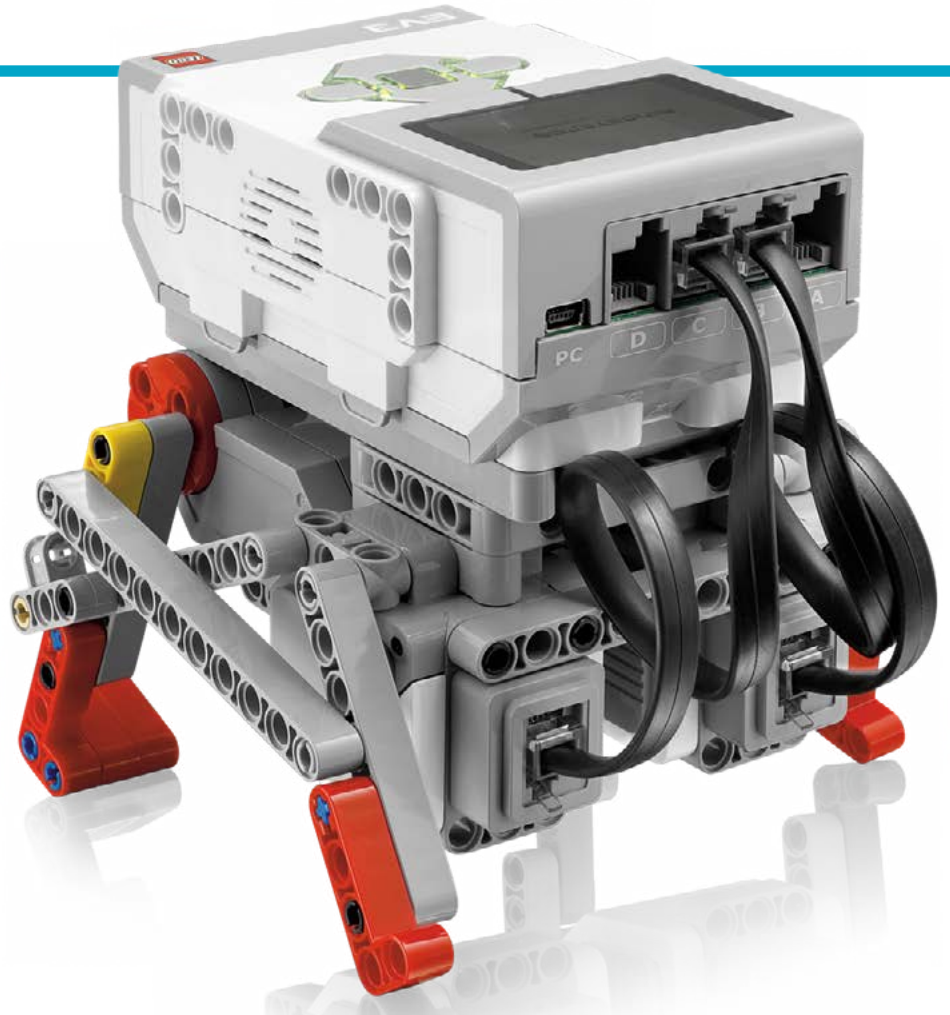
LEGO mindstorms education EV3

Make it Move Without Wheels



Teacher's Guide Design Engineering Projects Curriculum

Make It Move Without Wheels

KEY:
Press the buttons for tips and guidance:

Introduction

Introduction

LEGO® Education is pleased to bring you Design Engineering Projects, innovative materials that allow students to design, build, and program robots to solve specific problems.

LEGO MINDSTORMS Education EV3 Design Engineering Projects are designed for use with the LEGO MINDSTORMS Education EV3 Core Set (45544) and the LEGO MINDSTORMS Education EV3 Programming App.

Who Is It For?

Using the Design Engineering Projects materials, you can immerse your students in physical science, technology, and mathematical concepts. Students can apply these concepts in creative problem-solving projects supported by digital documentation tools, and a software programming environment. You can also emphasize technical writing, as well as oral and written communication skills, and teamwork. No prior knowledge of LEGO building, MINDSTORMS® programming concepts, or data logging is required before using this material.

What Is It For?

As they work on these Design Engineering Projects, students are the engineers. Each student is a member of a small team in which they brainstorm ideas for solving a design challenge, and then build, program, and test their model to evaluate how well it worked. As they are learning and having fun within their teams, students are applying science, technology, and mathematics skills, and developing technical language and other communication skills.

This Design Engineering Projects Teacher's Guide provides you with a complete overview of each lesson with multimedia, and interactive features, and a complete overview of what the students will be doing, including:

- Robots In Action videos to provide inspiration, examples of mechanisms and programmed behaviors, and discussion questions
- A sample solution to support you
- Building Ideas to support brainstorming and creative idea generation during the lesson

The students documentation, where they record their work, can be viewed within this book alongside the Teacher's Notes. It includes the following pages related to the engineering process:

Design Brief

Brainstorm

Select the Best Solution

Build and Program

Test and Analyze

Review and Revise

Communicate

Four assessment rubrics have been added to the student projects to support assessment. See the *Assessment* section for more details.

Students can access their documentation and assessment materials through Google Forms.

Before Starting the First Lesson

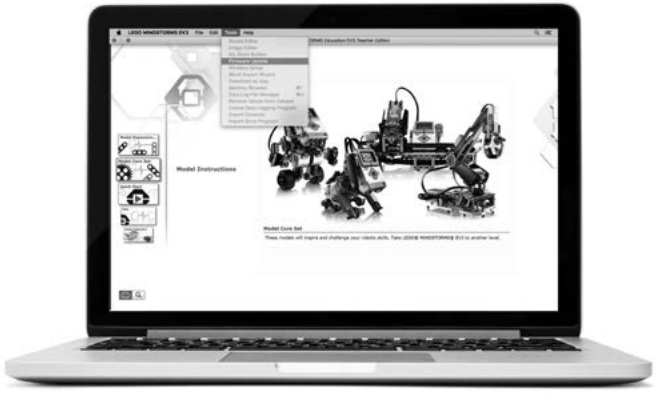
If you have never worked with LEGO® MINDSTORMS® Education EV3 before, you should ensure the following:

1. Each device has a preinstalled version of the LEGO MINDSTORMS Education EV3 Programming App.

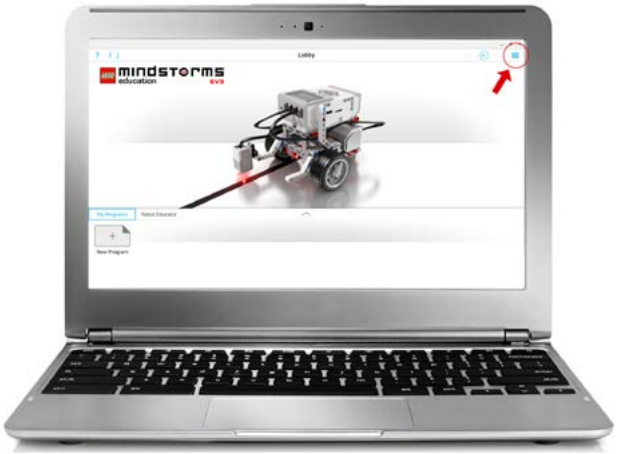
2. Each EV3 Brick has the latest firmware and is fully charged. To install firmware, you need a desktop version of the EV3 Software. For more instructions, refer to the User Guide, which you can access from the EV3 Software Menu.

3. Before connecting computers and EV3 Bricks via Bluetooth in the classroom, we recommend renaming each EV3 Brick. This can be done in two ways:
   a. Update the name via the desktop EV3 Software using a USB cable.
   b. Update to firmware V1.07E or later and change the name via the EV3 Brick Settings Area (see the User Guide for more help).

1 Install the EV3 Programming app



2 Access Firmware from the Tools Menu



3 Help can be found in the Menu of the EV3 Programming App

4 Quick Start Video helps you to get started

4. Check out the Quick Start Video.

You may want the students to understand the names and functions of the different elements in the brick set. Discuss the naming and basic functionality of the key hardware components, and establish a set of brick management rules.

The Element Survey will help you understand the names of the components, as well as give a greater understanding of what is in the box.

mindstorms education EV3

LEGO® Element Survey 45544

10x
Bushing, ½-module, yellow
4239601

10x
Bushing, 1-module, gray
4211622

60x
Connector peg with friction, 2-module, black
4121715

10x
Connector peg, 2-module, gray
4211807

8x
Connector peg with axle, 2-module, beige
4666579

6x
Connector peg, 3-module, beige
4514554

20x
Connector peg with friction/axle, 2-module, blue
4206482

30x
Connector peg with friction, 3-module, blue
4514553

22x
Connector peg with bushing, 3-module, red
4140806

2x
Axle with stud, 3-module, dark beige
6031821

2x
Axle with stop, 4-module, dark gray
4560177

2x
Axle with stop, 8-module, dark gray
4499858

10x
Axle, 2-module, red
4142865

14x
Axle, 3-module, gray
4211815

4x
Axle, 4-module, black
370526

6x
Axle, 5-module, gray
4211639

4x
Axle, 6-module, black
370626

5x
Axle, 7-module, gray
4211805

2x
Axle, 8-module, black
370726

2x
Axle, 9-module, gray
4535768

2x
Axle, 10-module, black
373726

2x
Axle, 12-module, black
370826

4x
Pointer, 3-module, white
4173941

4x
T-Beam, 3x3-module, black
4552347

How Much Time Do I Need?

The time taken to complete each of the Projects depends on a number of factors, including the level of complexity, the age of the student, the student's experience with LEGO® Mindstorms® Education, and their familiarity with the concepts covered in the Project.

There are three Categories of Projects, with one Project in each Category. The Categories are designed to progress from simple to more complex. Open-ended design is encouraged. The following estimates will give you an idea of the amount of time needed for an average student to complete the building and programming of a Project in each of the Categories.

Project Category	Suggested Completion Time (In minutes)
Make It Move Without Wheels	45 - 120
Make It Smarter and Faster	90 - 120
Make a System That Communicates	120 - 180

If you do not have double-block class time, students can use the digital tools to document their work and then pick up where they left off during the next class period. Documenting the process may encourage students to share their work and consider other design ideas. Allow your students to see and evaluate a variety of ideas and solutions by having each student group present and discuss their projects among a larger group or the whole class.

One of the most important lessons of these Projects is that there is no one perfect solution. There are benefits and drawbacks to every design. More creative solutions may emerge as students share their work. You can also modify the design brief so students have easier or more difficult criteria for satisfactorily completing the Project.

These lessons cover three units of study:

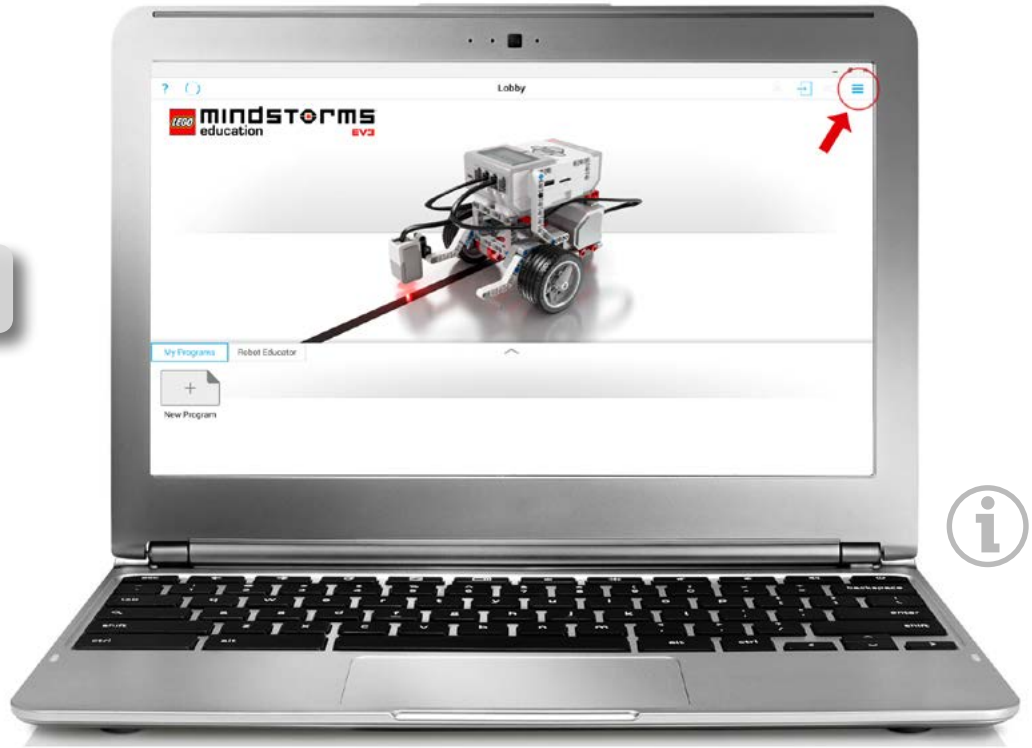
- science
- engineering
- applied mathematics

This is one of three Design Engineering Projects available in Google Forms. The categories covered are *Make It Move*, *Make It Smarter*, and *Make A System*. This project, *Make It Move Without Wheels*, challenges students to design, build, and program a robot that can move a distance of 30 cm and use no wheels for locomotion. This is a creative design challenge and demands experimenting with other kinds of mechanisms and sensors. After you have completed this challenge, try out the other two Design Engineering Projects.

How Do I Use the Robot Educator Tutorials with the Design Engineering Projects?

The EV3 Programming App includes six Robot Educator tutorials. Your students do not need to do all of these tutorials before beginning the Design Engineering Projects. Some teachers like to have the students work through a few tutorials before beginning the Design Engineering Projects. Others prefer to have students learn hands-on about the EV3 Software and hardware as they design their own robots.

If you prefer to start students with the tutorials before beginning the Design Engineering Projects, refer to Robot Educator – Introduction to Robotics Lesson Plan. For most middle school students beginning a robotics course, the Introduction to Robotics Lesson Plan route is a good start. Students completing this route will be familiar with the main EV3 building and programming features, and will be ready for a design challenge.



Five assessment pages are included within each Project:

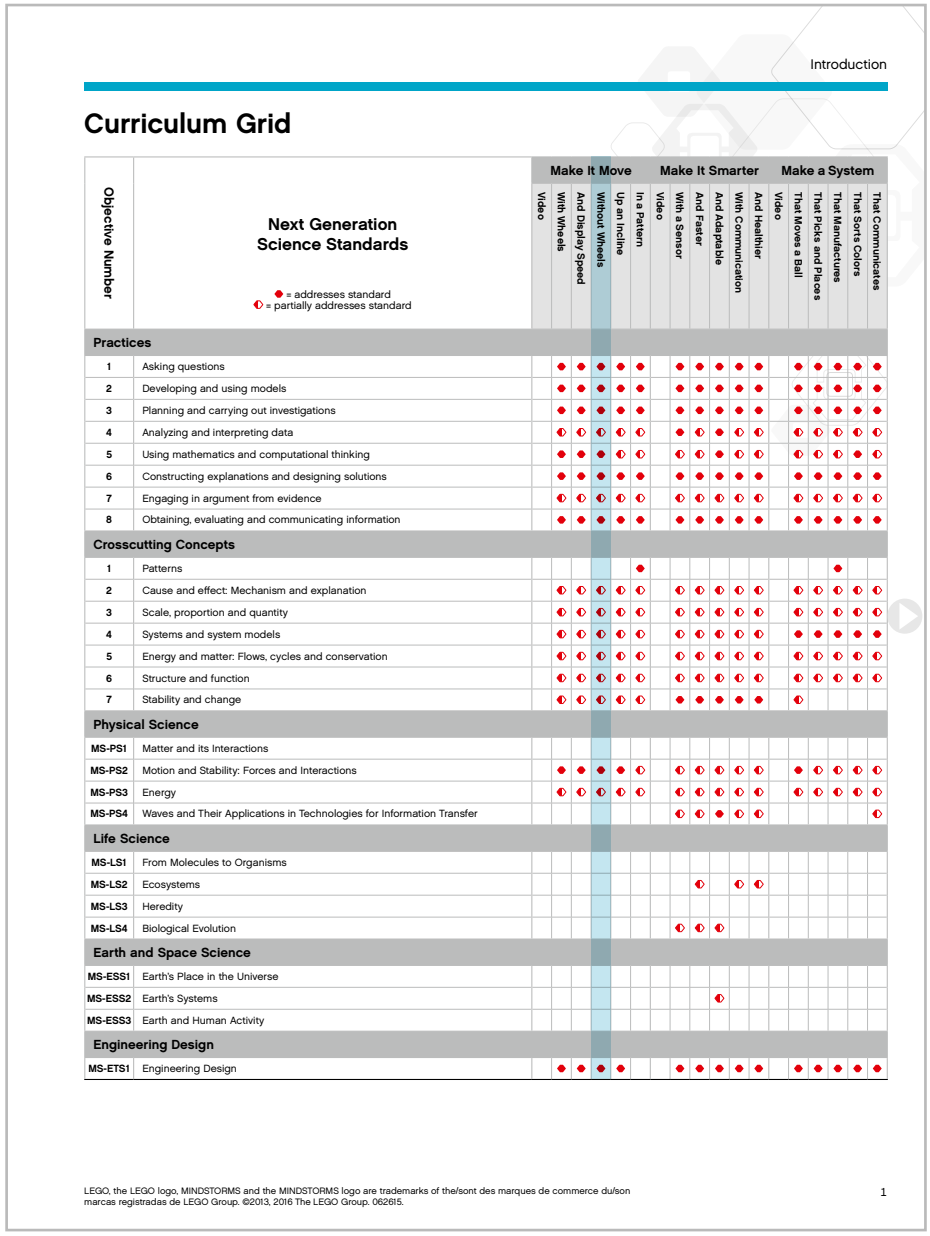
Describe Your Ideas: A page within the student documentation to be used after brainstorming to help students identify three ways to solve the design problem. This page provides specific student support for considering multiple ideas, which is part of the Next Generation Science Standards performance expectations.

Evaluate Design and NGSS Goals: Two of four rubrics within the student documentation on which students can evaluate their project work according to engineering-related learning goals from the Next Generation Science Standards:

- How well did their design meet the requirements of the design brief?
- How well did they use a selected Next Generation Science Standard engineering practice?

Evaluate Creativity and Collaboration: Two more rubric pages on which students can evaluate their project work according to learning goals which are prominent in both the Common Core and 21st century learning literature, specifically:

- How creative was their solution?
- How well did their team work together?



Introduction

Curriculum Grid

Objective Number	Next Generation Science Standards ● = addresses standard ◐ = partially addresses standard	Make It Move						Make It Smarter						Make a System					
		Video	With Wheels	And Display Speed	Without Wheels	Up an Incline	In a Pattern	Video	With a Sensor	And Faster	And Adaptable	With Communication	And Healthier	Video	That Moves a Ball	That Picks and Places	That Manufactures	That Sorts Colors	That Communicates
Practices																			
1	Asking questions		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
2	Developing and using models		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
3	Planning and carrying out investigations		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
4	Analyzing and interpreting data		◐	◐	◐	◐	◐		●	◐	●	◐	◐		◐	◐	◐	◐	◐
5	Using mathematics and computational thinking		●	●	●	◐	◐		◐	◐	●	◐	◐		◐	◐	◐	●	◐
6	Constructing explanations and designing solutions		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
7	Engaging in argument from evidence		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
8	Obtaining, evaluating and communicating information		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
Crosscutting Concepts																			
1	Patterns						●										●		
2	Cause and effect: Mechanism and explanation		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
3	Scale, proportion and quantity		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
4	Systems and system models		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		●	●	●	●	●
5	Energy and matter: Flows, cycles and conservation		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
6	Structure and function		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
7	Stability and change		◐	◐	◐	◐	◐		●	●	●	●	●		◐				
Physical Science																			
MS-PS1	Matter and its Interactions																		
MS-PS2	Motion and Stability: Forces and Interactions		●	●	●	●	◐		◐	◐	◐	◐	◐		●	◐	◐	◐	◐
MS-PS3	Energy		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
MS-PS4	Waves and Their Applications in Technologies for Information Transfer								◐	◐	●	◐	◐						◐
Life Science																			
MS-LS1	From Molecules to Organisms																		
MS-LS2	Ecosystems									◐		◐	◐						
MS-LS3	Heredity																		
MS-LS4	Biological Evolution								◐	◐	◐								
Earth and Space Science																			
MS-ESS1	Earth's Place in the Universe																		
MS-ESS2	Earth's Systems										◐								
MS-ESS3	Earth and Human Activity																		
Engineering Design																			
MS-ETS1	Engineering Design		●	●	●	●			●	●	●	●	●		●	●	●	●	●

Each rubric includes four levels: Bronze, Silver, Gold and Platinum. The intention is to help students reflect on what they have done well in relation to the learning goals and what they might do better.

