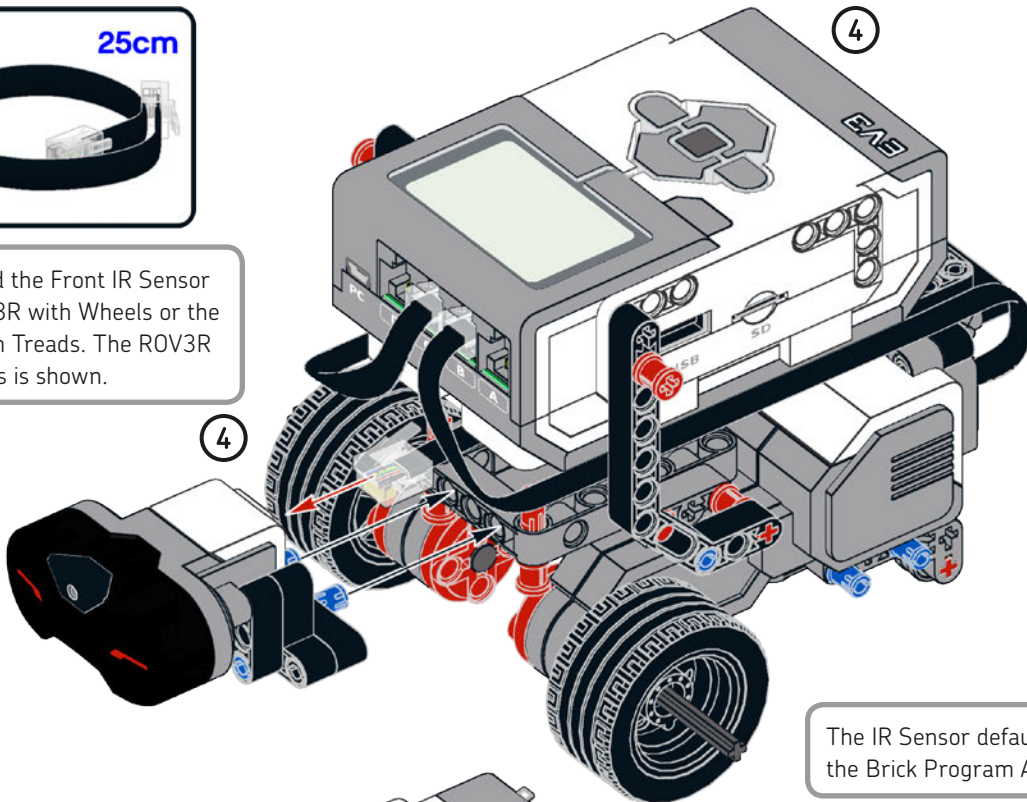


ROV3R with front IR sensor

1

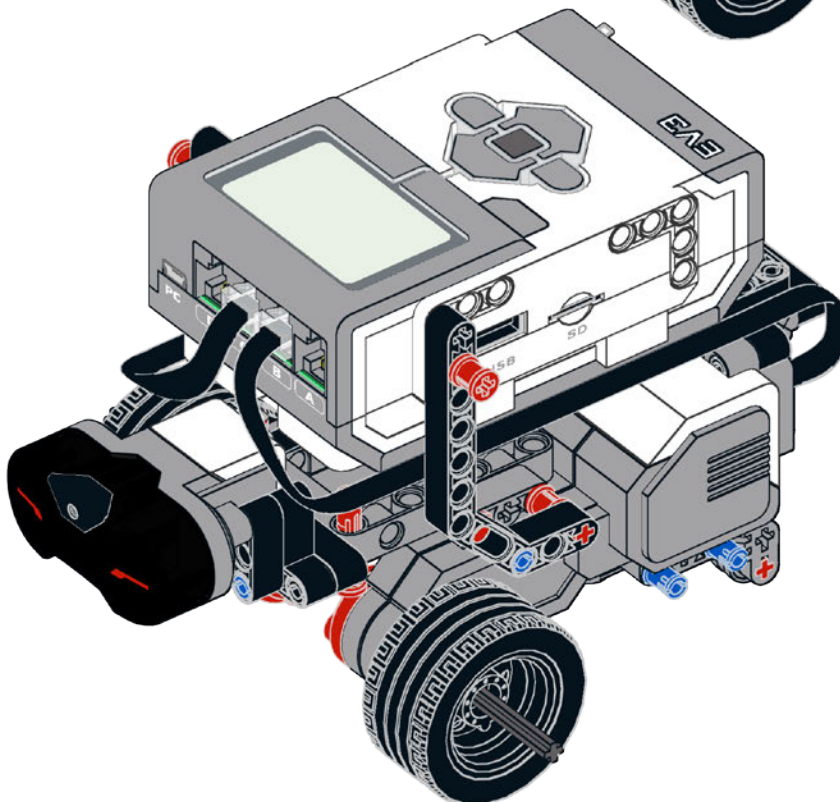


You can add the Front IR Sensor to the ROV3R with Wheels or the ROV3R with Treads. The ROV3R with Wheels is shown.



The IR Sensor default port for the Brick Program App is 4.

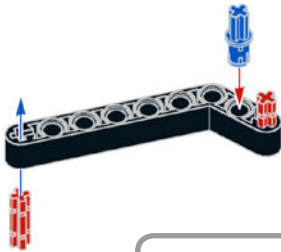
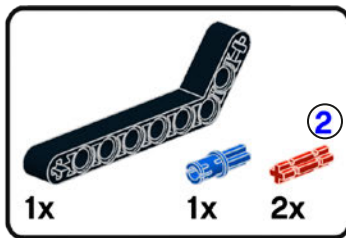
2



The ROV3R with Front IR Sensor is now complete.

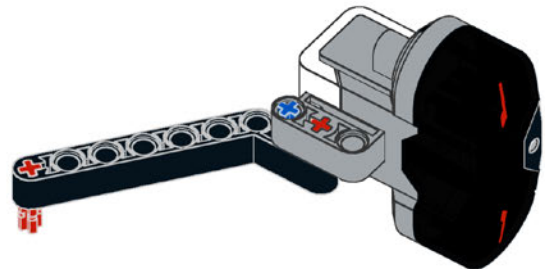
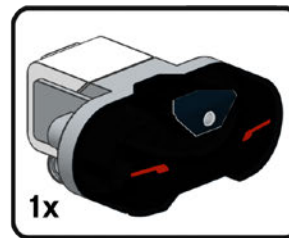
wall-following module

1



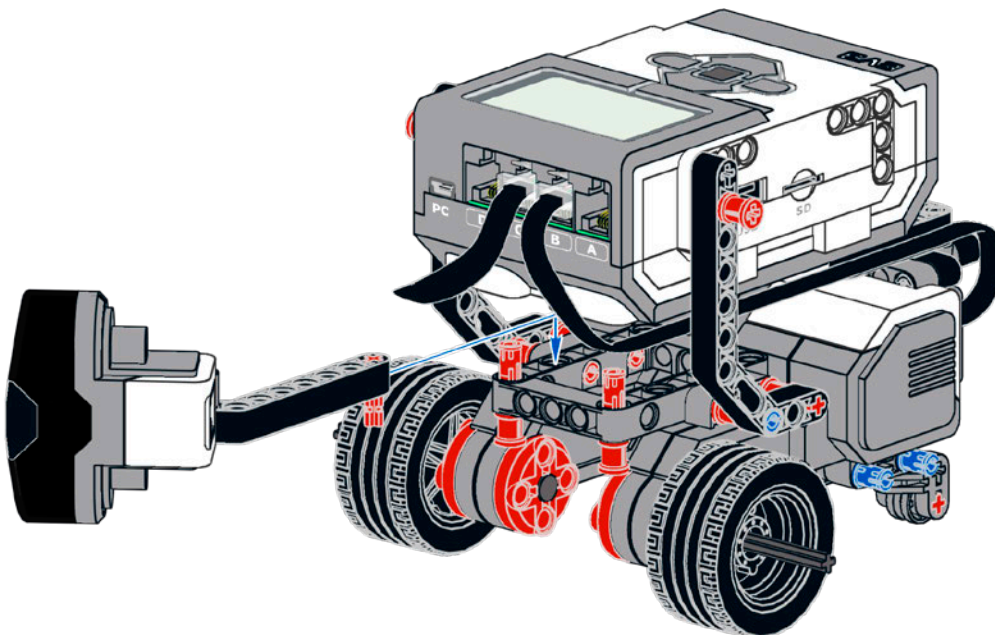
Here I've used an axle pin and 2M axles to make it easy to disassemble the IR Sensor and this module from ROV3R. For a sturdier assembly, you should use pins that snap into holes, like pins with friction or axle pins.