Students should mark the box to indicate the appropriate rubric level. If you prefer to emphasize formative assessment, ask the students to record dates in the rubric that correspond to their completion of each level.

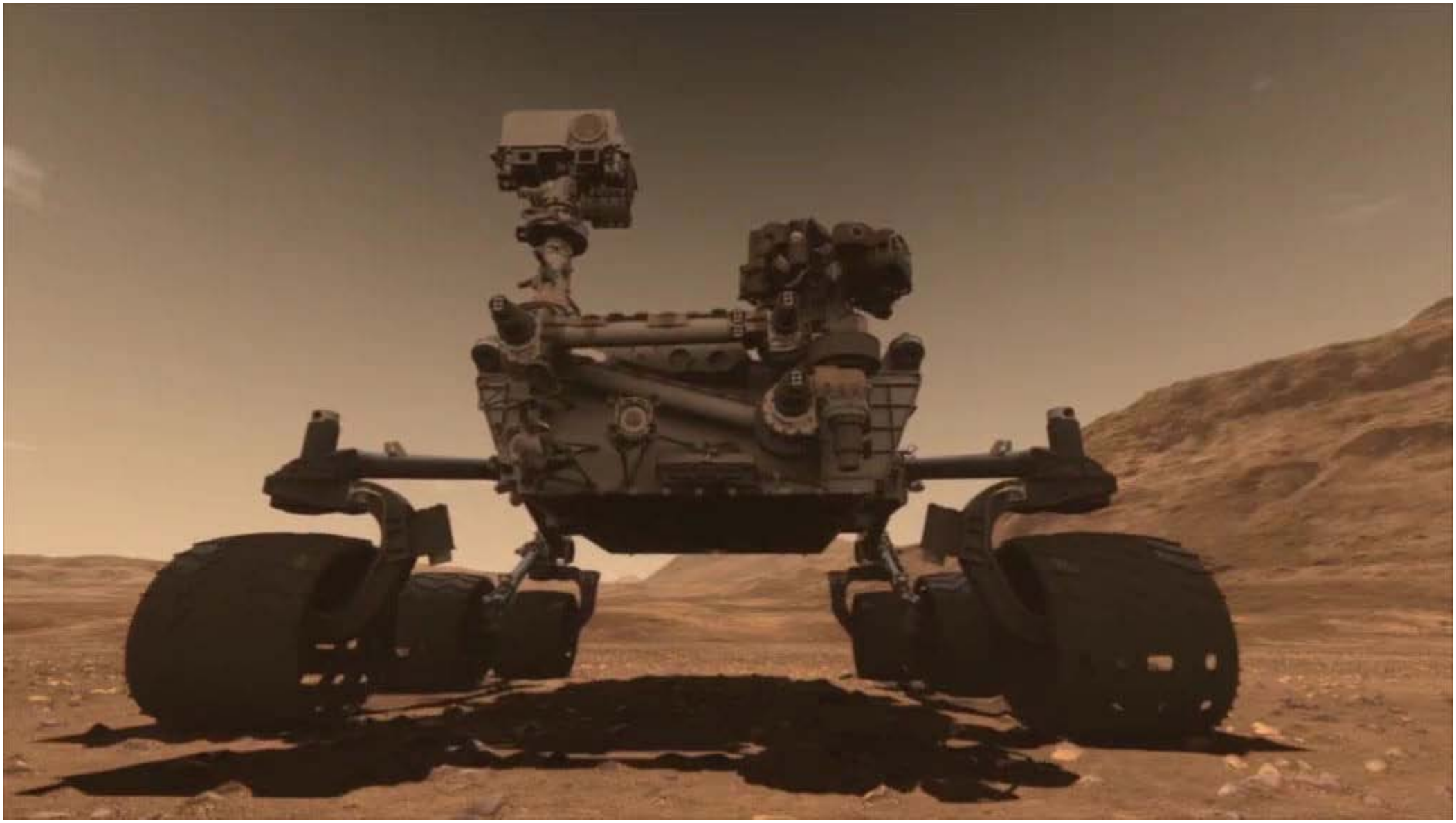
Curriculum Grids

These Curriculum Grids show the relationship of Design Engineering Projects to science, engineering, technology, and math standards.

The three projects, *Make It Move Without Wheels*, *Make It Smarter and Faster*, and *Make a System That Communicates*, are highlighted on the Curriculum Grid to match relevant standards. The other projects are available in the full desktop version of Design Engineering Projects.

Make It Move Without Wheels

Make It Move Video



Overview and Design Brief

Objectives

Students will:

- Understand that engineers design to satisfy a need
- Practice teamwork and communication skills, such as listening to others and arguing for ideas based on evidence
- Build their own robot that can move forward using some mechanism other than wheels
- Write a program that makes their robot move at least 30 cm
- Become familiar with the importance of balance (center of mass) in a structure

Vocabulary

Motor, balance; you may also wish to introduce center of mass.

Materials Needed

Thirty centimeter length space for testing robots, plus a bit more for elbow room.

Prerequisites

Students should know how to create and download a program, and how to program a motor. This can be achieved through the *Curved Move Tutorial* found in Robot Educator in the EV3 Programming App.

Classroom Tips

Use the Make It Move Video and discussion questions to initiate group discussion about robotics and movement.

This project will appeal to the builders in the class. It is a technical building challenge; however, complex solutions are not required. The short, 30 cm distance can be satisfied with many simple one or two motor solutions.

Sample Solution

For one way to satisfy this design brief, see the *Walker Bot* sample solution, which includes a video, building instructions, and the program described at the end of these notes.

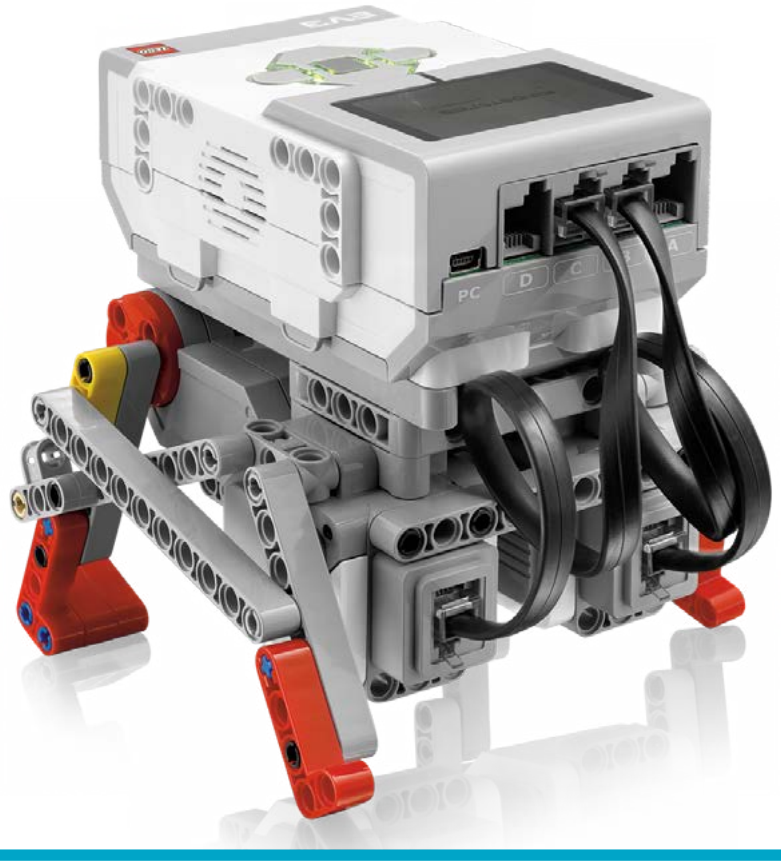
Building Ideas

Students can explore the Building Ideas for inspiration in creating their own robots. They can use the step-by-step instructions to learn how to put together functioning mechanisms, or use several different Building Ideas to build a more complex robotic system. This should only be used for students who are struggling to generate their own solutions.

Extensions

For more able students, challenge them to program their robots to measure distance moved based on the step length of their robot.

Let's Get Started



The following pages will guide you through the *Make It Move Without Wheels* Project.

Student

Make it Move Video

Teacher

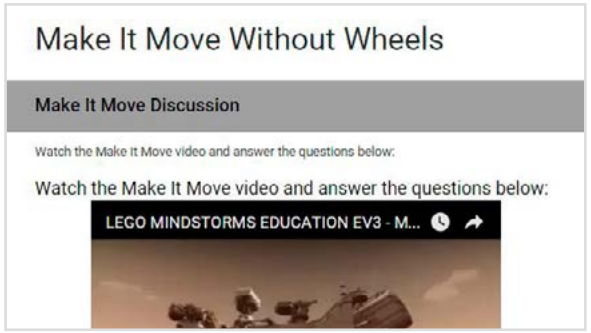
Make It Move Video

Use this video to:

- Connect students to real-life robots that move
- Connect students to physical science and mathematics principles: distance, speed, energy, and power systems; balance, stability, and center of mass; patterns of movement and coordinate systems; energy transfer; incline slope and other challenges for robot movement
- Consider how robots think; how they know where they are and what they need to do
- Inspire students to create their own robots that move

Student

Make It Move Discussion



Teacher

Make It Move Discussion

1. Look at the ways in which machines and robots move with and without wheels. Choose one example and trace how the movement transfers from one part to another.
   This question challenges students to observe and describe how a robot physically moves, and how to use physical science vocabulary such as *power*, *energy*, *work*, *center of mass*, and *stability*.

2. Compare the way the two walking robots move. What do you notice about how they balance as they walk?
   The ZI insect robot lifts one leg on one side but not on the other. The humanoid robot is maintains its balance in several ways (e.g., moving slowly, adjusting foot position, holding hands out and down to the side).

3. Look at the ways in which machines and robots move up hills or other inclined surfaces. These robots require more power to move uphill. What are some features that help them climb uphill?
   We can't see the motors or look at the power system directly, but we can see that there are tracks or tires with heavy treads to prevent slipping. The iRobot system shifts its front tracks to pull and lift the robot.

4. Which robot(s) moves in a regular pattern? What does moving in the pattern accomplish?
   What does moving in the pattern accomplish? The iRobot Scooba is cleaning the pool and repeating movements so the whole pool is cleaned. The NASA all-terrain robot uses a pattern to map a location, including obstructions.

Student

Design Brief

Teacher

Design Brief

Read the design brief to the students.

Student

Brainstorm

Make It Move Without Wheels

Brainstorm

Discuss different solutions to the design brief.

Think about how robots can move without wheels.

How will you:

- Connect the motor(s) to something to make the robot walk, crawl, or wiggle
- Program the robot to move

Which programming blocks will you use to:

Teacher

Brainstorm

Encourage an active brainstorming process so that students develop their conceptual understanding. For example, encourage them to:

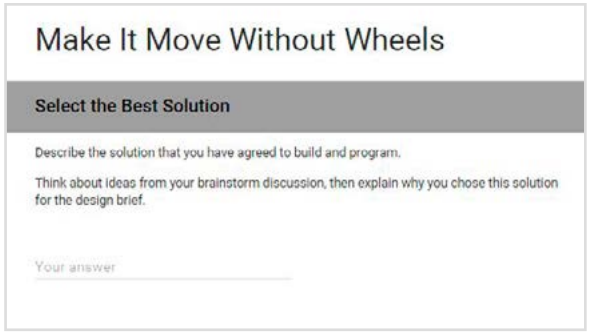
- Watch the Robots In Action video which shows robots for inspiration
- Show the examples suggested in Building Ideas to students who are struggling to generate their own solutions
- Personalize their robot, or describe a context in which a robot that moves without wheels is useful

Describe Your Ideas

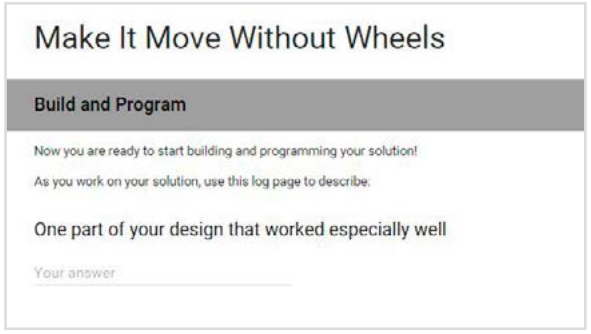
Students can document their ideas using Google Forms. Encourage students to use Google Docs to document their photos.

Student

Select the Best Solution



Build and Program



Teacher

Select the Best Solution

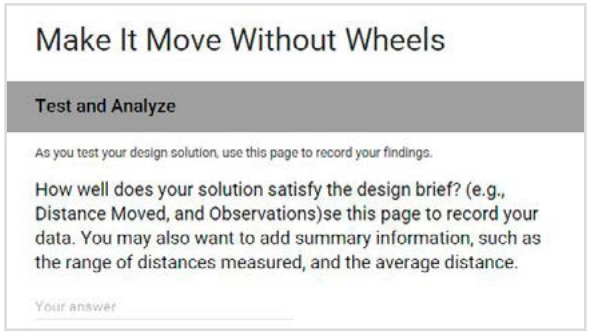
Encourage students to describe why they have chosen a particular solution. That way, when they are reviewing and revising, they will have specific information to use in evaluating their solution and deciding whether or not it was effective.

Build and Program

Encourage students to briefly summarize their work at the end of each class period. That way, they will remember where to begin during the next class period.

Student

Test and Analyze


Make It Move Without Wheels

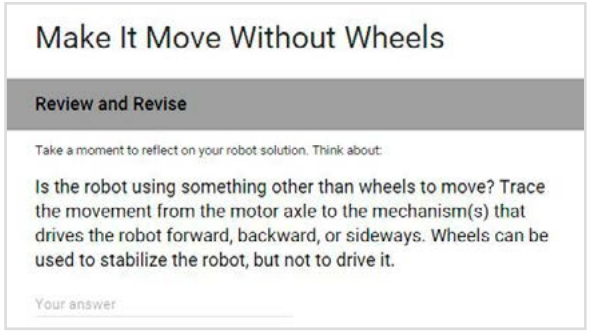
Test and Analyze

As you test your design solution, use this page to record your findings.

How well does your solution satisfy the design brief? (e.g., Distance Moved, and Observations)se this page to record your data. You may also want to add summary information, such as the range of distances measured, and the average distance.

Your answer

Review and Revise


Make It Move Without Wheels

Review and Revise

Take a moment to reflect on your robot solution. Think about:

Is the robot using something other than wheels to move? Trace the movement from the motor axle to the mechanism(s) that drives the robot forward, backward, or sideways. Wheels can be used to stabilize the robot, but not to drive it.

Your answer

Teacher

Test and Analyze

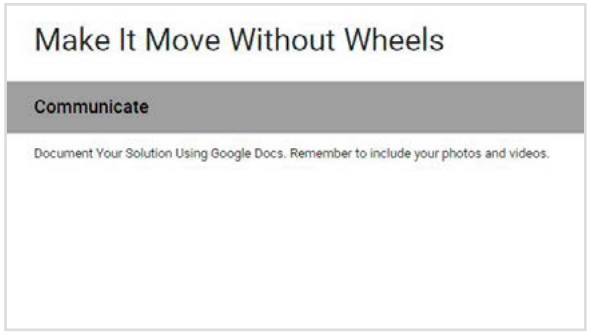
Students can record their test data in Google Forms.

Review and Revise

Encourage students to look back at the design brief and at their own brainstorming notes and test data.

Student

Communicate



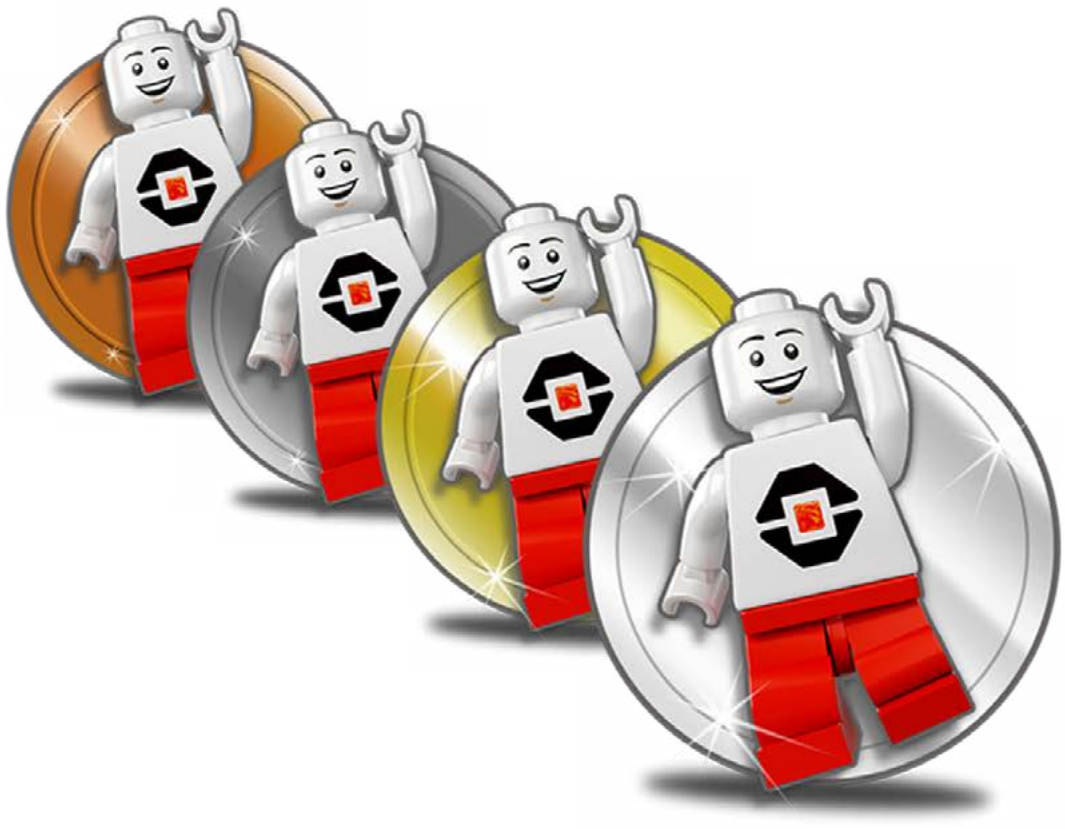
Teacher

Communicate

Here are some ideas to suggest to students:

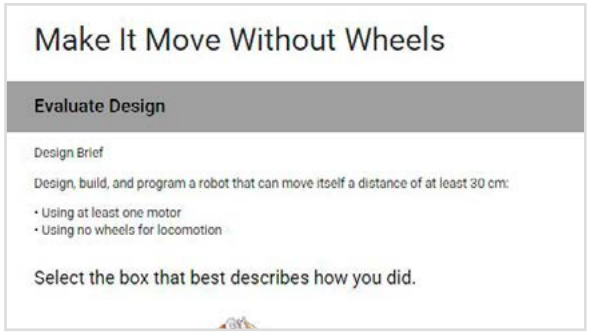
- Create a video of your project, especially your final presentation and your robot's performance.
- Explain some important features of your software program.
- Produce a building guide for your model by taking a series of photographs as you deconstruct it.
- Include an image of your program with comments.
- Add a team photograph!

Assessment Rubrics



Student

Evaluate Design


Make It Move Without Wheels

Evaluate Design

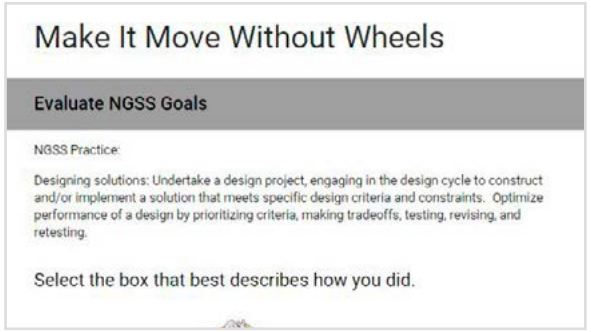
Design Brief

Design, build, and program a robot that can move itself a distance of at least 30 cm:

- Using at least one motor
- Using no wheels for locomotion

Select the box that best describes how you did.

Evaluate NGSS Goals


Make It Move Without Wheels

Evaluate NGSS Goals

NGSS Practice:

Designing solutions: Undertake a design project, engaging in the design cycle to construct and/or implement a solution that meets specific design criteria and constraints. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting.

Select the box that best describes how you did.

Teacher

Evaluate Design and NGSS Goals

Two rubrics are included in this and all Design Engineering Projects. The pages are fully editable.

Students can use the provided rubric to review their design goals, as well as their use of some NGSS practices. They can rate their level of work by adding a mark in the box next to the Bronze, Silver, Gold, or Platinum column.

You may also use the rubric to rate each team or student yourself.

You may want to encourage a peer-review process so that each group evaluates another group's project in addition to their own. This review process can help students develop skills in giving constructive feedback, as well as help them sharpen their analytical skills and use of data to support an argument.

Student

Evaluate Creativity

Evaluate Collaboration

Teacher

Evaluate Creativity and Collaboration

Using the provided rubric, students can review their creative and collaboration processes.

You may also use the rubric to rate each team or student yourself.

Student

Congratulations!

Make It Move Without Wheels

Congratulations! What will you design next?

Teacher

Congratulations!

Sample Solution

Sample Solution Video

Click on the video to see the robot move. The robot moves forward 30 cm.

Building Instructions

The Walker Bot solution is one example of many possible solutions for the Make It Move Without Wheels project.

Sample Solution Program

This program works with the Walker Bot. If you create a different robot, adjust the program to fit your solution.

This program:

- Moves the motors using the Move Tank Block at 60 percent power in reverse direction for 9 rotations
- Displays 30 cm at coordinates (2, 3) so the text is centered in the middle
- Waits for 3 seconds so you have time to see the text.

Students can explore the Building Ideas for inspiration in creating their own robots. They can use the step-by-step instructions to learn how to put together functioning mechanisms, or use several different Building Ideas to build a more complex robotic system. These should only be used for students who are struggling to generate their own solutions.

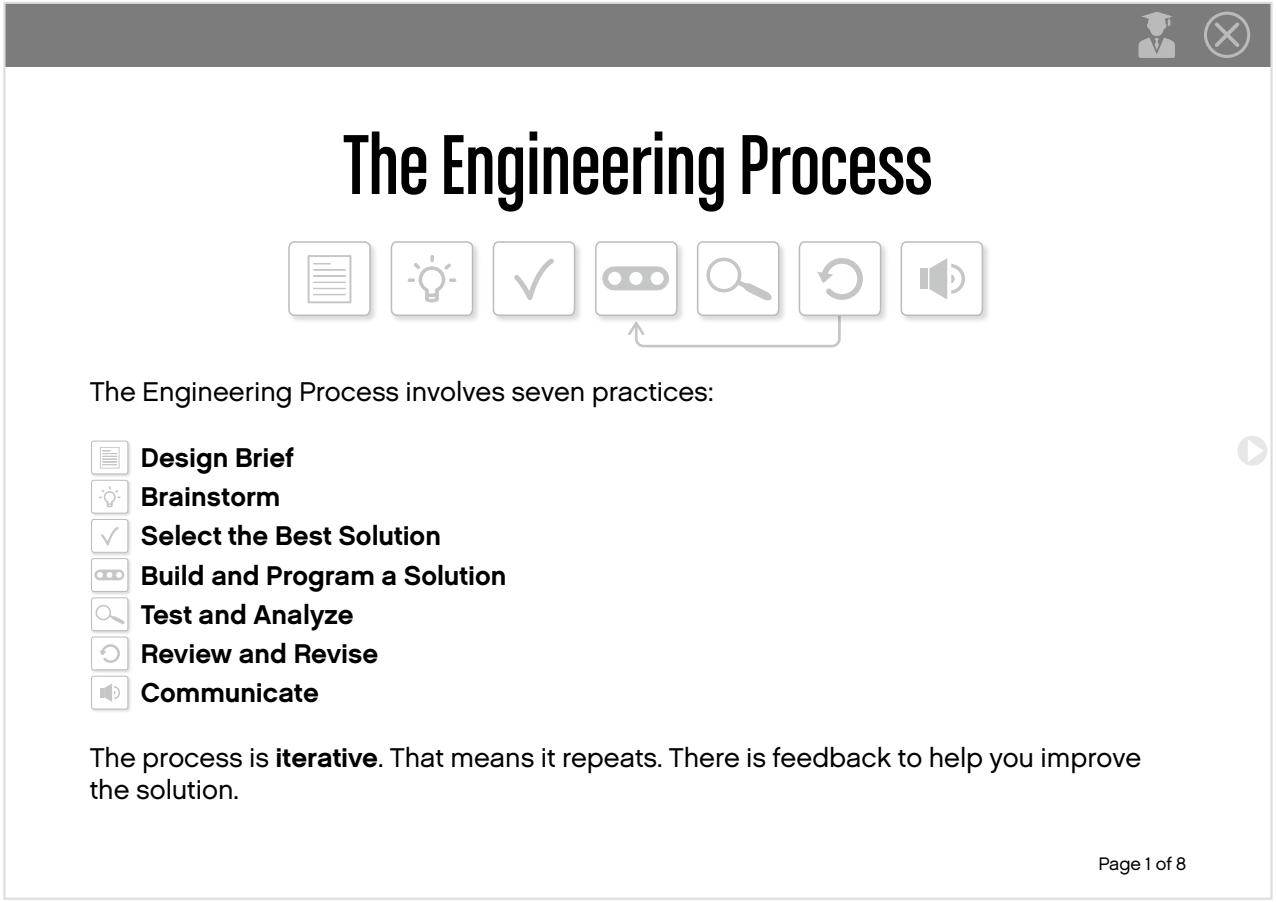
EV3 Frames

Leg 1

Leg 2

Large Motor and Connector

These Key Concepts resources support your engineering work by providing robotics ideas in relation to science and mathematical concepts, background material and vocabulary, information and examples of concepts in use, and tools for developing better understanding.



The Engineering Process

The Engineering Process involves seven practices:

- **Design Brief**
- **Brainstorm**
- **Select the Best Solution**
- **Build and Program a Solution**
- **Test and Analyze**
- **Review and Revise**
- **Communicate**

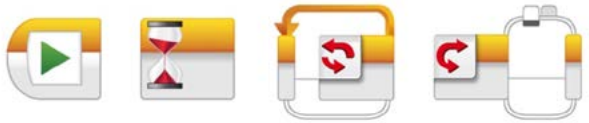
The process is **iterative**. That means it repeats. There is feedback to help you improve the solution.

Page 1 of 8

Robot Logic

When you download a program to an EV3 robot, you are making the robot smarter. Your programs tell the robot how to sense its surroundings, move, collect data, and make decisions.

To program decision making, use these blocks on the Flow palette: **Start**, **Wait**, **Loop**, and **Switch**.



These blocks are built on true/false logic. The logic built into programs allows robots to think. It is how robots know how to make decisions.

Congratulations!

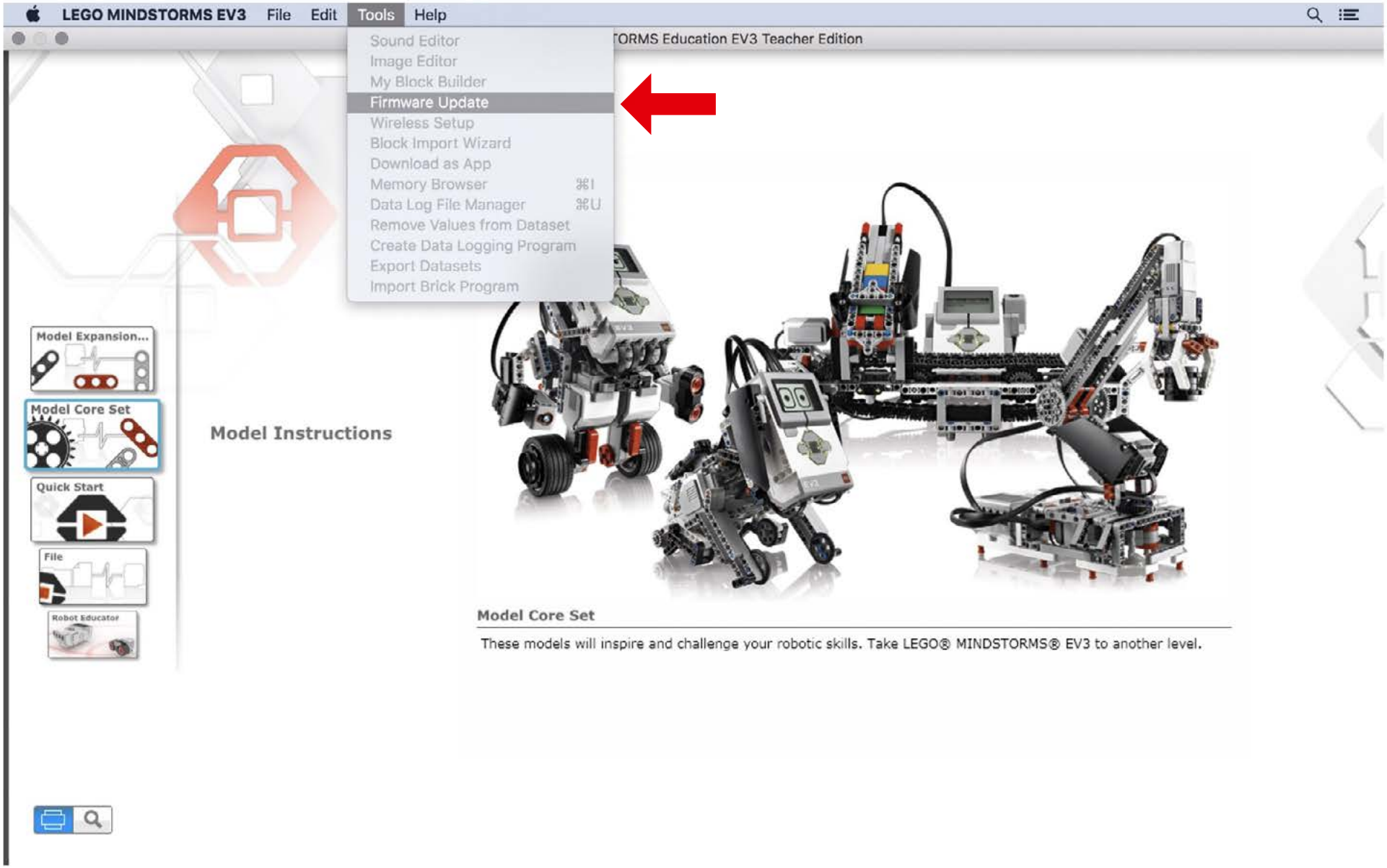
You have finished your first EV3 Design Engineering Project. What will you do next?

Try out one of these two Design Engineering Projects also available to download.

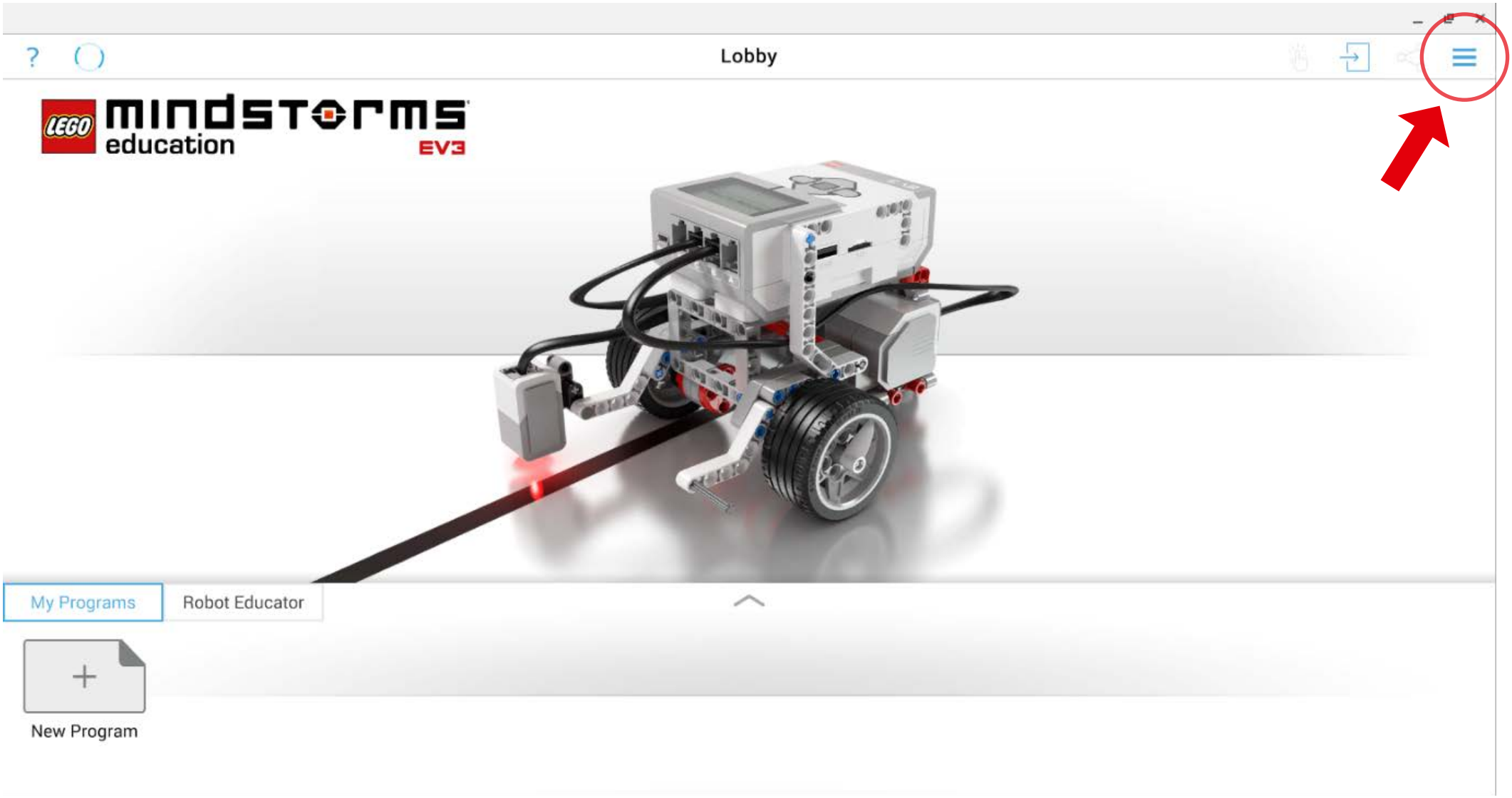
Make It Smarter and Faster

Make a System That Communicates

Firmware Update screen



Help screen – step 1



LEGO® Element Survey 45544

10x
Bushing, ½-module, yellow
4239601

10x
Bushing, 1-module, gray
4211622

60x
Connector peg with friction, 2-module, black
4121715

10x
Connector peg, 2-module, gray
4211807

8x
Connector peg with axle, 2-module, beige
4666579

6x
Connector peg, 3-module, beige
4514554

20x
Connector peg with friction/axle, 2-module, blue
4206482

30x
Connector peg with friction, 3-module, blue
4514553

22x
Connector peg with bushing, 3-module, red
4140806

2x
Axle with stud, 3-module, dark beige
6031821

2x
Axle with stop, 4-module, dark gray
4560177

2x
Axle with stop, 8-module, dark gray
4499858

10x
Axle, 2-module, red
4142865

14x
Axle, 3-module, gray
4211815

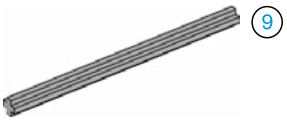
4x
Axle, 4-module, black
370526

6x
Axle, 5-module, gray
4211639

4x
Axle, 6-module, black
370626

5x
Axle, 7-module, gray
4211805

2x
Axle, 8-module, black
370726



2x
Axle, 9-module, gray
4535768

2x
Axle, 10-module, black
373726

2x
Axle, 12-module, black
370826

4x
Pointer, 3-module, white
4173941

4x
T-Beam, 3x3-module, black
4552347

4x
Beam with crosshole, 2-module, black
6006140

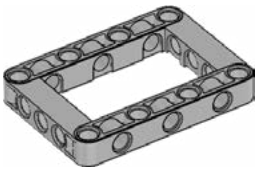
2x
Beam, 3-module, black
4142822

4x
Beam, 3-module, green
6007973

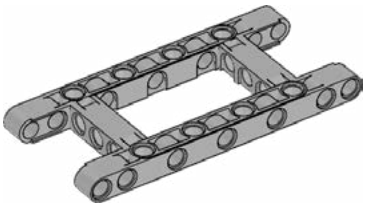
4x
Beam, 3-module, red
4153718

4x
Beam, 3-module, blue
4509376

4x
Beam, 3-module, yellow
4153707

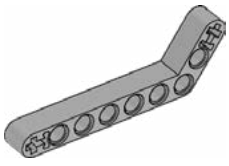


3x
Frame, 5x7-module, gray
4539880



1x
Frame, 5x11-module, gray
4540797

6x
Angular beam, 4x4-module, white
4509912

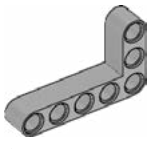


4x
Angular beam, 3x7-module, gray
4211624

4x
Angular beam, 4x6-module, black
4112282

4x
Double angular beam, 3x7-module, white
4495412

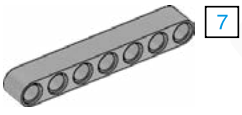
6x
Angular beam, 2x4-module, red
4141270



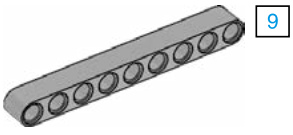
2x
Angular beam, 3x5-module, gray
4211713

4x
Angular beam, 3x5-module, white
4585040

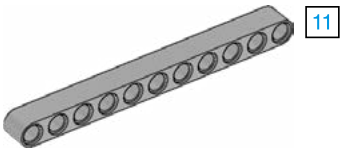
4x
Beam, 5-module, gray
4211651



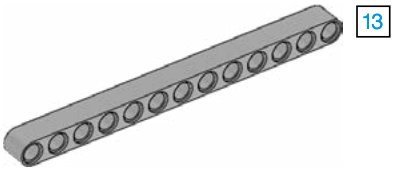
4x
Beam, 7-module, gray
4495930



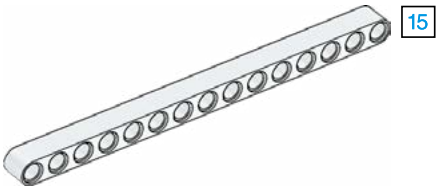
6x
Beam, 9-module, gray
4211866



4x
Beam, 11-module, gray
4611705



6x
Beam, 13-module, gray
4522934



6x
Beam, 15-module, white
4542578

4x
Double connector peg, 3-module, gray
4560175

6x
Double connector peg, 3x3-module, gray
4225033

4x
Angular connector peg, 3x3-module, gray
4296059

8x
Cross block, 2-module, gray
4211775

8x
Cross block, 3-module, dark gray
4210857

6x
Cross block, 3x2-module, gray
4538007

8x
Double cross block, 3-module, black
4121667

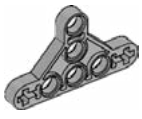
4x
Cross block fork, 2x2-module, black
4162857