2



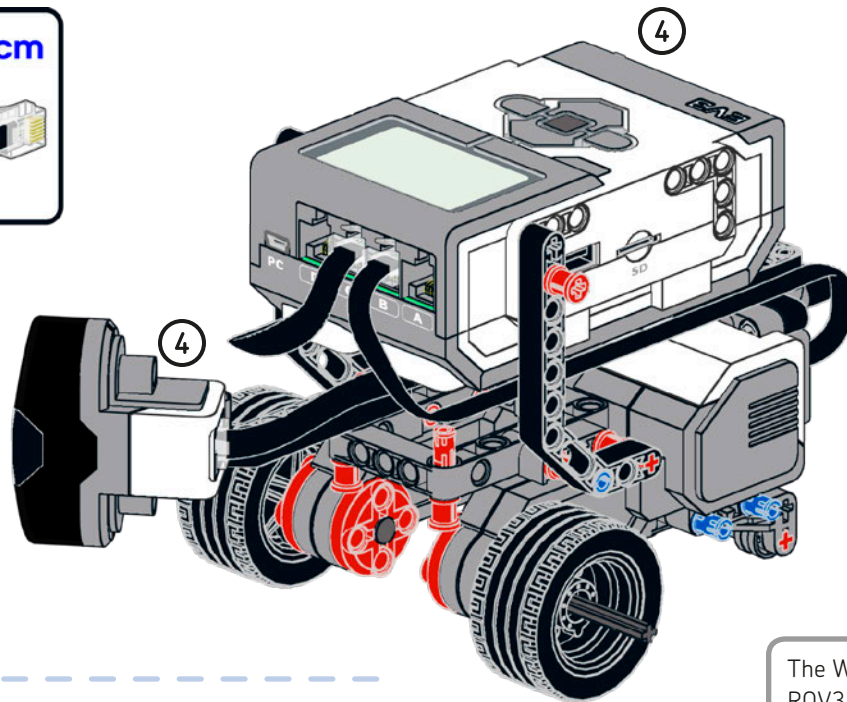
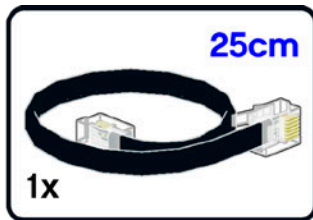
wall-following ROV3R

1



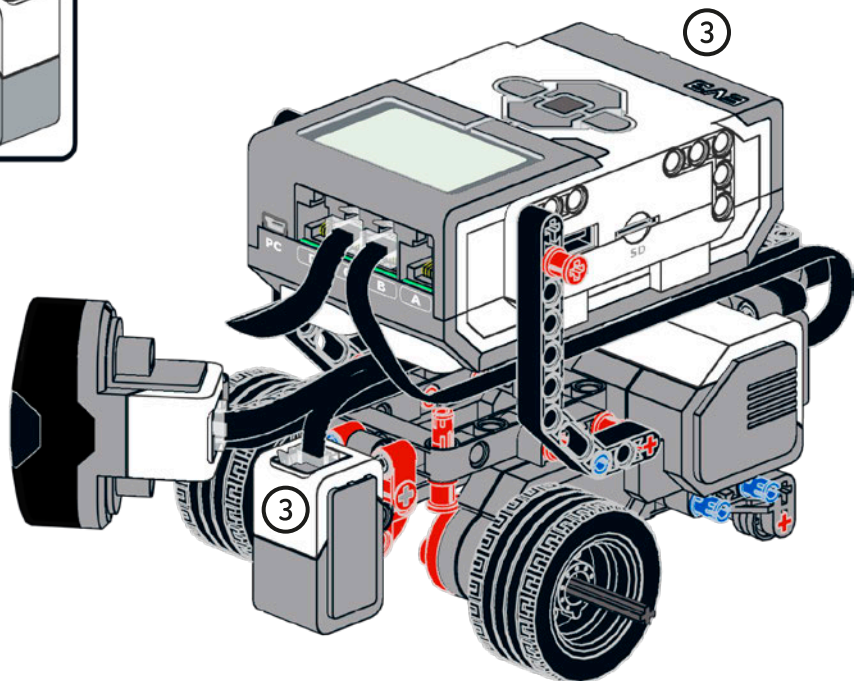
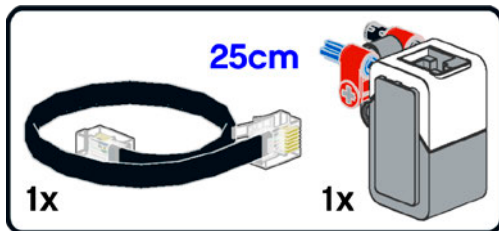
You can add the Wall-Following Module to the ROV3R with Wheels or the ROV3R with Treads. The ROV3R with Wheels is shown.

2



**alternative: ROV3R with
wall-following and line-following
modules**

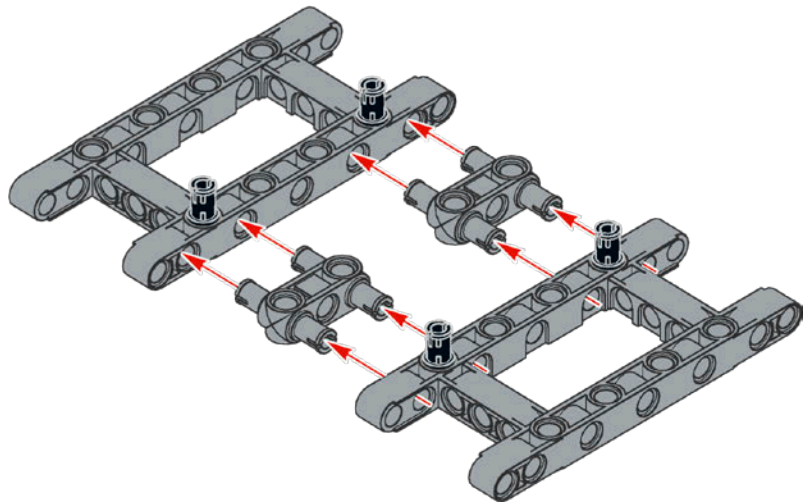
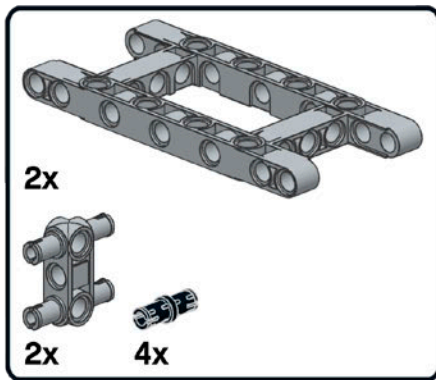
The Wall-Following
ROV3R is now
complete.