4x
Cross block, 2x2-module, black
4140430

2x
Cross beam, 2x1-module, red
6008527

2x
Connector peg with handle, 3-module, black
4563044

2x
½ beam, 4-module, black
4142236



4x
½ triangle beam, 5x3-module, gray
6009019

2x
3-spoke angular block, 3x120°, gray
4502595

4x
Tube, 2-module, gray
4526985

6x
Bushing/axle extender, 2-module, red
4513174

4x
Angular block 1, 0°, black
4107085

4x
Angular block 2, 180°, black
4107783

2x
Angular block, 6 (90°), black
4107767

4x
Rubber beam with crossholes, 2-module, black
4198367

4x
Gear, 8-tooth, dark gray
4514559

2x
Bevel gear, 12-tooth, beige
4565452

4x
Gear, 16-tooth, gray
4640536

4x
Gear, 24-tooth, dark gray
4514558

2x
Gear, 40-tooth, gray
4285634

2x
Double bevel gear, 12-tooth, black
4177431

2x
Double bevel gear, 20-tooth, black
4177430

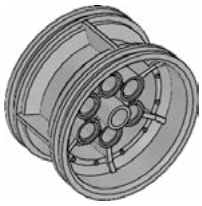
2x
Double bevel gear, 36-tooth, black
4255563

2x
Worm gear, gray
4211510

4x
Gear, 4-tooth, black
4248204

2x
Turntable bottom, 28-tooth, gray
4652235

2x
Turntable top, 28-tooth, black
4652236



2x
Hub, 43.2x26 mm, gray
4634091

2x
Low profile tire, 56x28 mm, black
6035364

4x
Tire, 30.4x4 mm, black
6028041

4x
Hub, 24x4 mm, dark gray
4587275

1x
Steel Ball, silver metalic
6023956

1x
Ball bearing, dark gray
4610380

54x
Track, 5x1,5-module, black
6014648

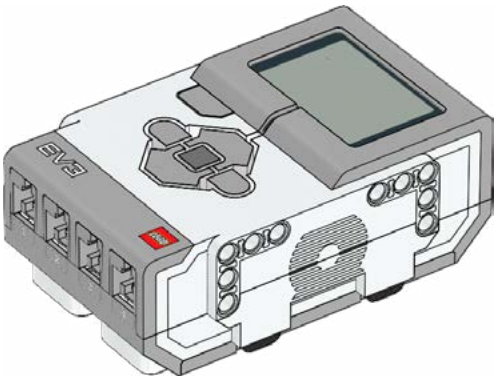
4x
Sprocket, 40.7x15 mm, black
4582792

1x
Right curved panel, 5x11-module, black
4543490

1x
Left curved panel, 5x11-module, black
4541326

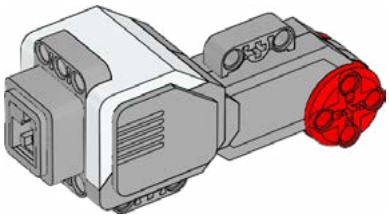
1x
Left curved panel, 3x5-module, black
4566251

1x
Right curved panel, 3x5-module, black
4566249

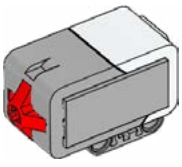


1x
EV3 Brick
6009996

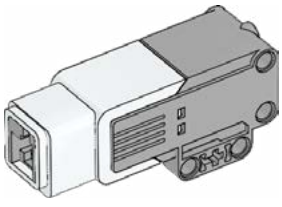
1x
Color Sensor
6008919



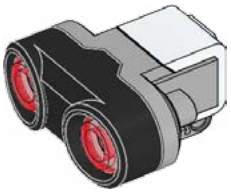
2x
Large Motor
6009430



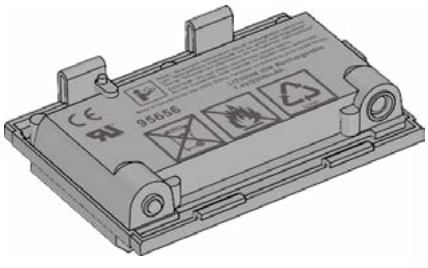
2x
Touch Sensor
6008472



1x
Medium Motor
6008577



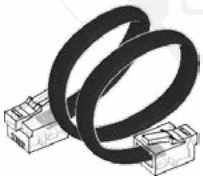
1x
Ultrasonic Sensor
6008924



1x
Rechargeable Battery
6012820

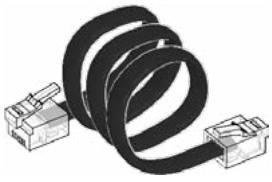
1x
Gyro Sensor
6008916

25 cm / 10 in.



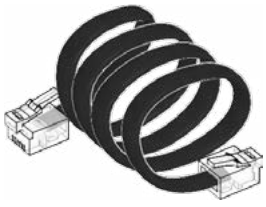
4x
Cable, 25 cm / 10 in.
6024581

35 cm / 14 in.

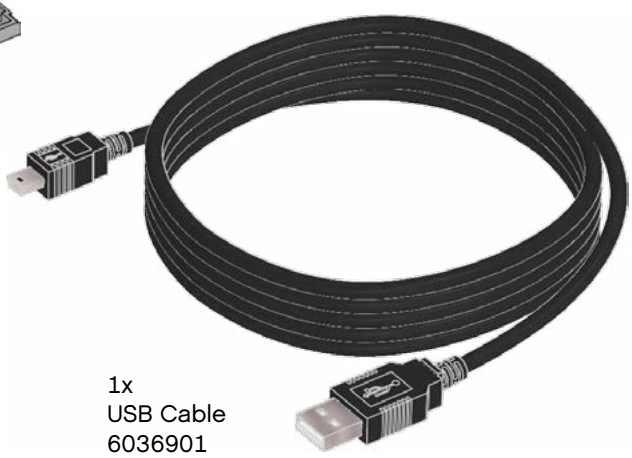


2x
Cable, 35 cm / 14 in.
6024583

50 cm / 20 in.



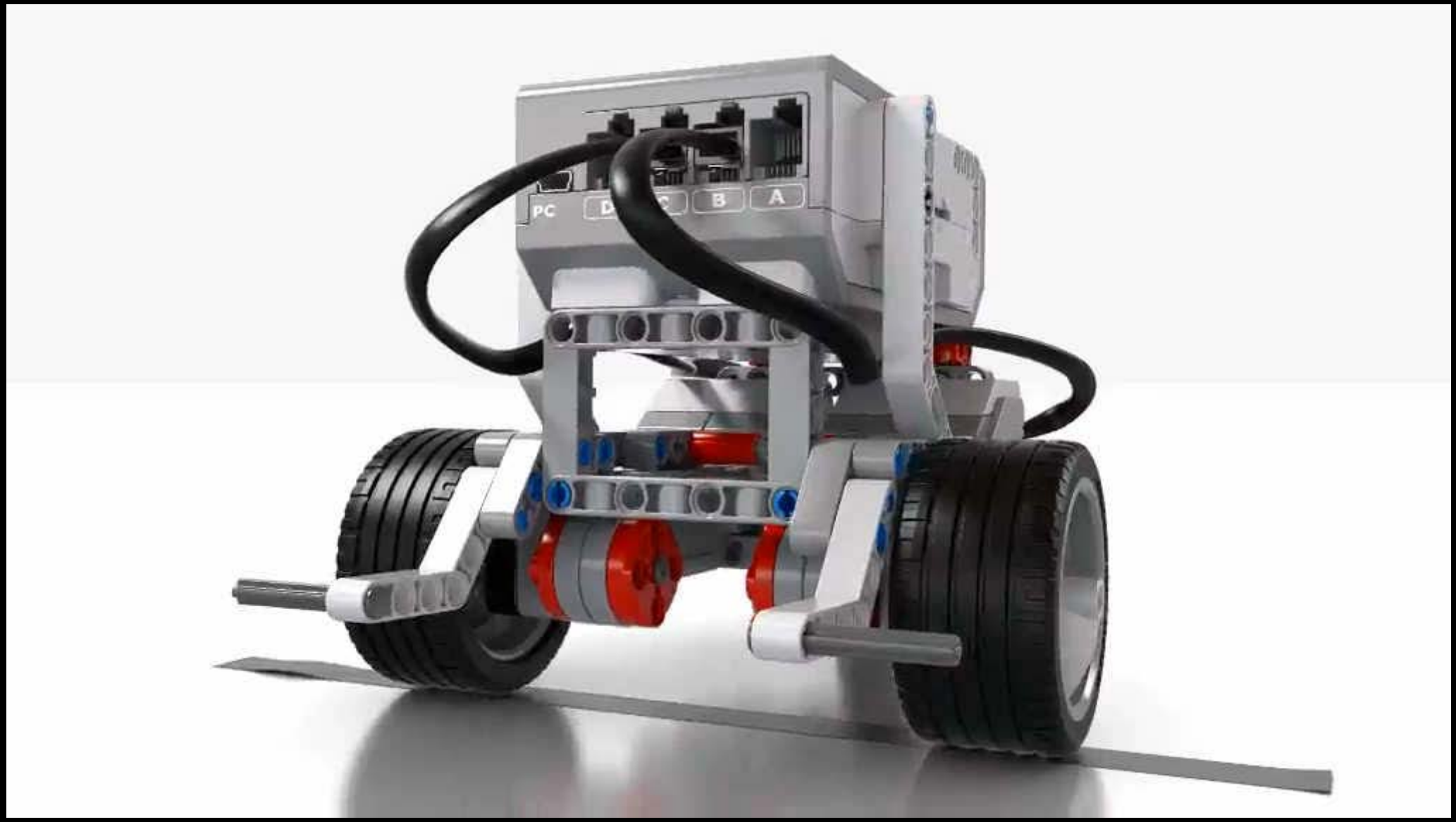
1x
Cable, 50 cm / 20 in.
6024585



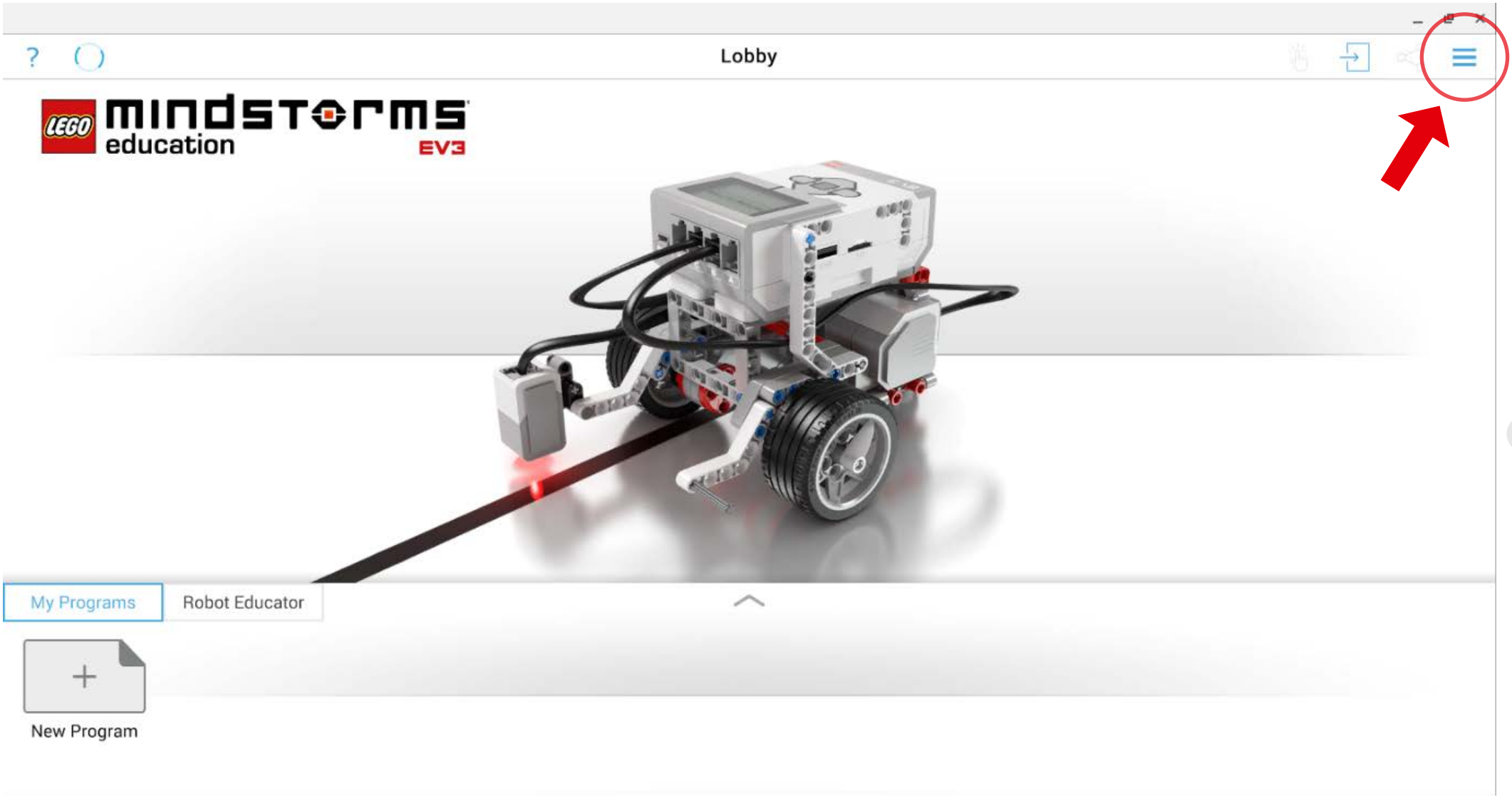
1x
USB Cable
6036901

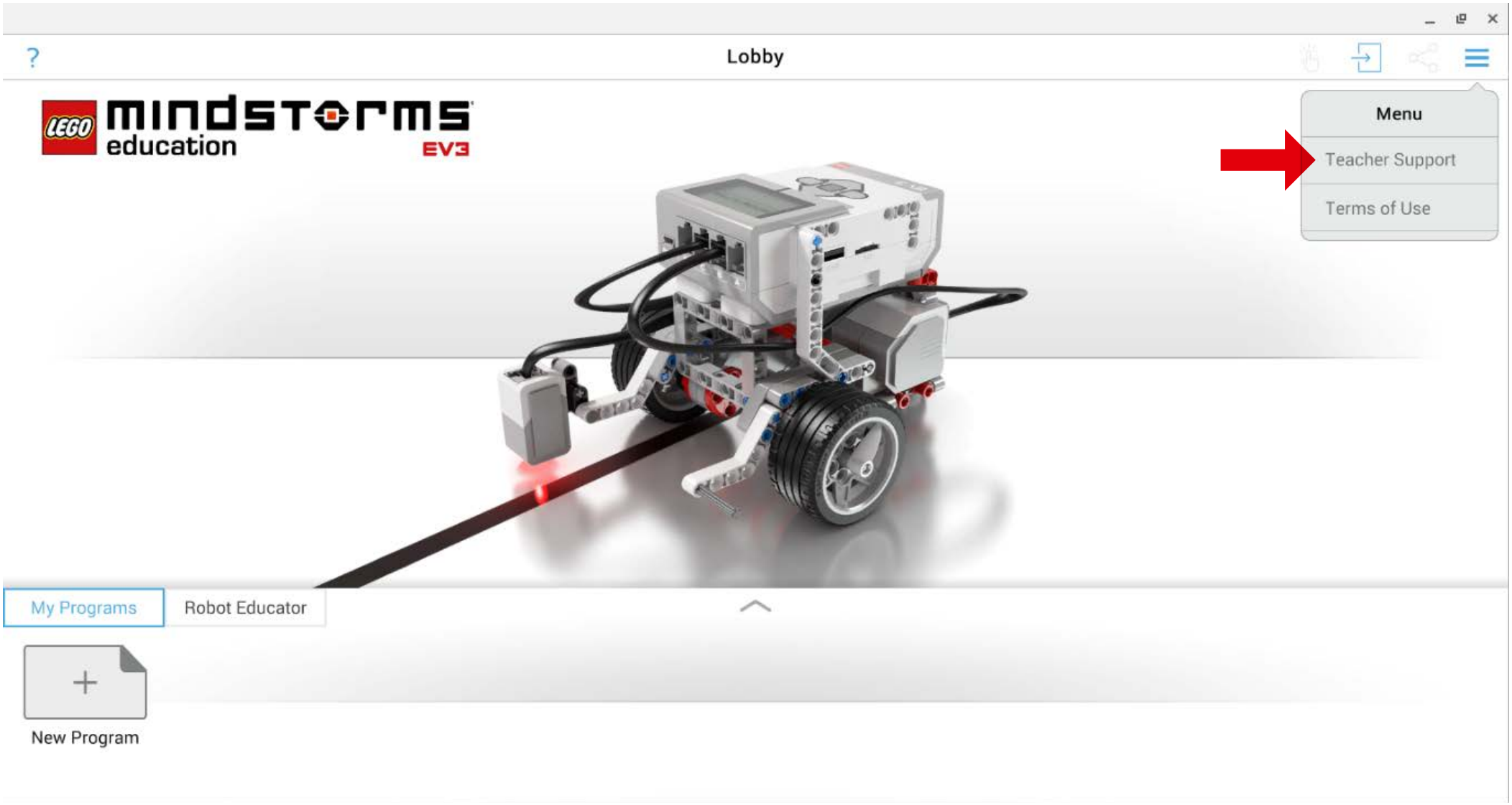
Quick Start video

Point and Curve Turn video



Teacher Support screen




Lobby
mindstorms education EV3
Menu
Teacher Support
Terms of Use
My Programs
Robot Educator
New Program

Curriculum Grid

Objective Number	Next Generation Science Standards ● = addresses standard ◐ = partially addresses standard	Make It Move						Make It Smarter						Make a System					
		Video	With Wheels	And Display Speed	Without Wheels	Up an Incline	In a Pattern	Video	With a Sensor	And Faster	And Adaptable	With Communication	And Healthier	Video	That Moves a Ball	That Picks and Places	That Manufactures	That Sorts Colors	That Communicates
Practices																			
1	Asking questions		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
2	Developing and using models		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
3	Planning and carrying out investigations		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
4	Analyzing and interpreting data		◐	◐	◐	◐	◐		●	◐	●	◐	◐		◐	◐	◐	◐	◐
5	Using mathematics and computational thinking		●	●	●	◐	◐		◐	◐	●	◐	◐		◐	◐	◐	●	◐
6	Constructing explanations and designing solutions		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
7	Engaging in argument from evidence		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
8	Obtaining, evaluating and communicating information		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
Crosscutting Concepts																			
1	Patterns						●										●		
2	Cause and effect: Mechanism and explanation		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
3	Scale, proportion and quantity		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
4	Systems and system models		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		●	●	●	●	●
5	Energy and matter: Flows, cycles and conservation		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
6	Structure and function		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
7	Stability and change		◐	◐	◐	◐	◐		●	●	●	●	●		◐				
Physical Science																			
MS-PS1	Matter and its Interactions																		
MS-PS2	Motion and Stability: Forces and Interactions		●	●	●	●	◐		◐	◐	◐	◐	◐		●	◐	◐	◐	◐
MS-PS3	Energy		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
MS-PS4	Waves and Their Applications in Technologies for Information Transfer								◐	◐	●	◐	◐						◐
Life Science																			
MS-LS1	From Molecules to Organisms																		
MS-LS2	Ecosystems									◐		◐	◐						
MS-LS3	Heredity																		
MS-LS4	Biological Evolution								◐	◐	◐								
Earth and Space Science																			
MS-ESS1	Earth's Place in the Universe																		
MS-ESS2	Earth's Systems										◐								
MS-ESS3	Earth and Human Activity																		
Engineering Design																			
MS-ETS1	Engineering Design		●	●	●	●			●	●	●	●	●		●	●	●	●	●

Objective Number	Common Core Mathematics Standards ● = addresses standard ◐ = partially addresses standard	Make It Move						Make It Smarter						Make a System					
		Video	With Wheels	And Display Speed	Without Wheels	Up an Incline	In a Pattern	Video	With a Sensor	And Faster	And Adaptable	With Communication	And Healthier	Video	That Moves a Ball	That Picks and Places	That Manufactures	That Sorts Colors	That Communicates
Practices																			
1.1	Make sense of problems and persevere in solving them		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
1.2	Reason abstractly and quantitatively		●	●		●	●		●	●	●		●		●	●	●	●	●
1.3	Construct viable arguments and critique the reasoning of others	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
1.4	Model with mathematics		●	●		●	●		●		●				●	●	●	●	
1.5	Use appropriate tools strategically	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
1.6	Attend to precision		●	●		●	●			●					●	●	●	●	●
1.7	Look for and make use of structure																		
1.8	Look for and express regularity in repeated reasoning																		
Ratios and Proportional Relationships																			
Grade 6	Understand ratio concepts and use ratio reasoning to solve problems		●	●		●	●												
Grade 7	Analyze proportional relationships and use them to solve real-world and mathematical problems		●	●		●	●				●								
The Number System																			
Grade 6	Apply and extend previous understandings of multiplication and division to divide fractions by fractions		◐	◐															
Grade 6	Compute fluently with multidigit numbers and find common factors and multiples		●	●		●			●		●		●						
Grade 6	Apply and extend previous understandings of numbers to the system of rational numbers																		
Grade 7	Apply and extend previous understandings of operations with fractions to add, subtract, multiply and divide rational numbers		●	●		●	●		●		●		●						
Grade 8	Understand that there are numbers that are not rational, and approximate them by rational numbers		●	●															
Expressions and Equations																			
Grade 6	Apply and extend previous understandings of arithmetic to algebraic expressions		●	●		●			●		●								
Grade 6	Reason about and solve one-variable equations and inequalities																		
Grade 6	Represent and analyze quantitative relationships between dependent and independent variables		●	●															
Grade 7	Use properties of operations to generate equivalent expressions																		
Grade 7	Solve real-life and mathematical problems using numerical and algebraic expressions and equations		●	●															
Grade 8	Work with radicals and integer exponents																		
Grade 8	Understand the connections between proportional relationships, lines and linear equations									●									
Grade 8	Analyze and solve linear equations and pairs of simultaneous linear equations																		
Functions																			
Grade 8	Define, evaluate and compare functions																		
Grade 8	Use functions to model relationships between quantities																		

Continues...

Continued from previous page

Objective Number	Common Core Mathematics Standards ● = addresses standard ◐ = partially addresses standard	Make It Move						Make It Smarter						Make a System					
		Video	With Wheels	And Display Speed	Without Wheels	Up an Incline	In a Pattern	Video	With a Sensor	And Faster	And Adaptable	With Communication	And Healthier	Video	That Moves a Ball	That Picks and Places	That Manufactures	That Sorts Colors	That Communicates
Geometry																			
Grade 6	Solve real-world and mathematical problems involving area, surface area and volume																		
Grade 7	Draw, construct and describe geometrical figures and the relationship between them						●									●			
Grade 7	Solve real-life and mathematical problems involving angle measure, area, surface area and volume															●	●		
Grade 8	Understand congruence and similarity using physical models, transparencies or geometry software		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
Grade 8	Understand the Pythagorean theorem					◐													
Grade 8	Solve real-world and mathematical problems involving volume of cylinders, cones and spheres																		
Statistics and Probability																			
Grade 6	Develop an understanding of statistical variability																		
Grade 6	Summarize and describe distributions																		
Grade 7	Use random sampling to draw inferences about a population																		
Grade 7	Investigate chance processes and develop, use and evaluate probability models																		
Grade 8	Investigate patterns of association in bivariate data																		

ITEEA Standards for Technological Literacy

● = addresses standard
◐ = partially addresses standard

Standard		Make It Move						Make It Smarter						Make a System					
		Video	With Wheels	And Display Speed	Without Wheels	Up an Incline	In a Pattern	Video	With a Sensor	And Faster	And Adaptable	With Communication	And Healthier	Video	That Moves a Ball	That Picks and Places	That Manufactures	That Sorts Colors	That Communicates
The Nature of Technology																			
1	Students will develop an understanding of the characteristics and scope of technology	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
2	Students will develop an understanding of the core concepts of technology	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
3	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Technology and Society																			
4	Students will develop an understanding of the cultural, social, economic and political effects of technology	●						●						●					
5	Students will develop an understanding of the effects of technology on the environment	●						●						●					
6	Students will develop an understanding of the role of society in the development and use of technology	●						●						●					
7	Students will develop an understanding of the influence of technology on history	●						●						●					
Design																			
8	Students will develop an understanding of the attributes of design		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
9	Students will develop an understanding of engineering design		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
10	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
Abilities for a Technological World																			
11	Students will develop abilities to apply the design process		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
12	Students will develop abilities to use and maintain technological products and systems	◐	◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
13	Students will develop abilities to assess the impact of products and systems		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
The Designed World																			
14	Students will develop an understanding of and be able to select and use medical technologies							◐						◐					
15	Students will develop an understanding of and be able to select and use agricultural and related biotechnologies							◐						◐					
16	Students will develop an understanding of and be able to select and use energy and power technologies	◐	●	●	●	●	●	◐	●	●	●	●	●	◐	●	●	●	●	●
17	Students will develop an understanding of and be able to select and use information and communication technologies							◐				◐		◐					◐
18	Students will develop an understanding of and be able to select and use transportation technologies	◐	◐	◐	◐	◐	◐							◐		◐		◐	◐
19	Students will develop an understanding of and be able to select and use manufacturing technologies													◐			◐		
20	Students will develop an understanding of and be able to select and use construction technologies																		

Standard	ISTE National Education Technology Standards ● = addresses standard ◐ = partially addresses standard	Make It Move						Make It Smarter						Make a System					
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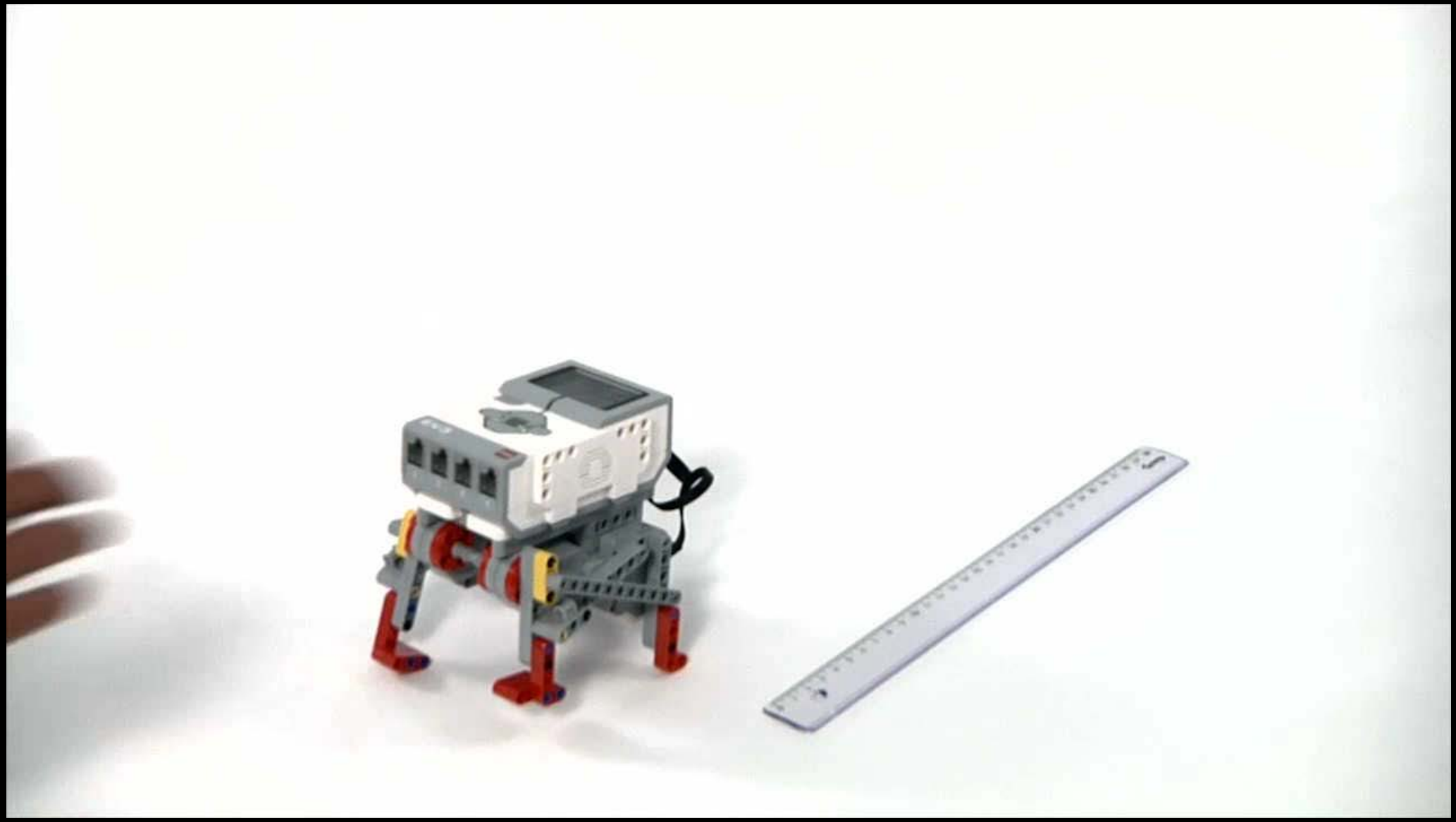
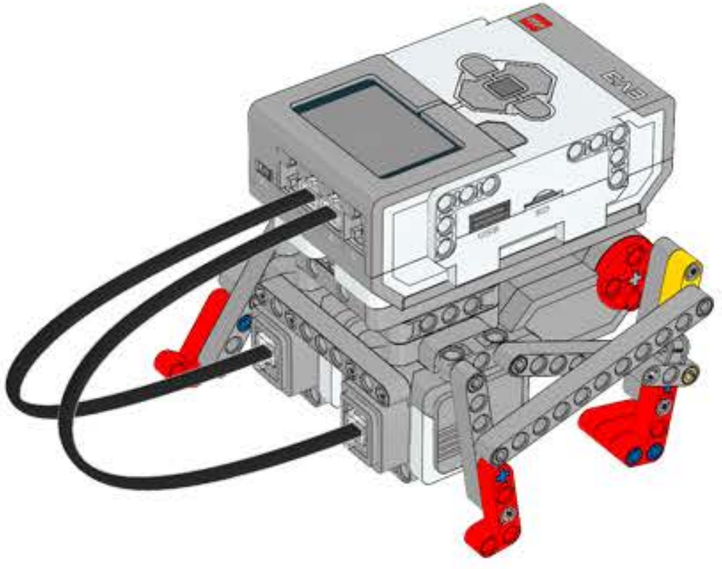
1. Creativity and Innovation																			
	Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.																		
a	Apply existing knowledge to generate new ideas, products or processes		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
b	Create original works as a means of personal or group expression		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
c	Use models and simulations to explore complex systems and issues		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
d	Identify trends and forecast possibilities	◐						◐						◐					
2. Communication and Collaboration																			
	Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.																		
a	Interact, collaborate and publish with peers, experts or others employing a variety of digital environments and media																		
b	Communicate information and ideas effectively to multiple audiences using a variety of media and formats		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
c	Develop cultural understanding and global awareness by engaging with learners of other cultures																		
d	Contribute to project teams to produce original works or solve problems		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
3. Research and Information Fluency																			
	Students apply digital tools to gather, evaluate and use information.																		
a	Plan strategies to guide inquiry		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
b	Locate, organize, analyze, evaluate, synthesize and ethically use information from a variety of sources and media	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
c	Evaluate and select information sources and digital tools based on the appropriateness to specific tasks		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
d	Process data and report results		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
4. Critical Thinking, Problem Solving and Decision Making																			
	Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.																		
a	Identify and define authentic problems and significant questions for investigation		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
b	Plan and manage activities to develop a solution or complete a project		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
c	Collect and analyze data to identify solutions and/or make informed decisions		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
d	Use multiple processes and diverse perspectives to explore alternative solutions		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
5. Digital Citizenship																			
	Students understand human, cultural and societal issues related to technology and practice legal and ethical behavior.																		
a	Advocate and practice safe, legal, and responsible use of information and technology																		
b	Exhibit a positive attitude toward using technology that supports collaboration, learning and productivity		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
c	Demonstrate personal responsibility for lifelong learning																		
d	Exhibit leadership for digital citizenship																		
6. Technology Operations and Concepts																			
	Students demonstrate a sound understanding of technology concepts, systems and operations.																		
a	Understand and use technology systems		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
b	Select and use applications effectively and productively		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐		◐	◐	◐	◐	◐
c	Troubleshoot systems and applications		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●
d	Transfer current knowledge to learning of new technologies		●	●	●	●	●		●	●	●	●	●		●	●	●	●	●

Medical Robots in Action video

Walker Bot video





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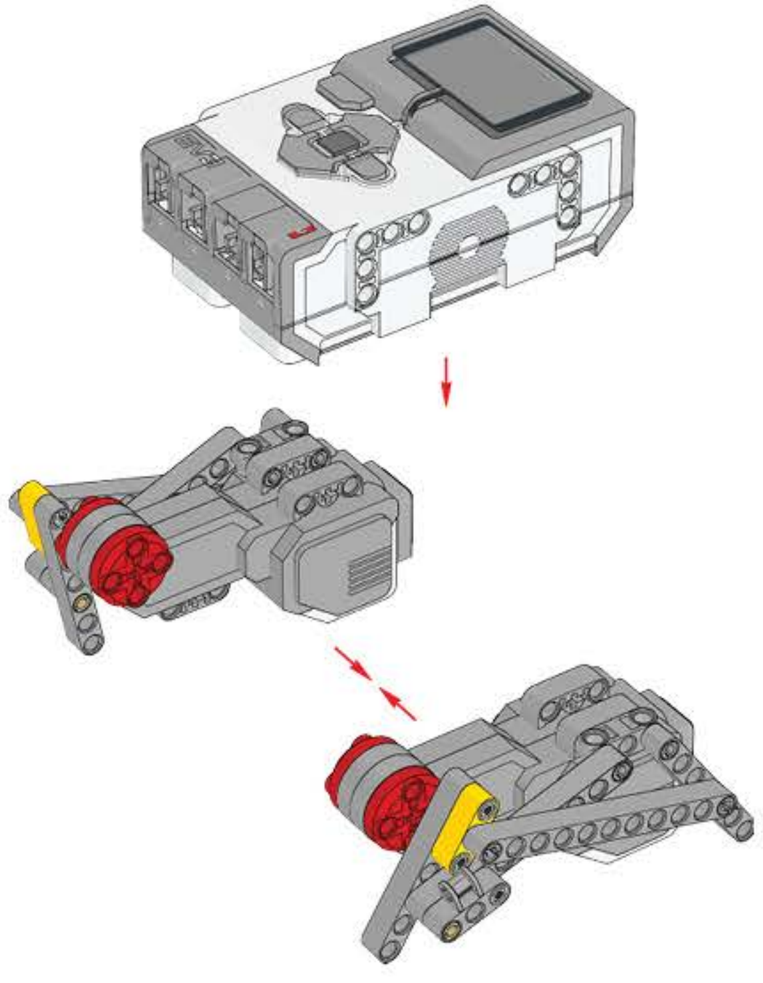

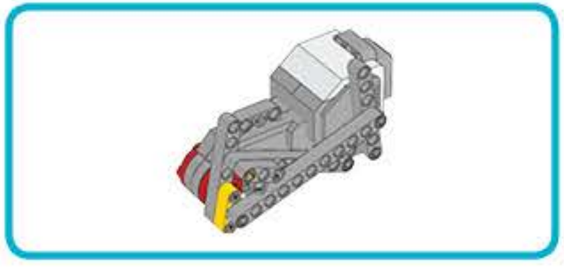

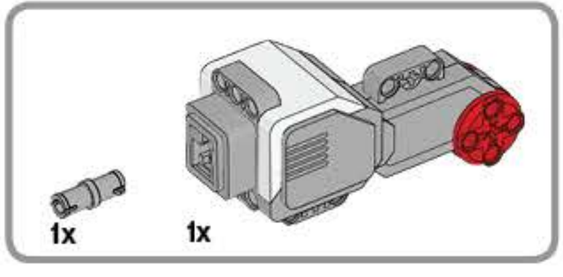

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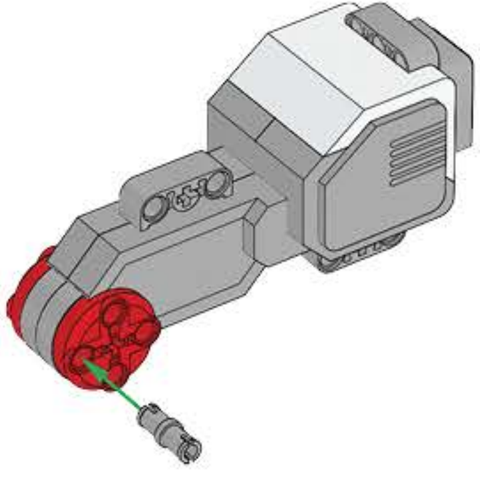

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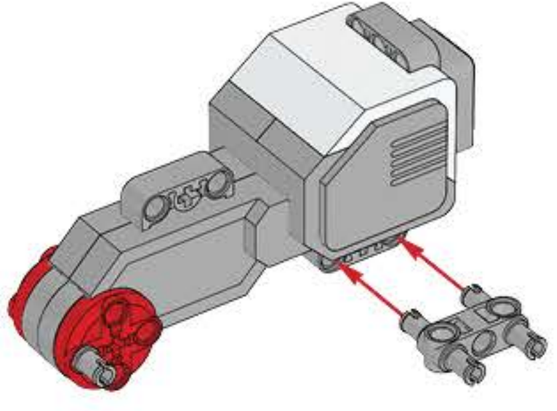

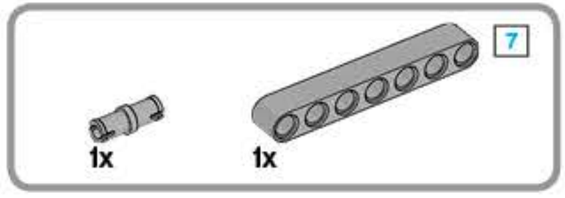

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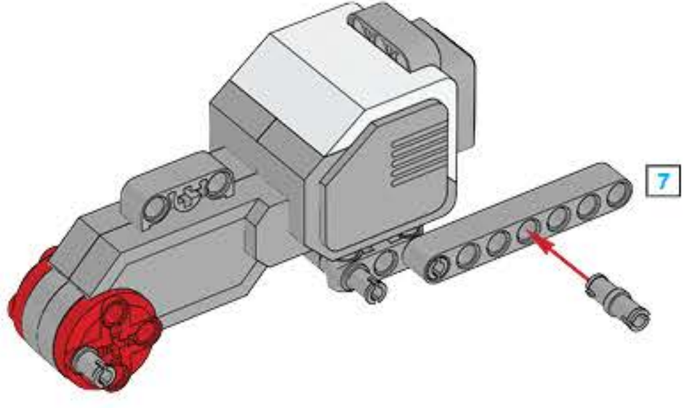