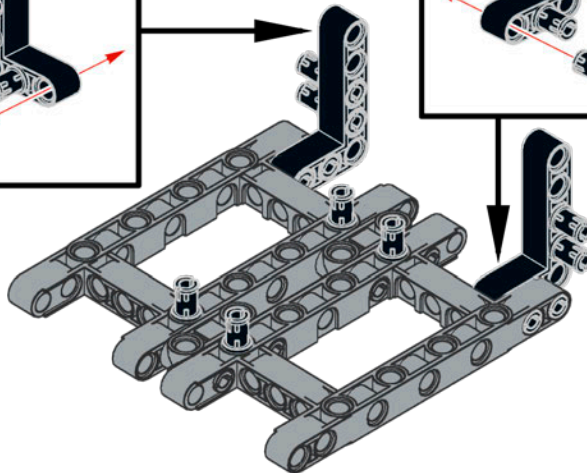
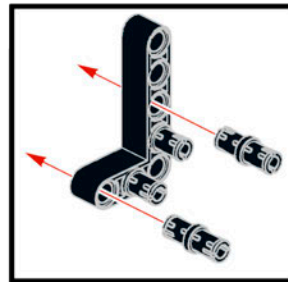
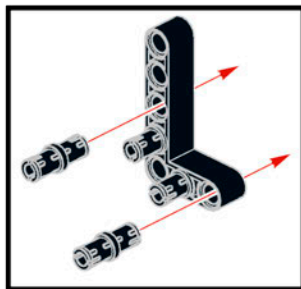
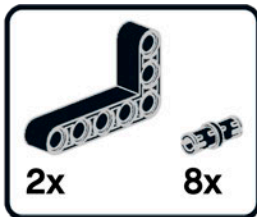
You can attach both the Line-Following Module and the Wall-Following Module to allow ROV3R to detect differently colored spots on the ground while following a wall. You might use this technique to allow a robot to determine its position in a room: Home base could be marked by a green spot, the robot's destination by a red spot, and so on.

Dexter's cleaning tool

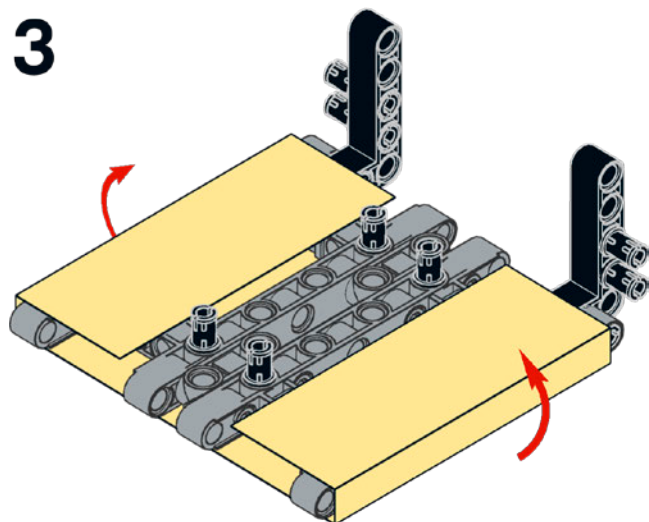
1



2

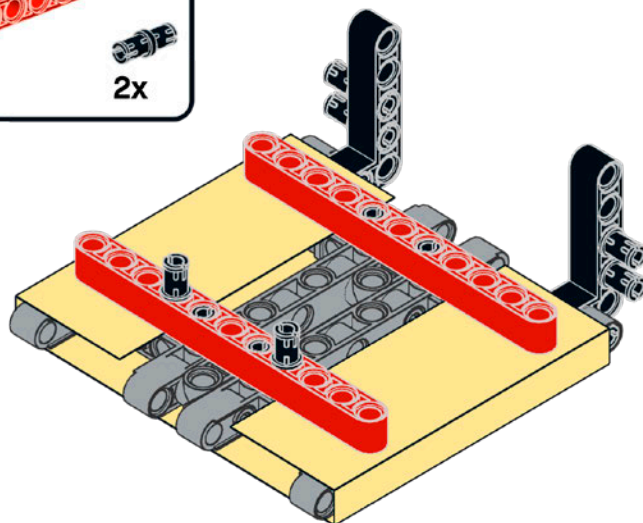
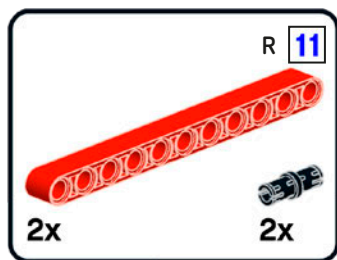


3



Wrap an electrostatic cleaning cloth around the frames. This allows you to pick up dirt and dust without using moving parts. Such cloths are typically treated with chemicals that give them a negative charge, which readily attracts dust particles as the robot moves around the room.

4



Lock the cloth into place using two 11M beams.



Dexter's Cleaning Tool is now complete.