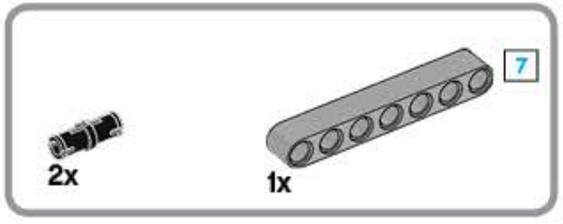

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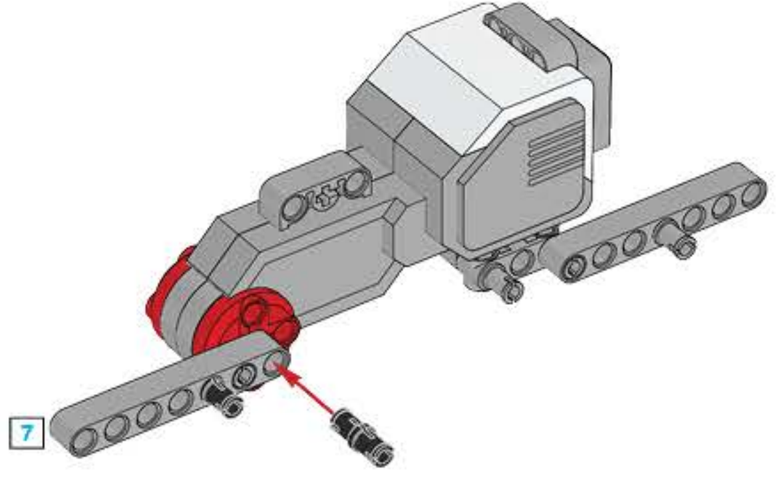

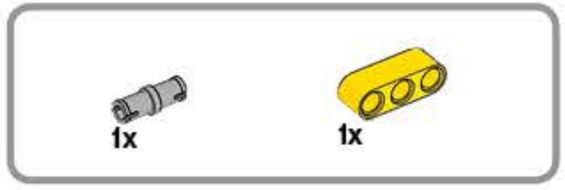

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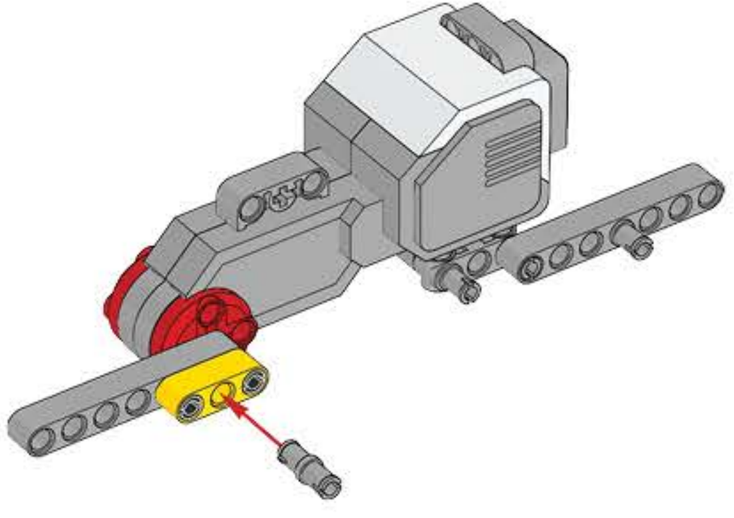

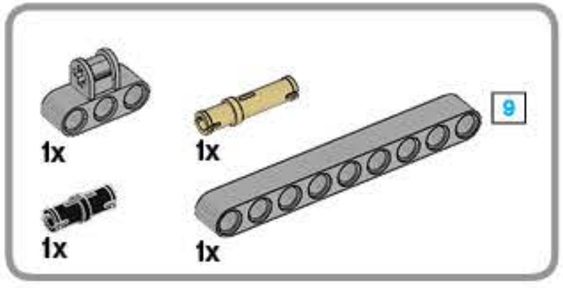

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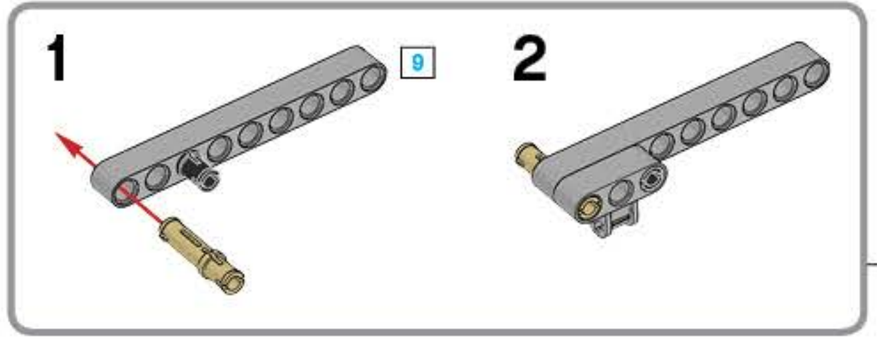

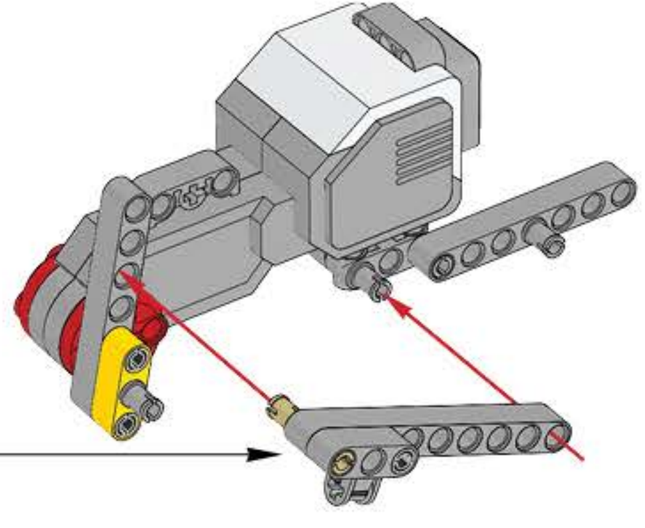

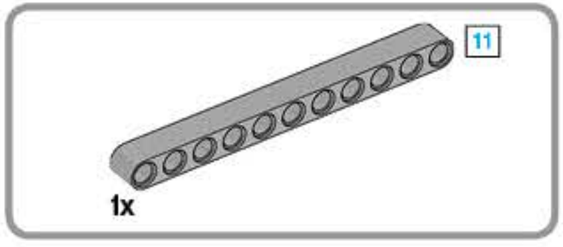

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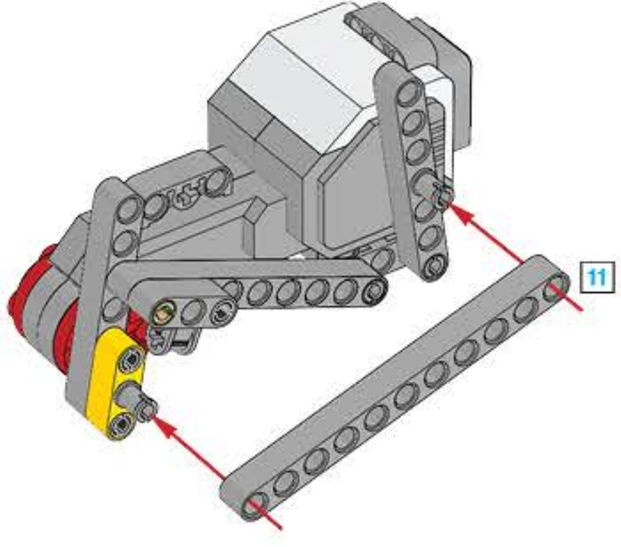

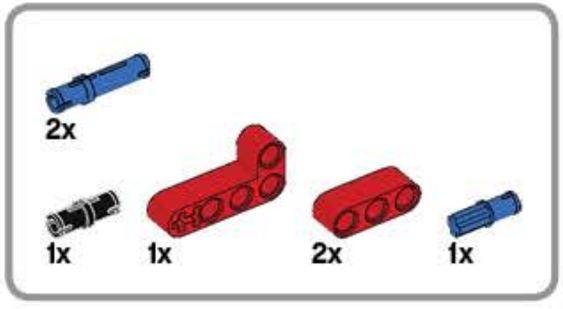

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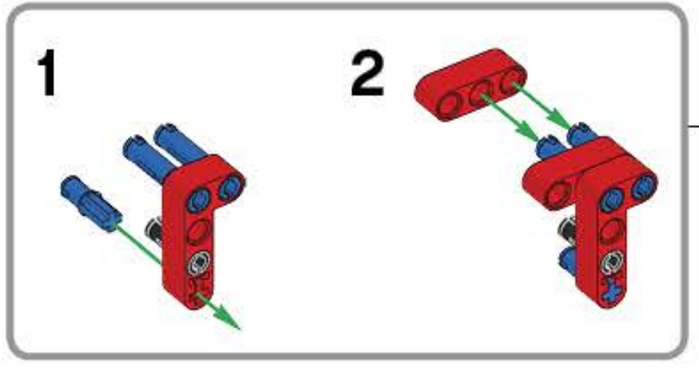

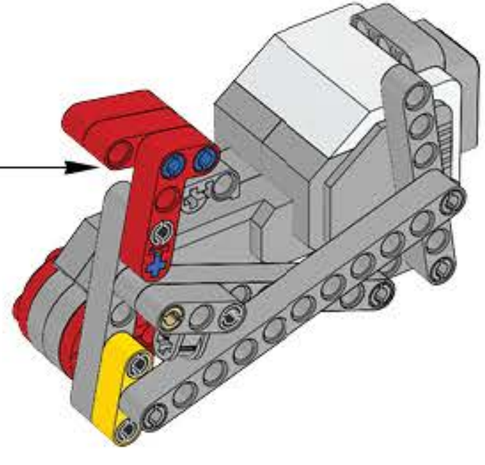

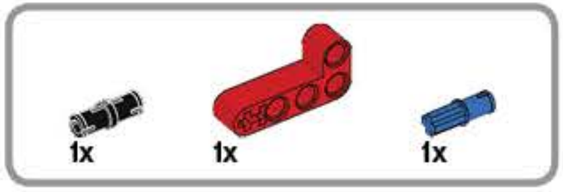

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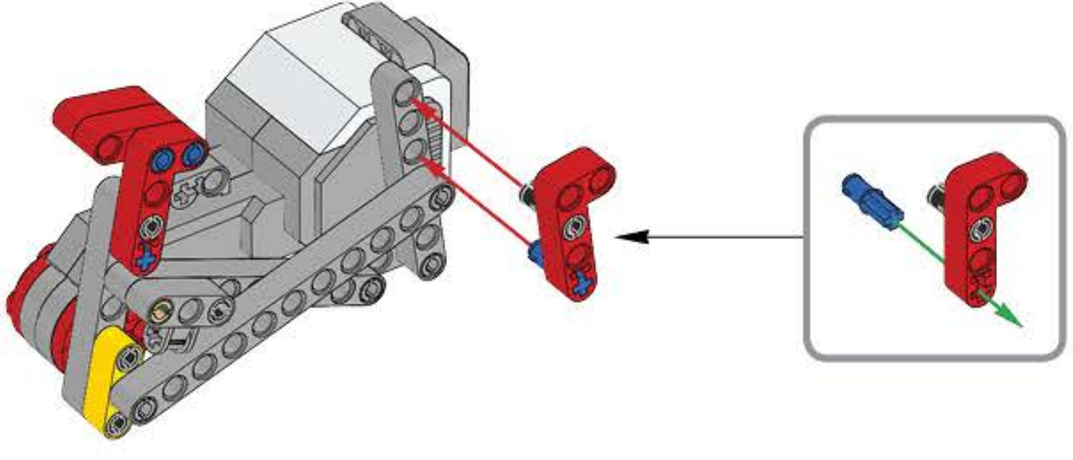

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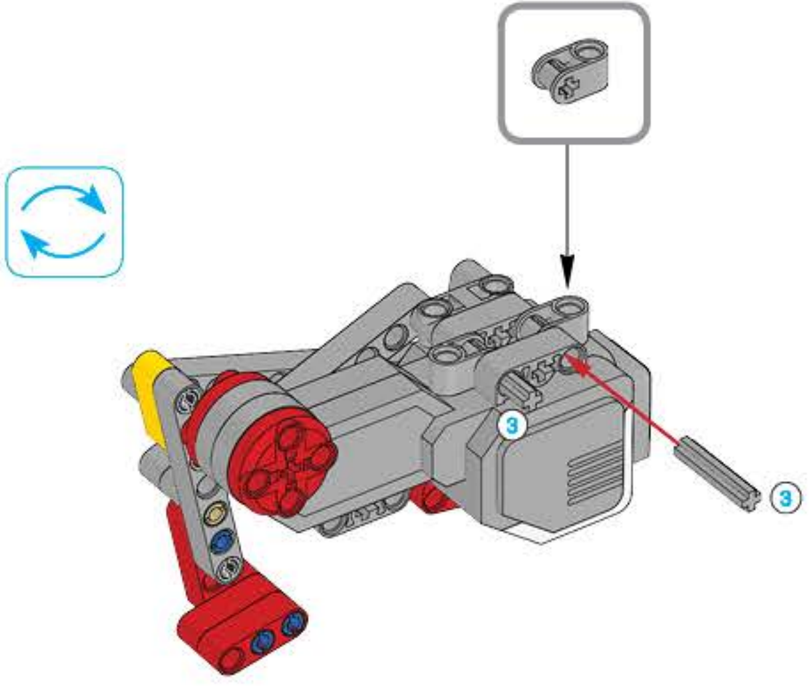

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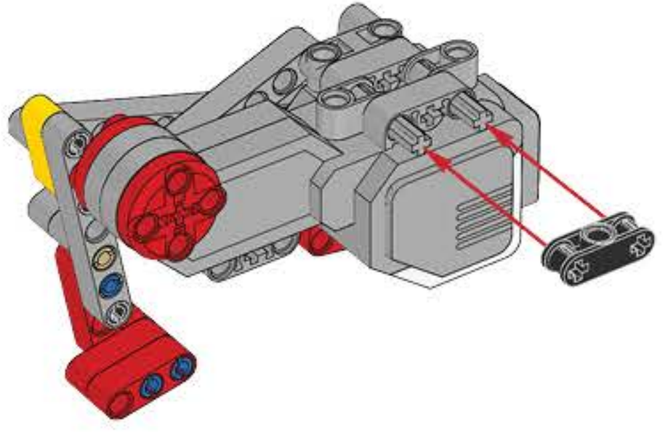

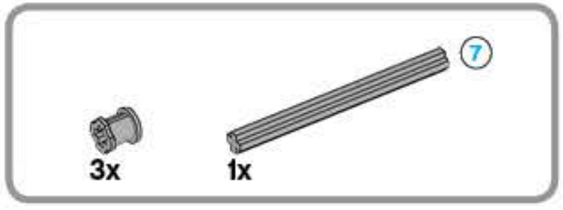

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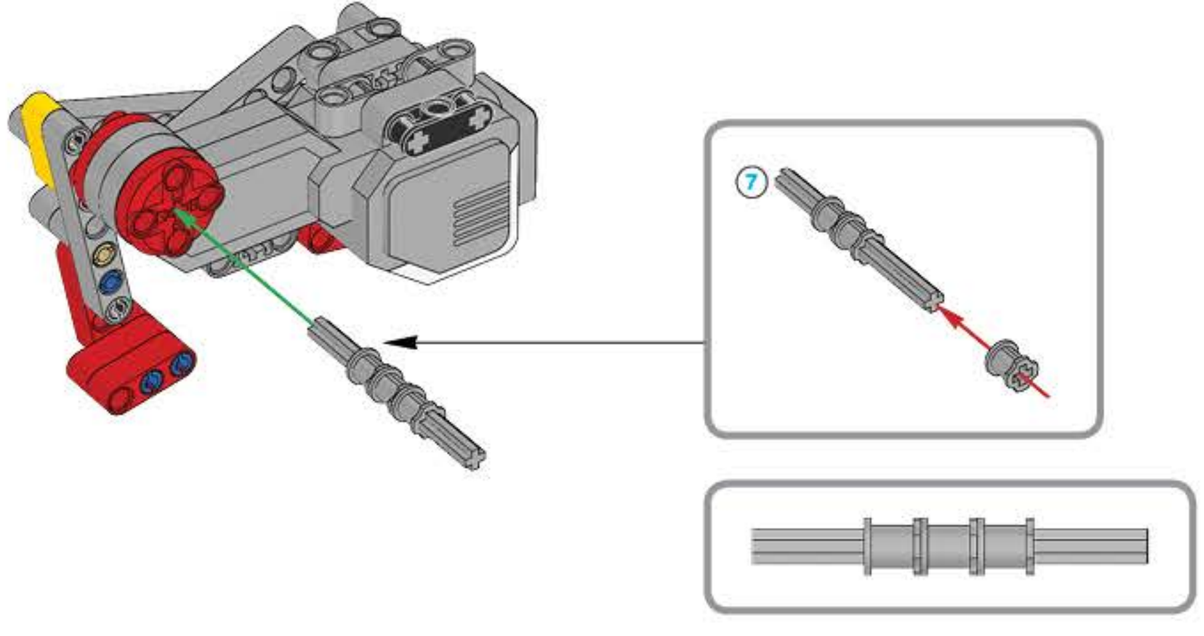

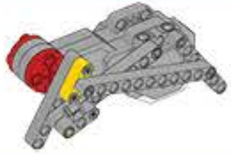

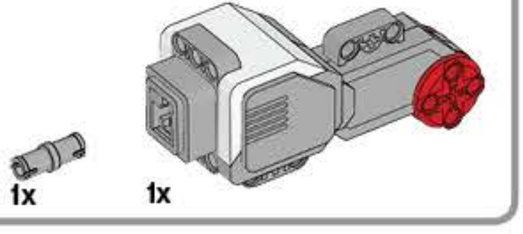

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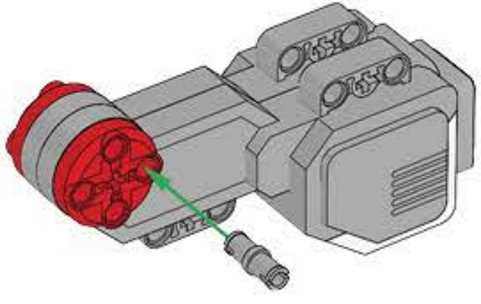

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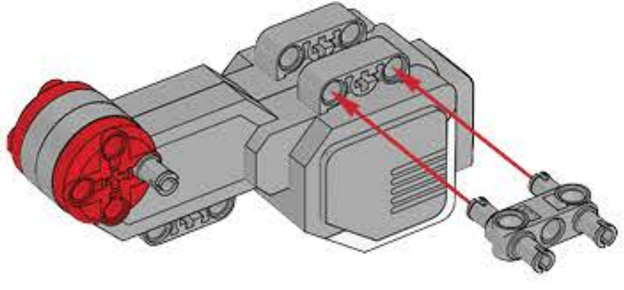

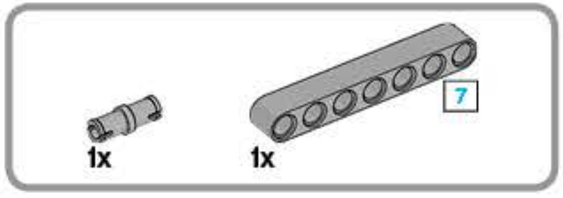

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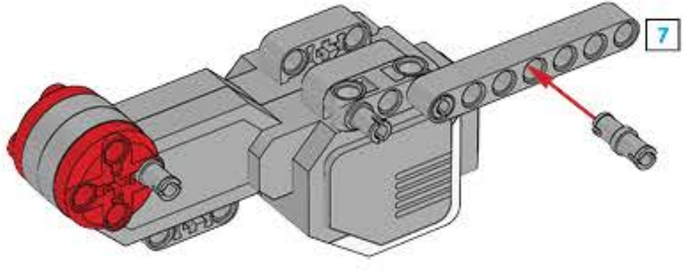

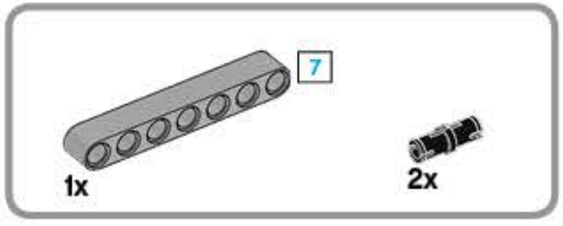

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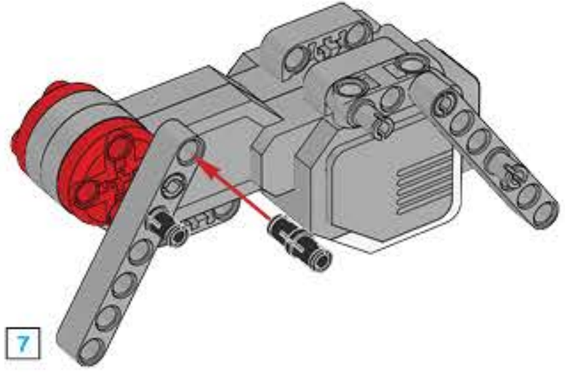

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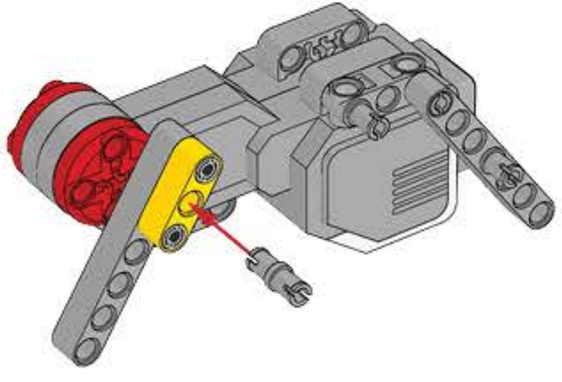

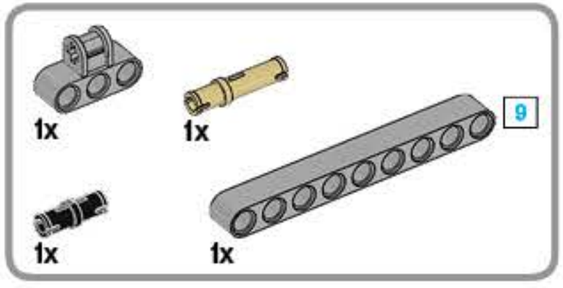

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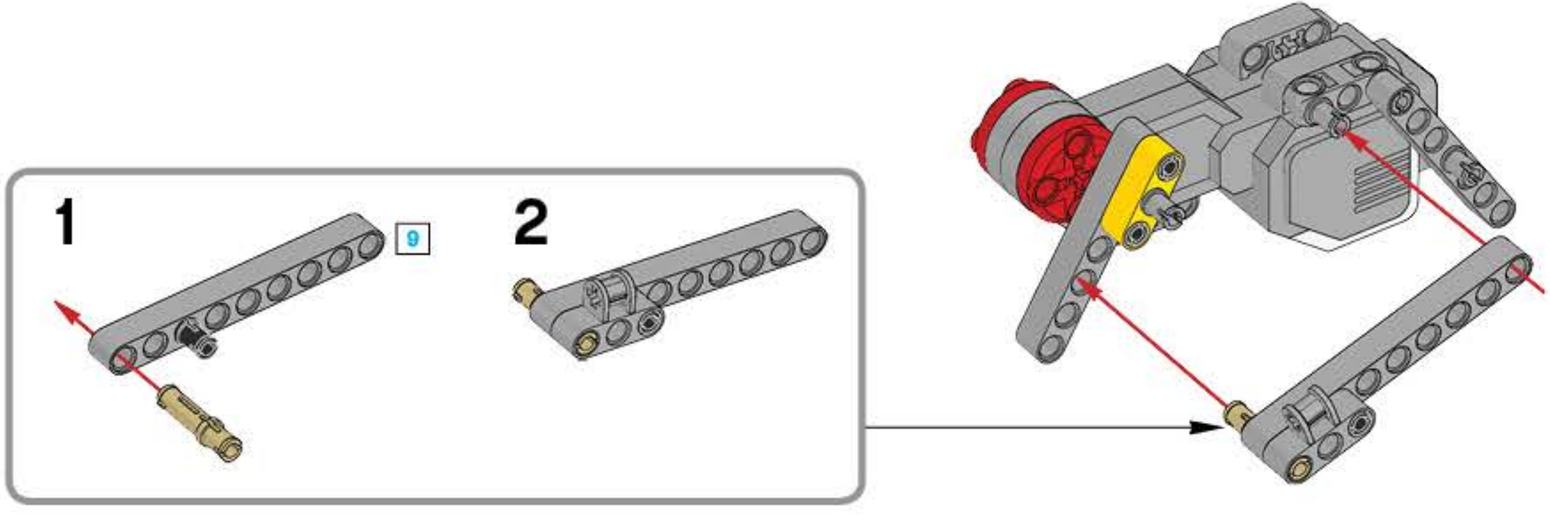

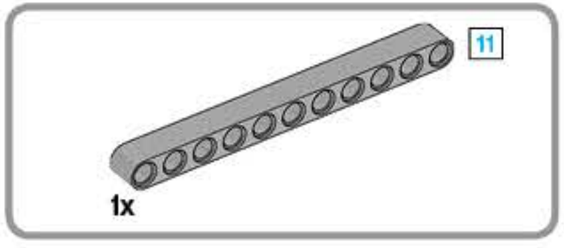

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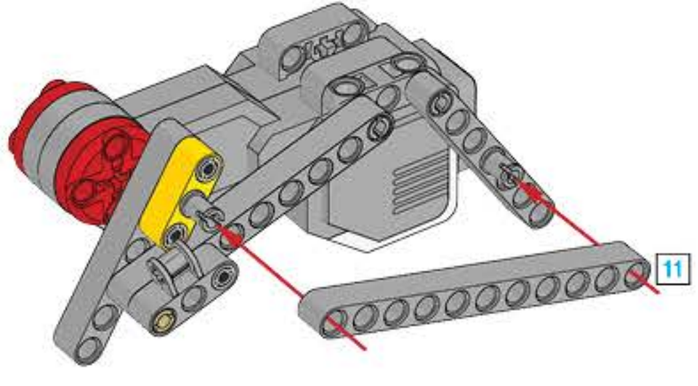

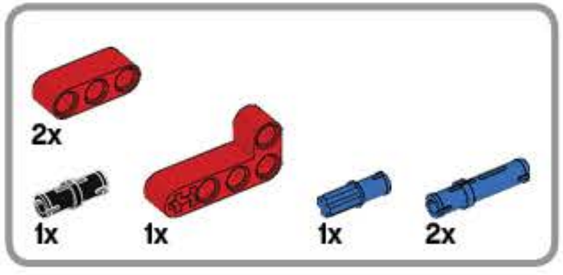

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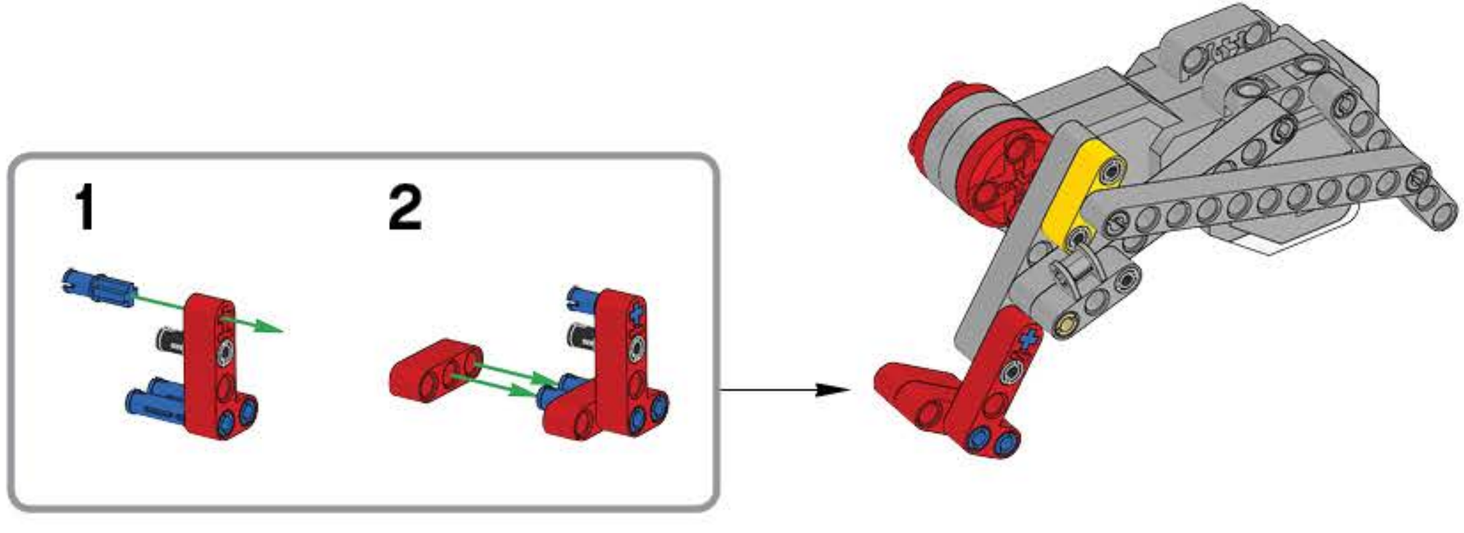

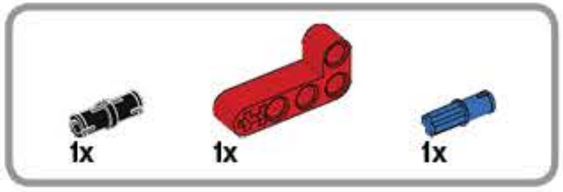

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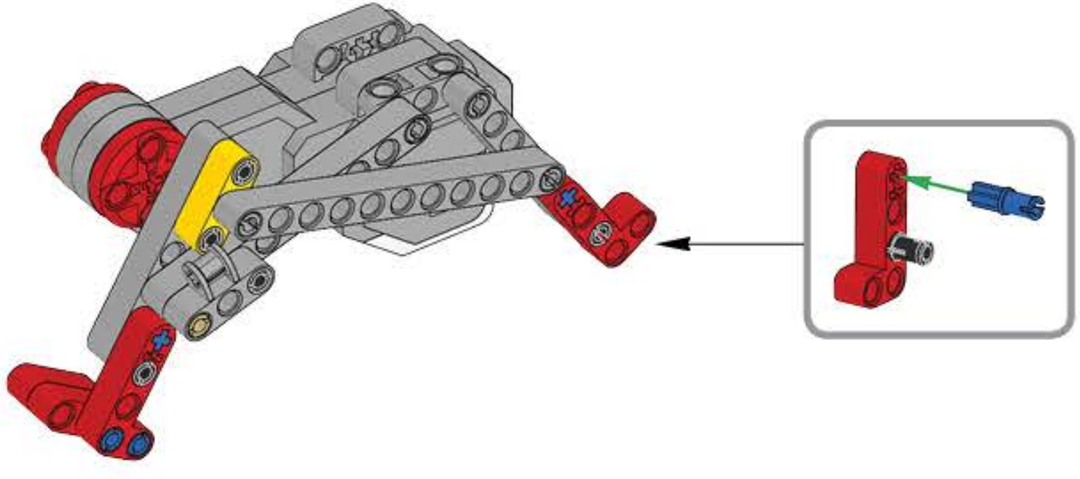

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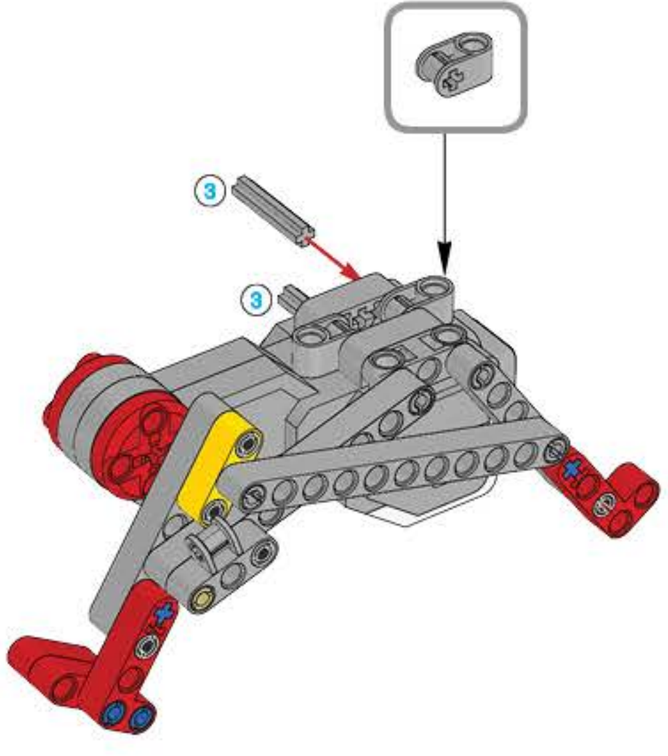

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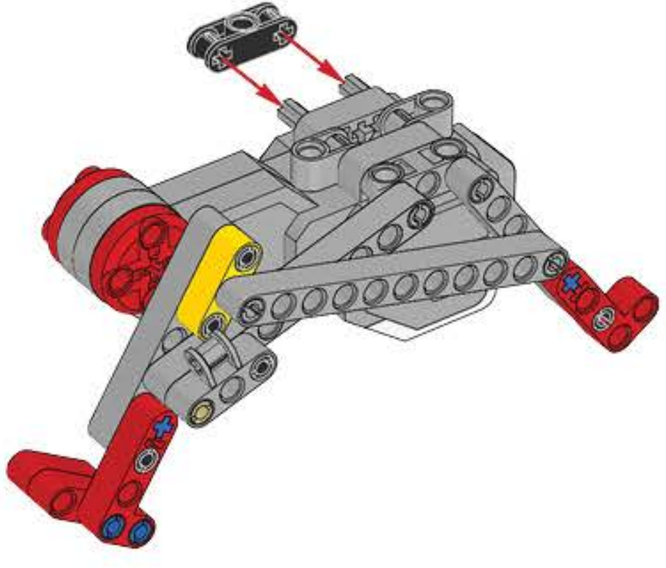

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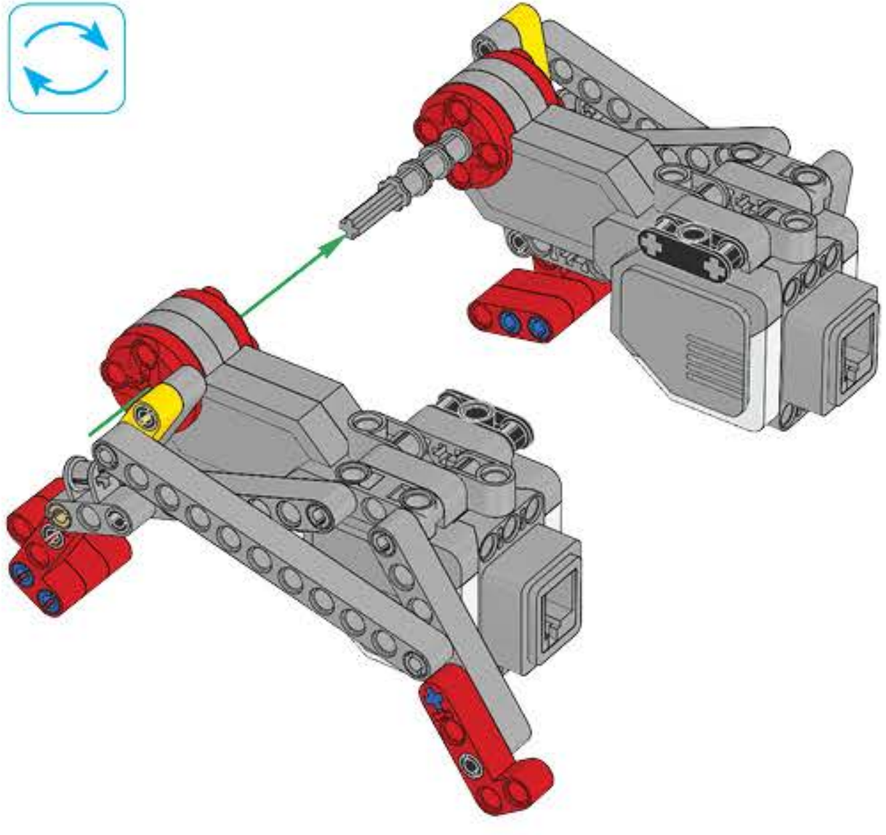

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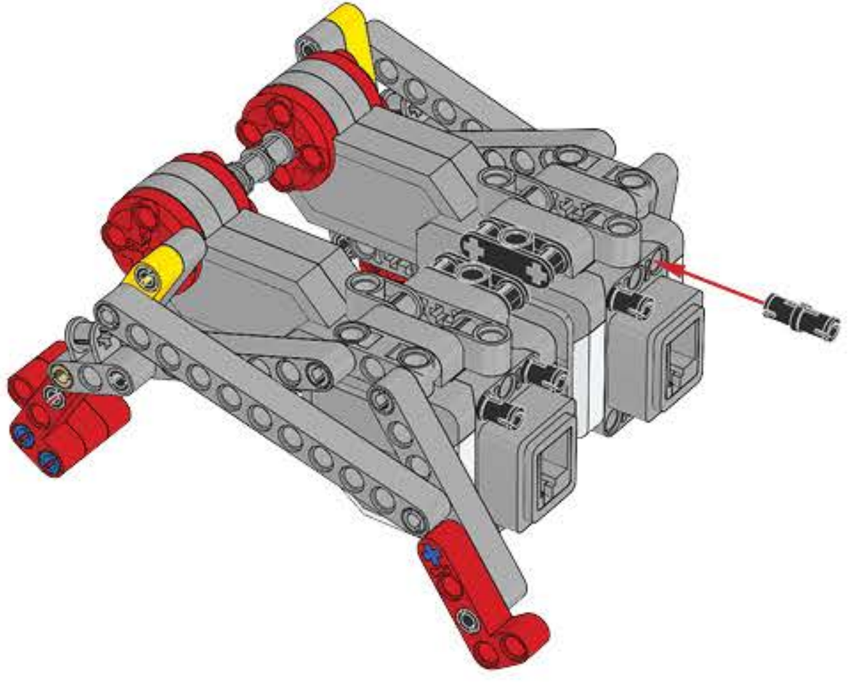

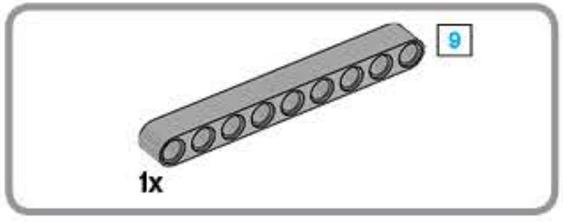

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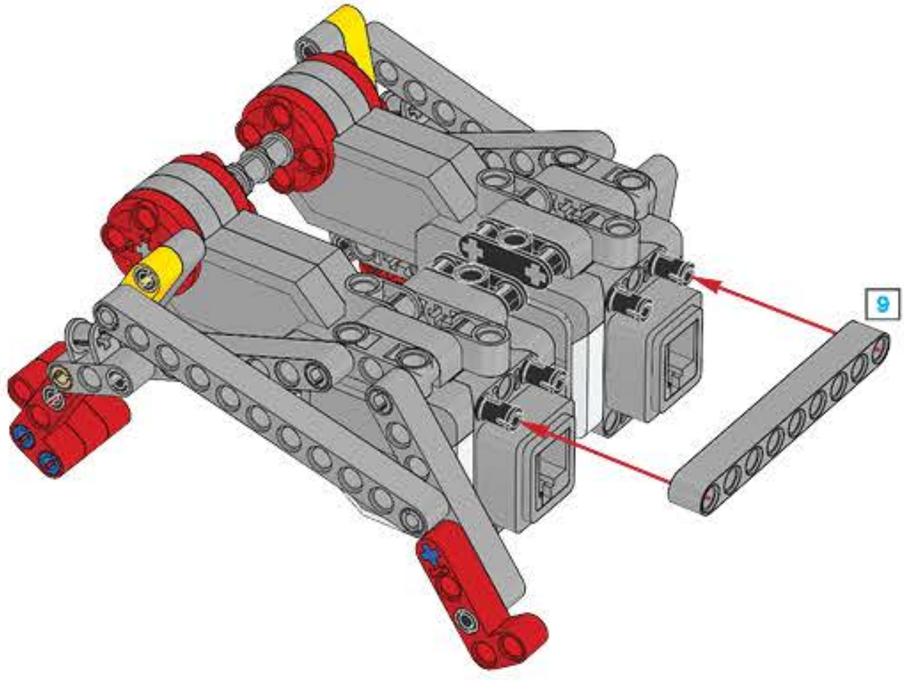