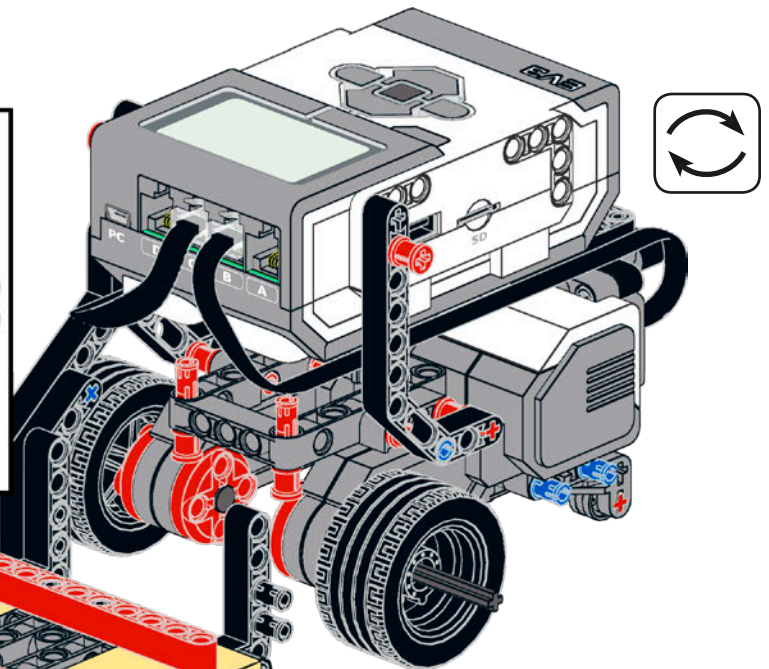
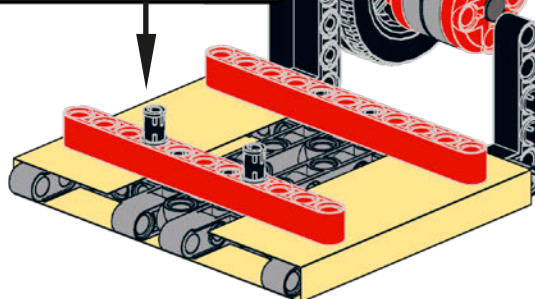
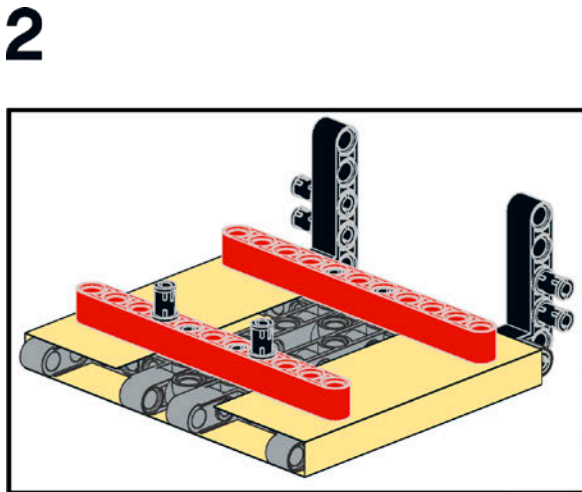
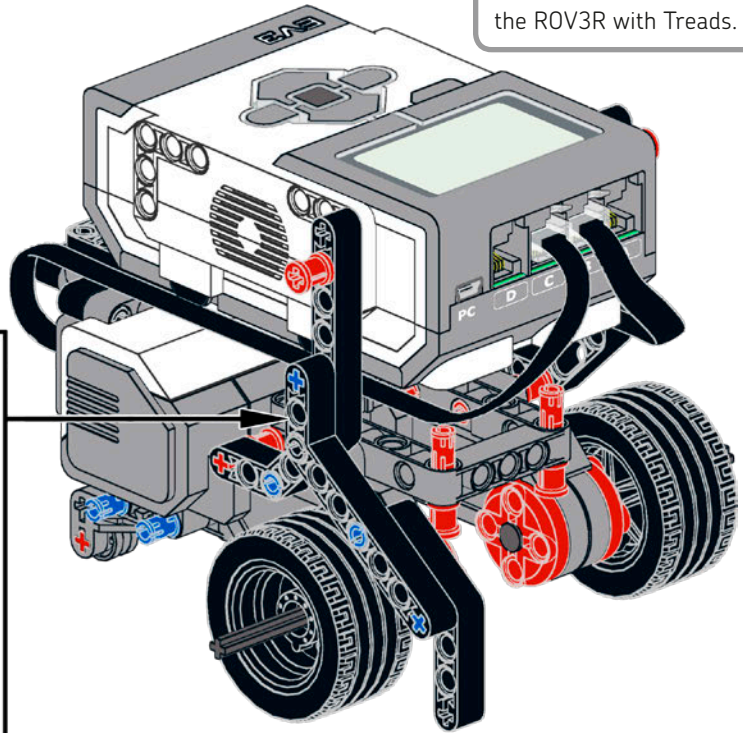
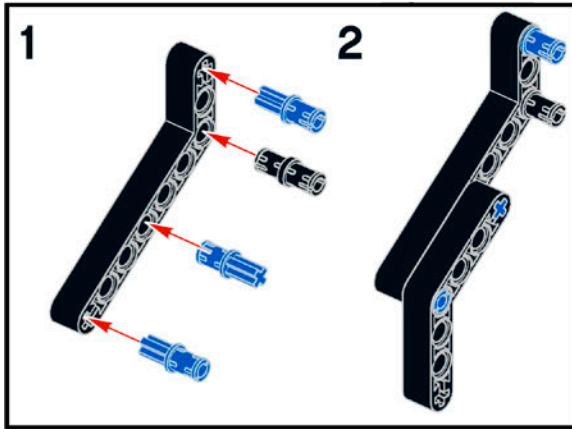
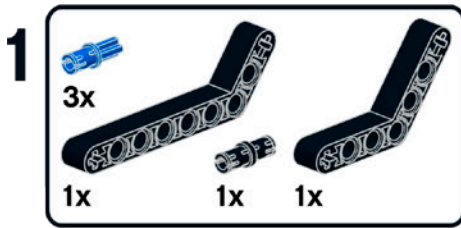
11



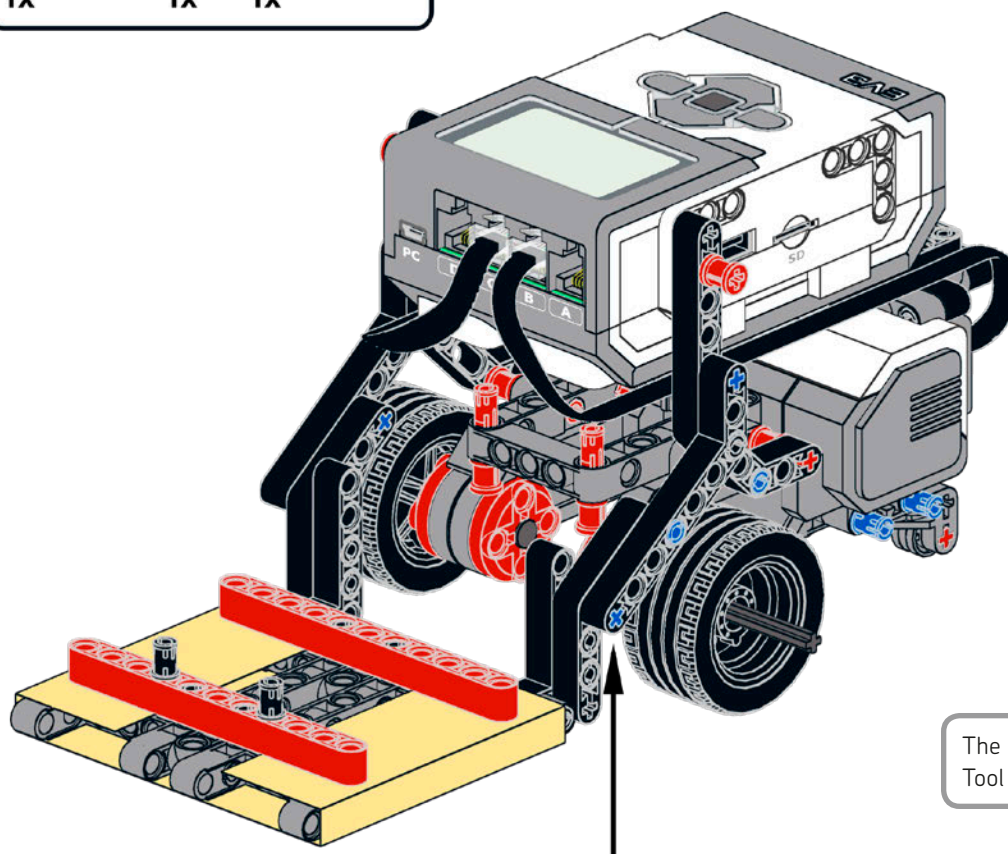
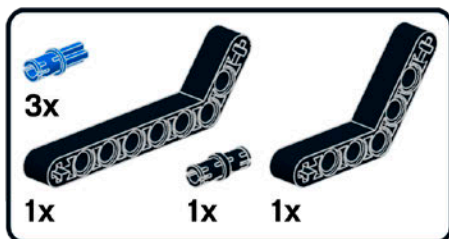
1:1

ROV3R with cleaning tool

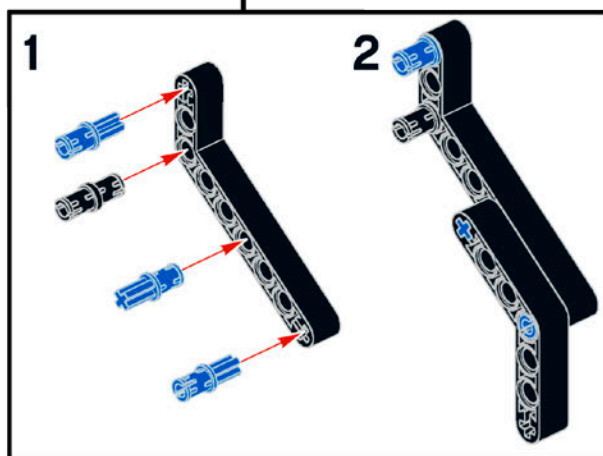
You can add Dexter's Cleaning Tool to the ROV3R with Wheels or the ROV3R with Treads.



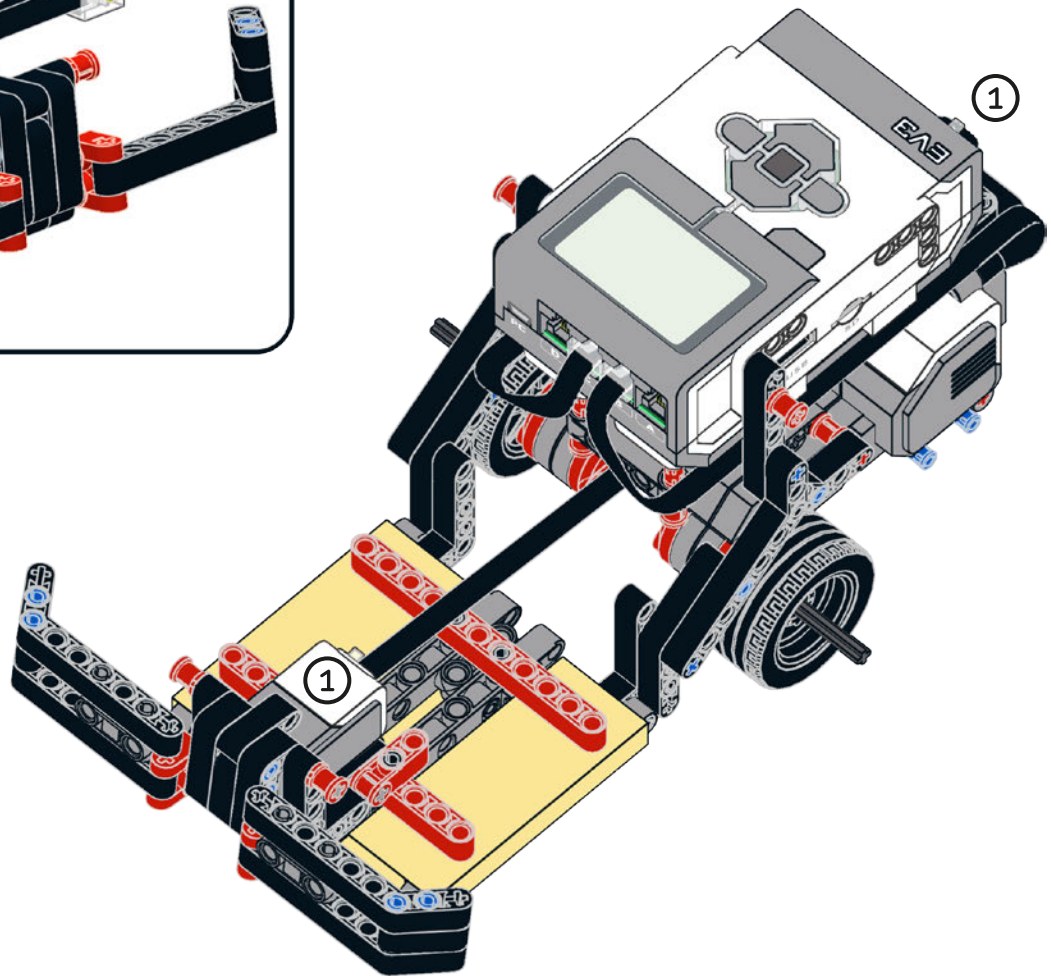
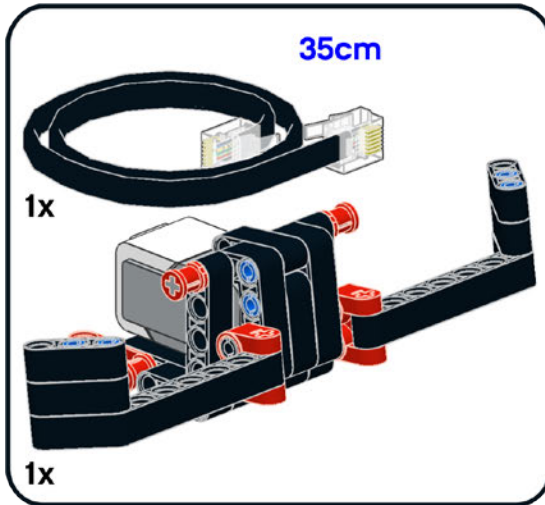
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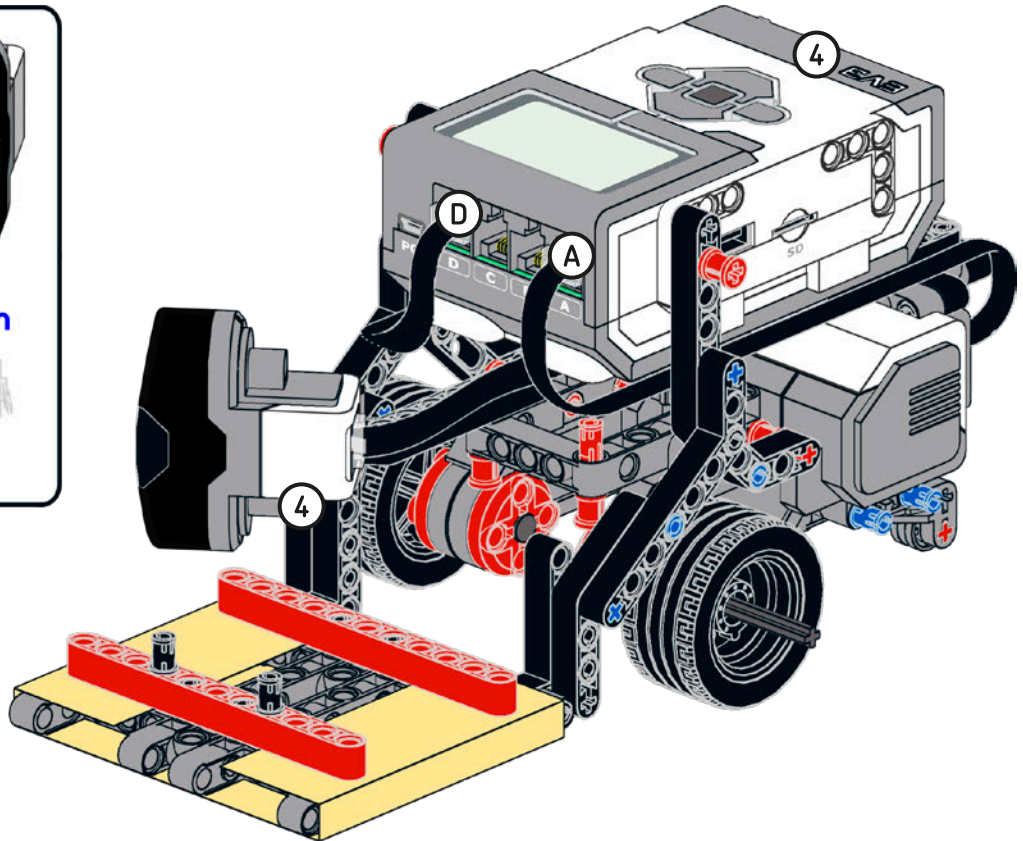
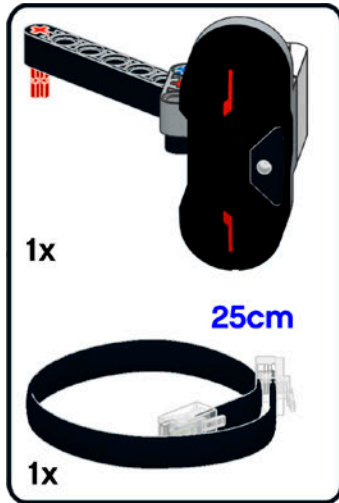
The ROV3R with Cleaning Tool is now complete.



alternative #1: ROV3R with cleaning tool and touch sensor bumper



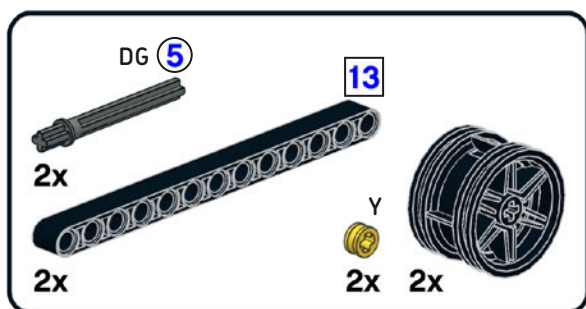
alternative #2: wall-following ROV3R with cleaning tool



When using the Brick Program App, you must connect motors and sensors to their default ports. The app sends a fixed amount of power to the motors on ports B and C, while it allows you to control the level of power for the motors attached to ports A and D independently. This will come in handy when you try to fine-tune the Line-Following ROV3R's movements in Chapter 4.

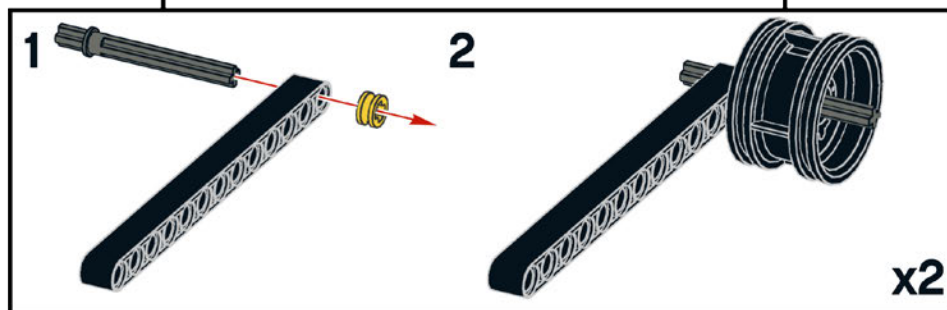
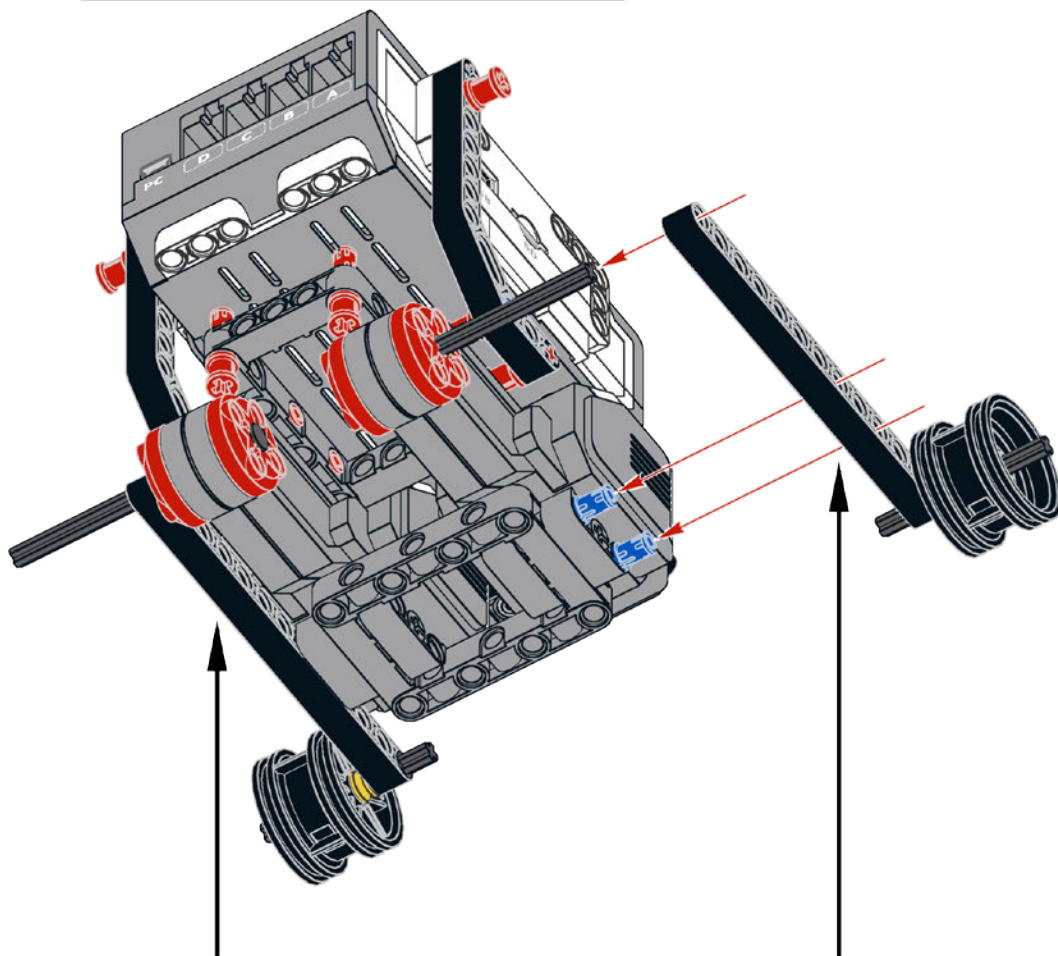
ROV3R with treads

1



To build the ROV3R with Treads, start with the Base Module (step 8 on page 22).

You can attach any of the modules in this chapter either to the ROV3R with Wheels or the ROV3R with Treads.

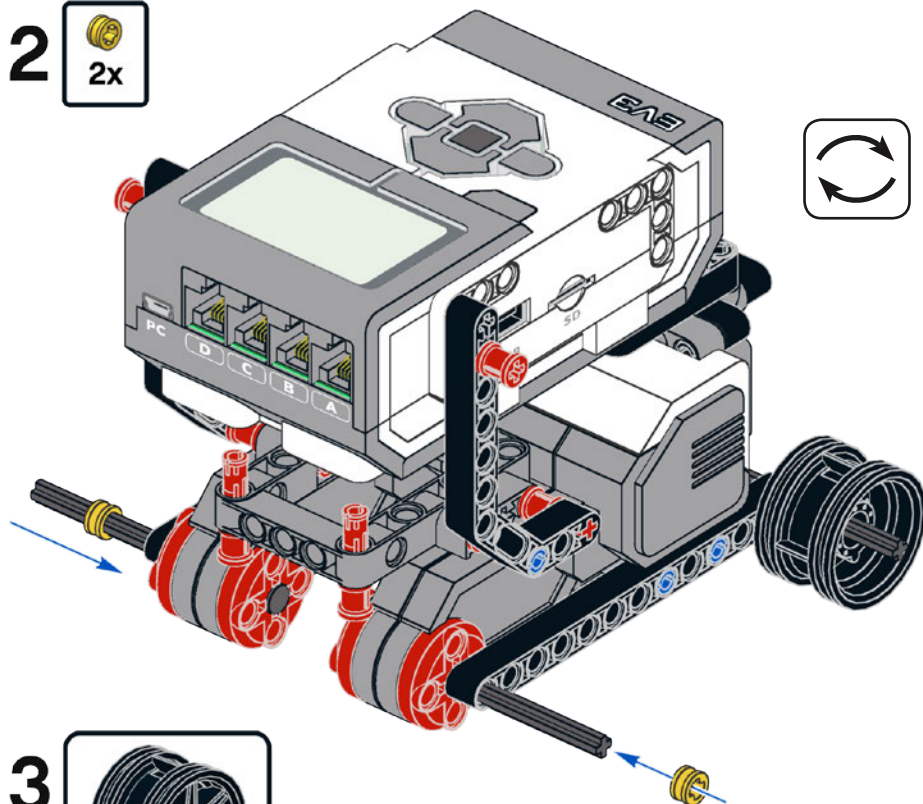


1:1

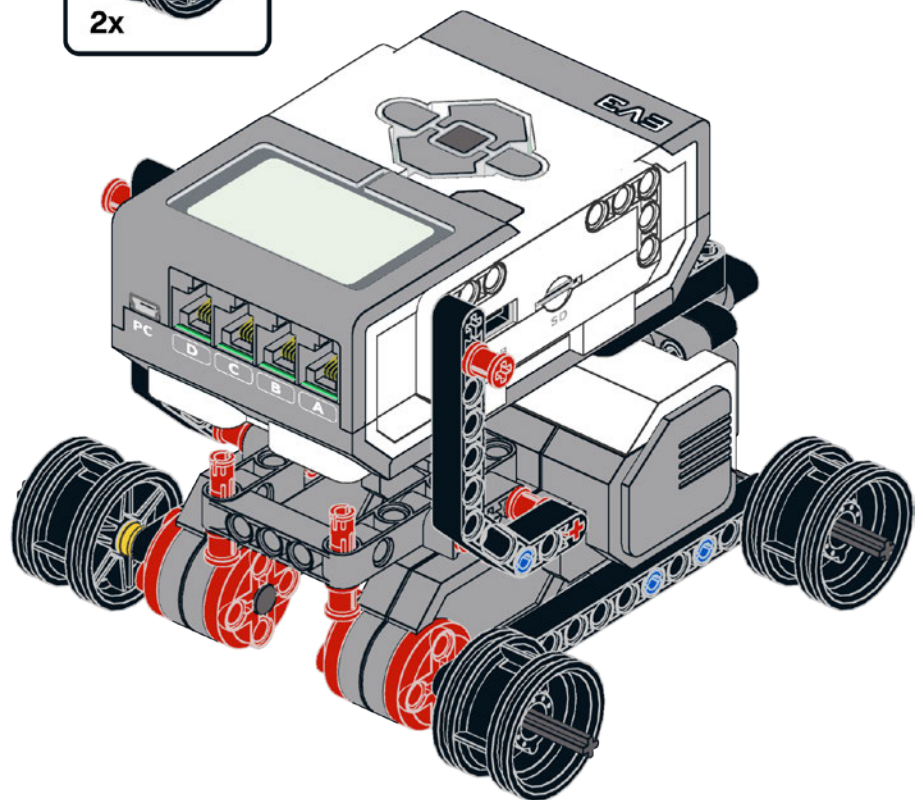


13

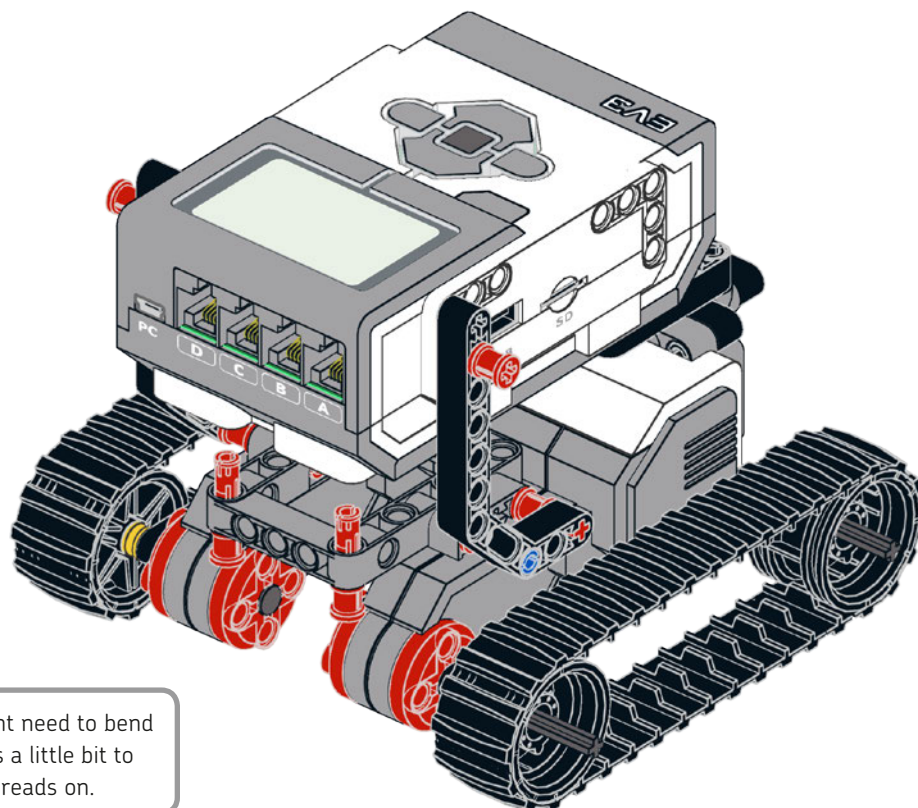
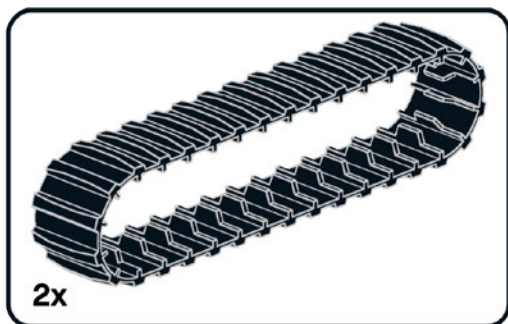
2



3



4



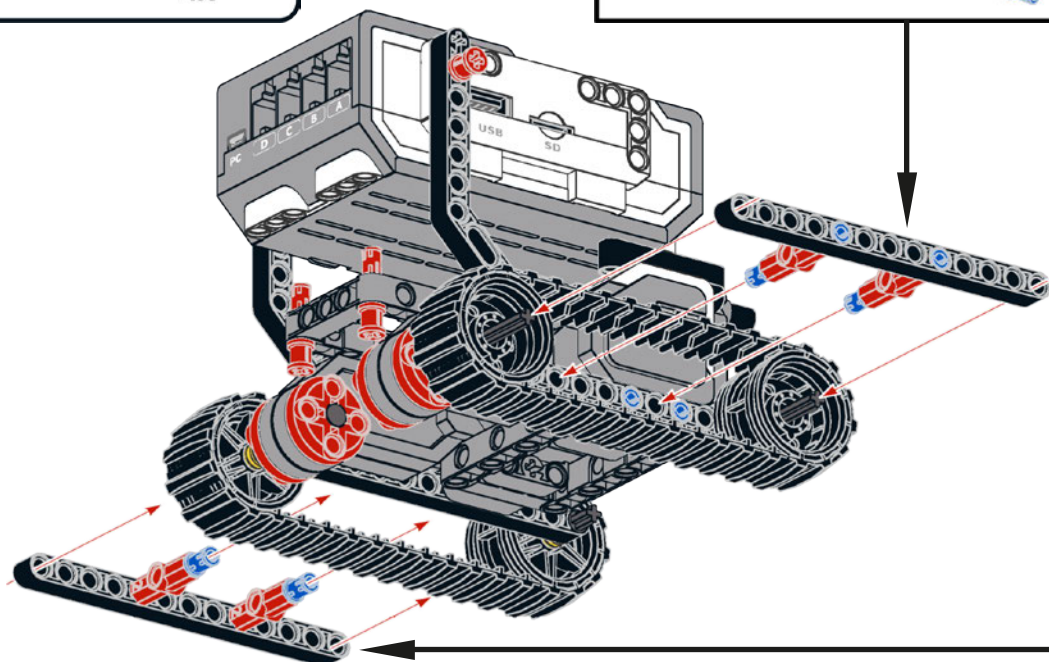
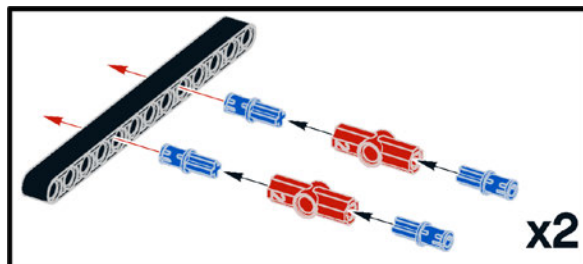
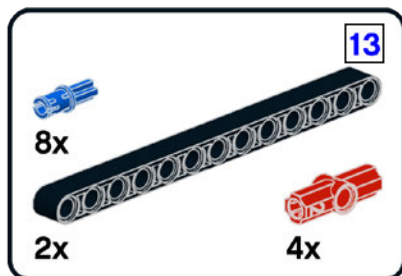
You might need to bend the axles a little bit to put the treads on.

1:1

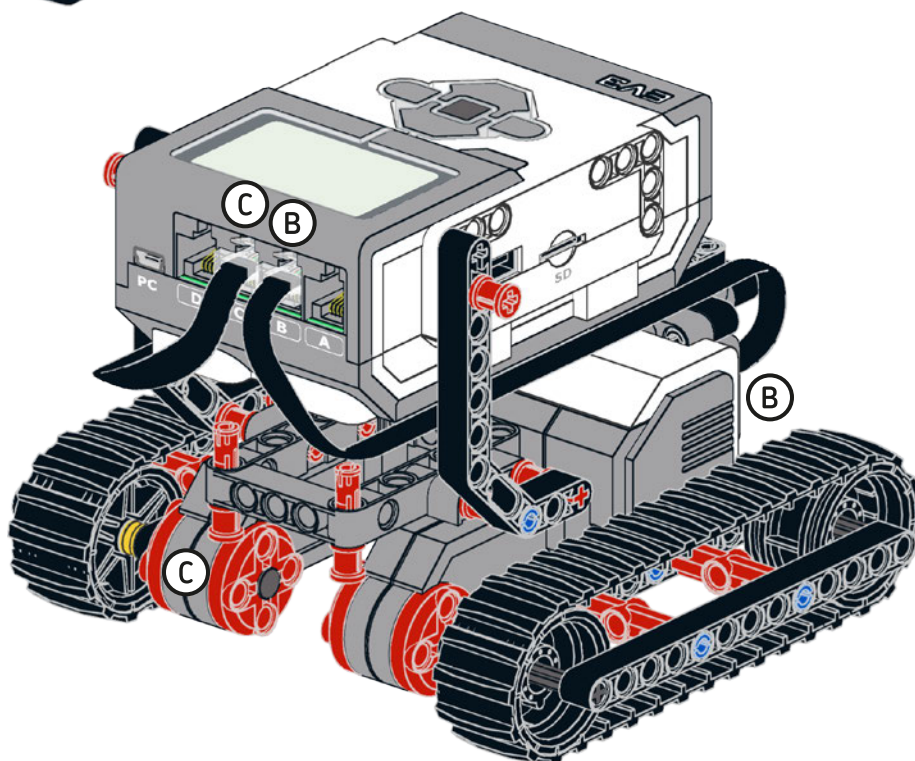
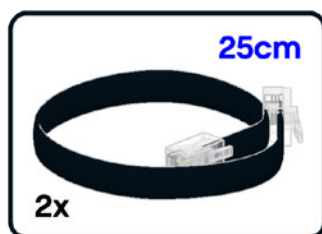


13

5

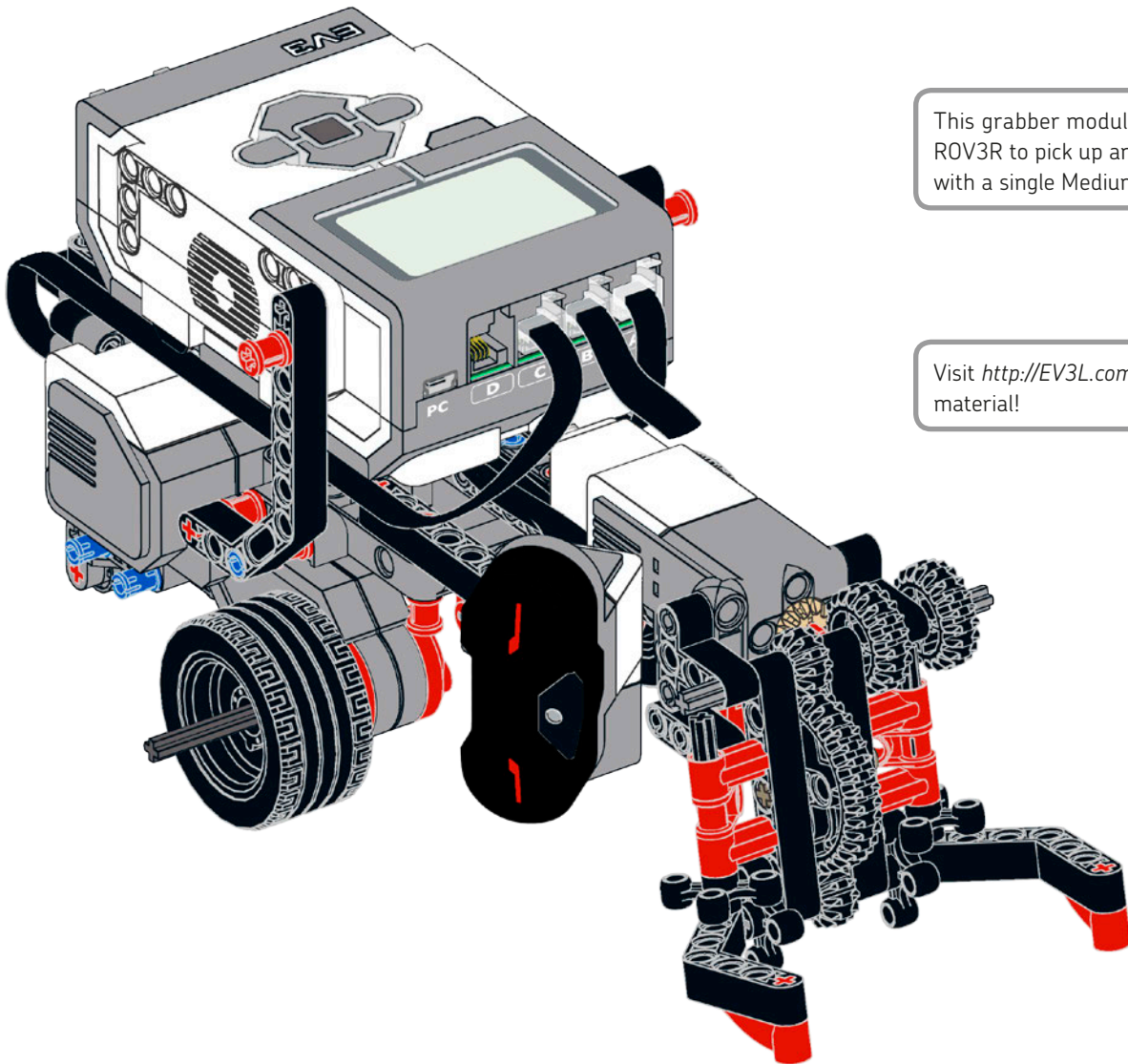


6



The ROV3R with Treads is now complete.

secret project: grabber module



This grabber module allows ROV3R to pick up and lift objects with a single Medium Motor.



Visit <http://EV3L.com/> for bonus material!

conclusion

In this chapter, you built ROV3R and equipped it with a variety of sensors and tools. As you followed the building instructions, you learned some fundamental building techniques, like bracing, and you got an overview of the LEGO MINDSTORMS EV3 system. Next you'll learn how to program ROV3R using the Brick Program App.