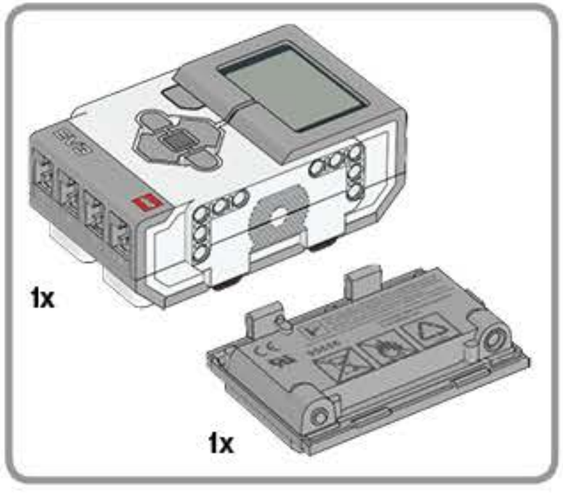

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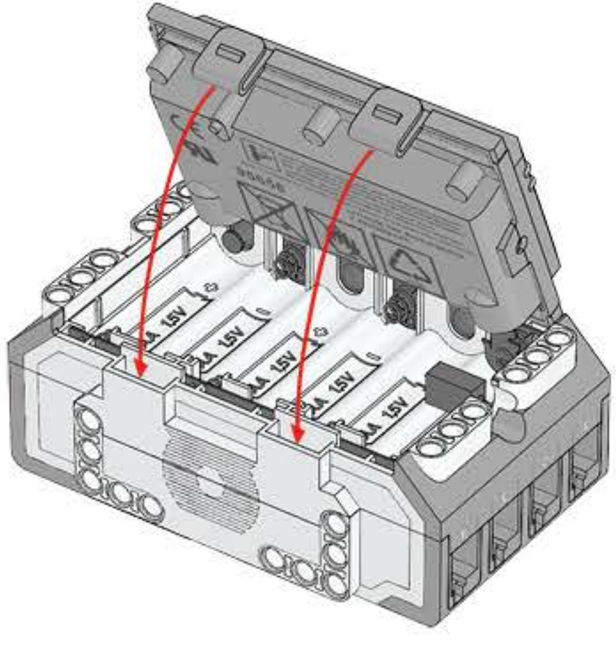

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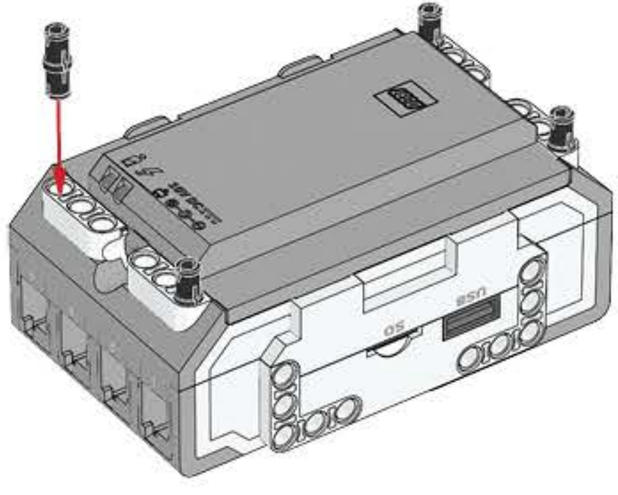

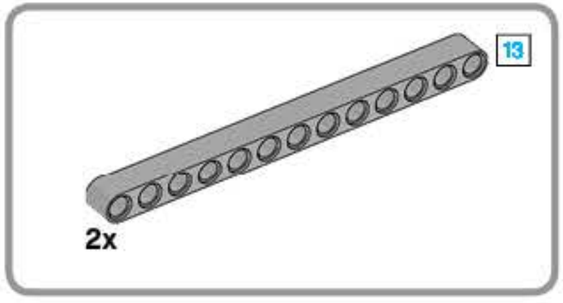

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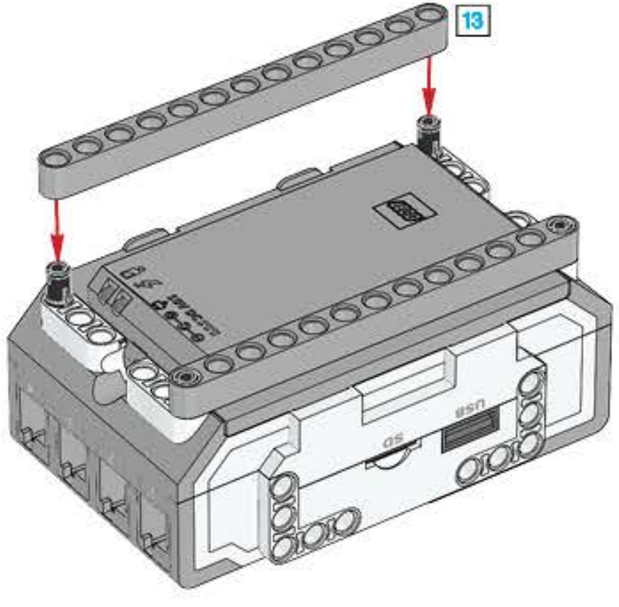

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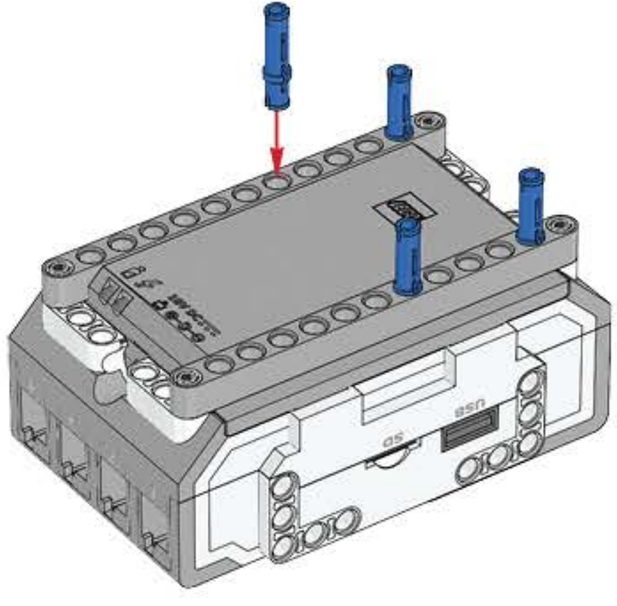

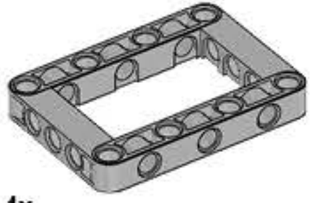

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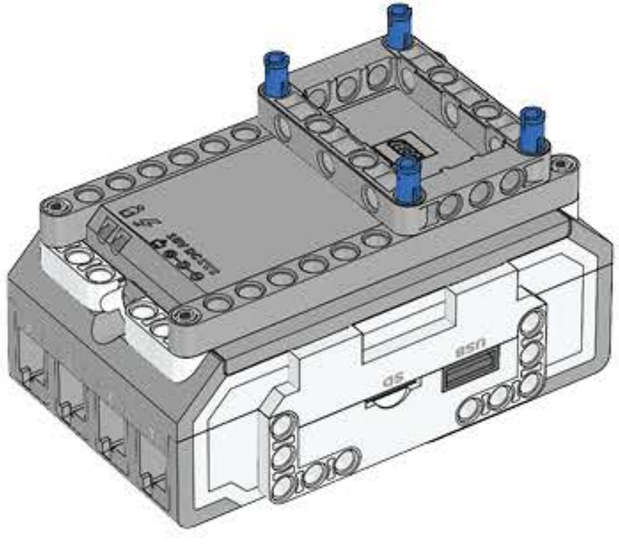

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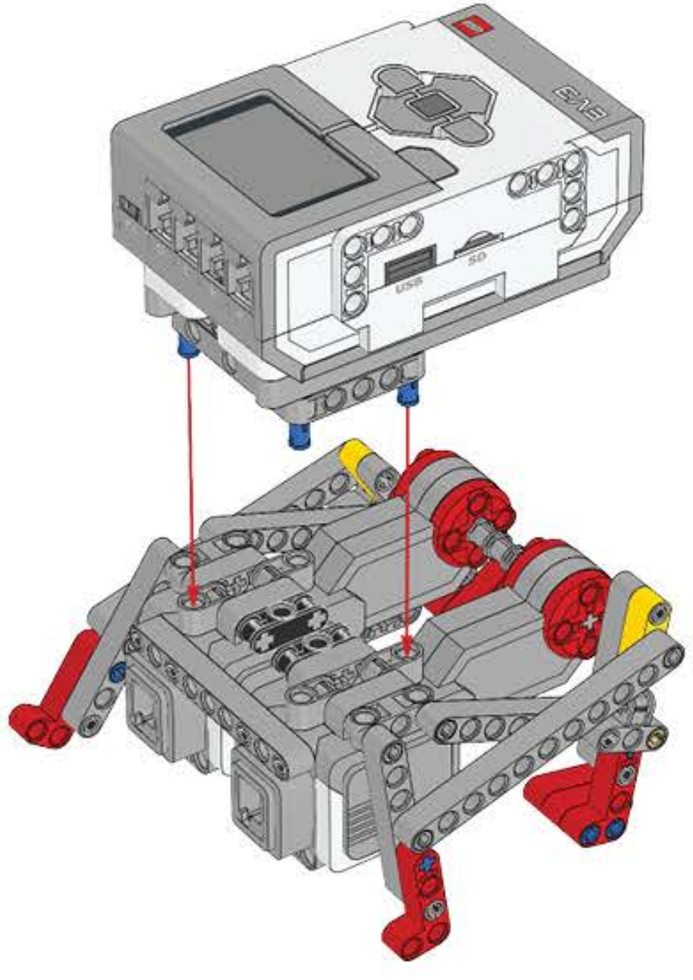

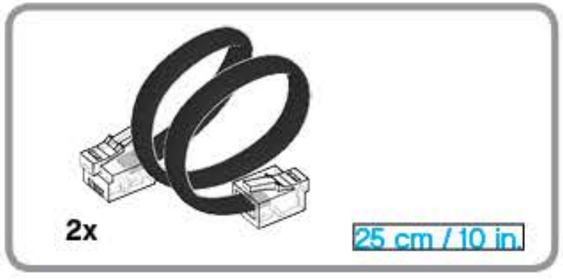

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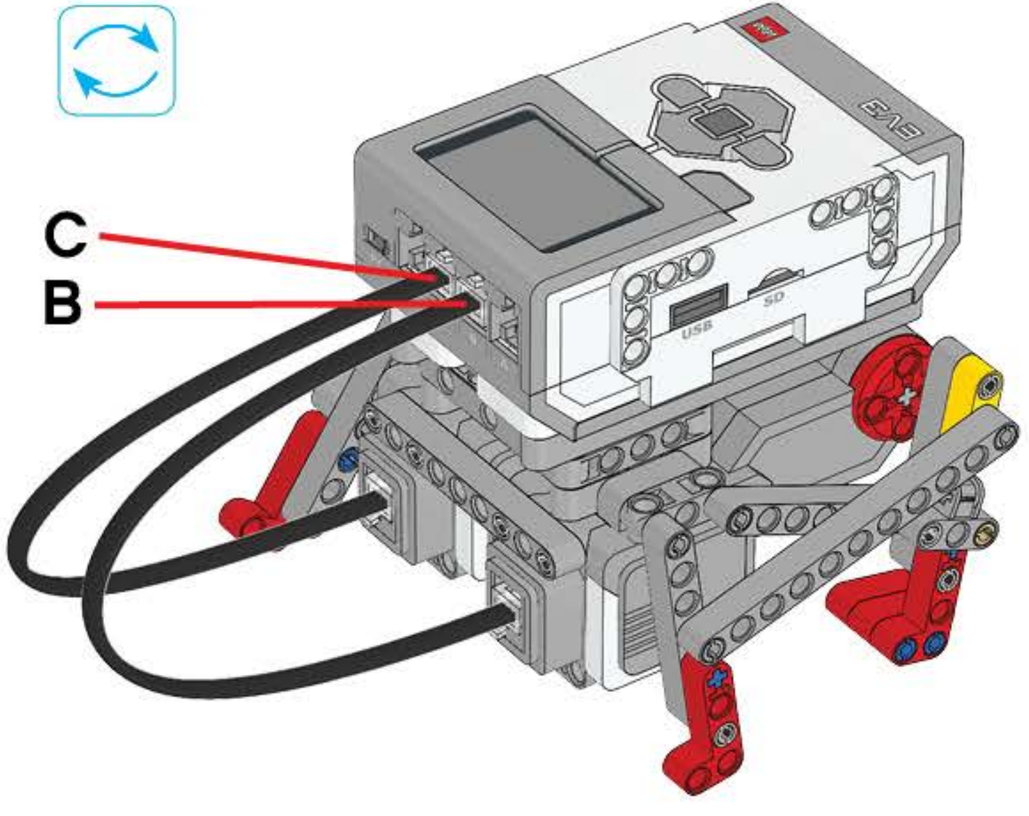

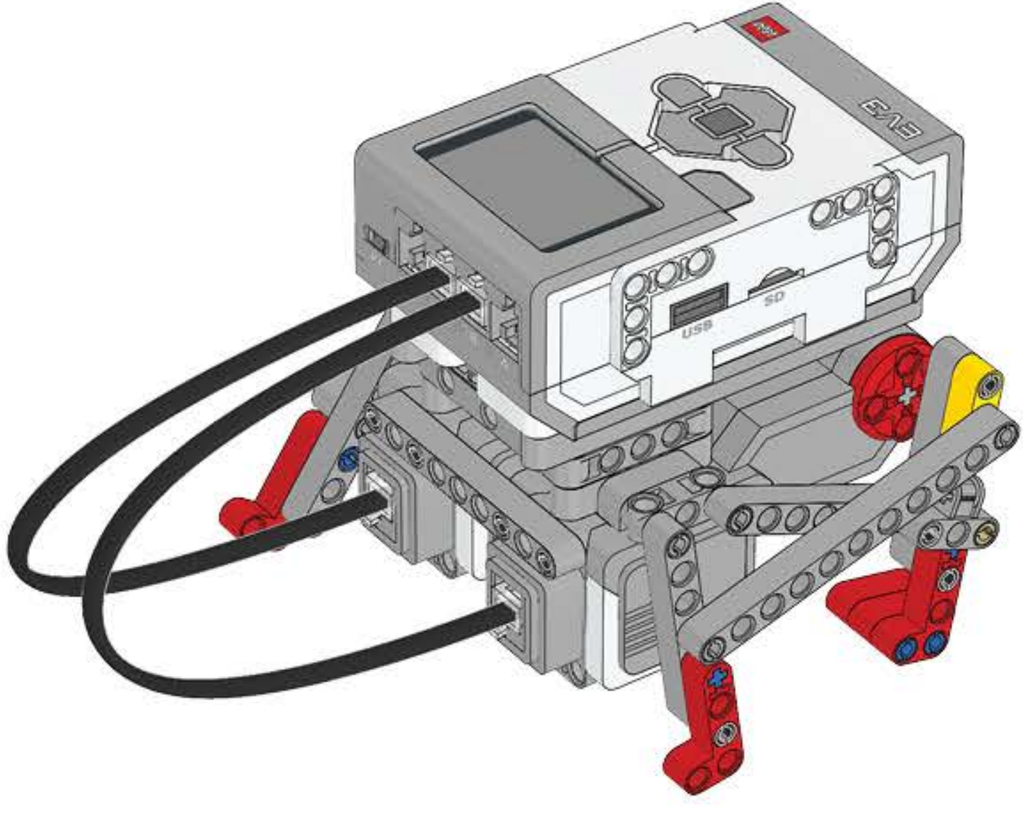
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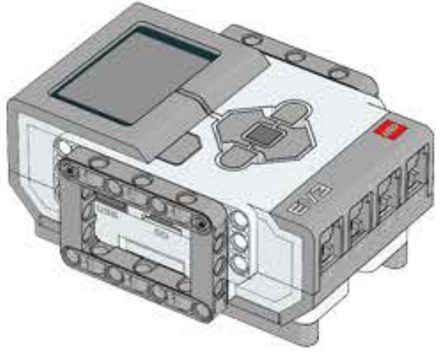

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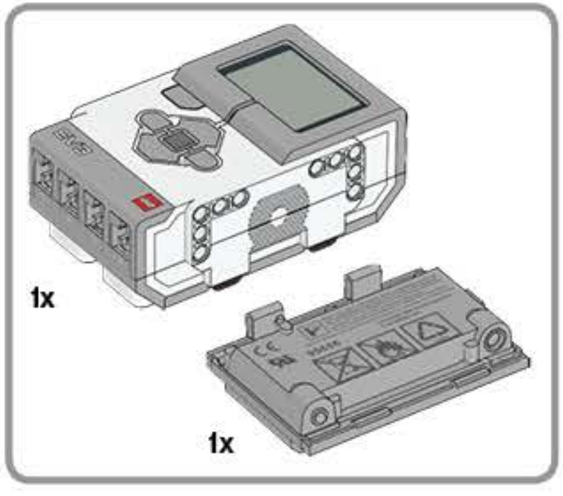

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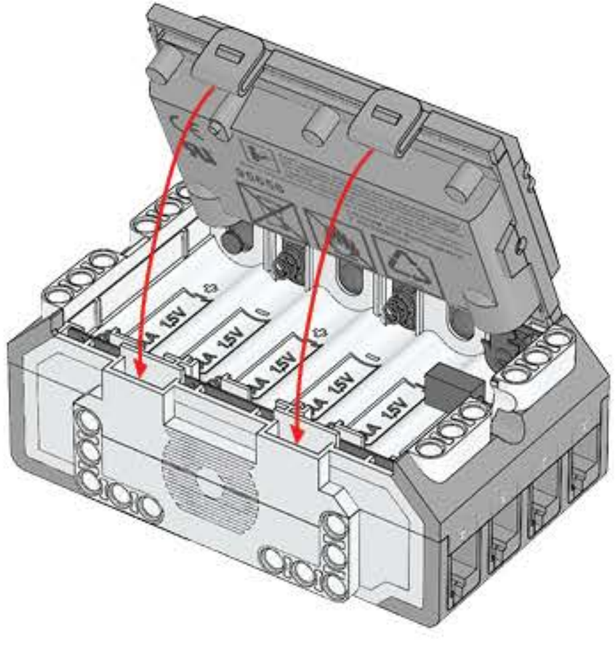

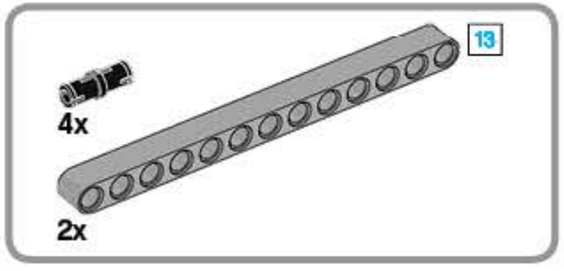

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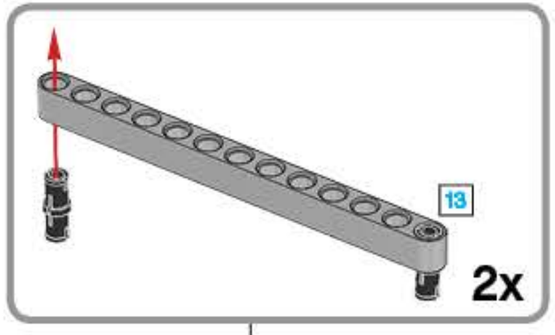

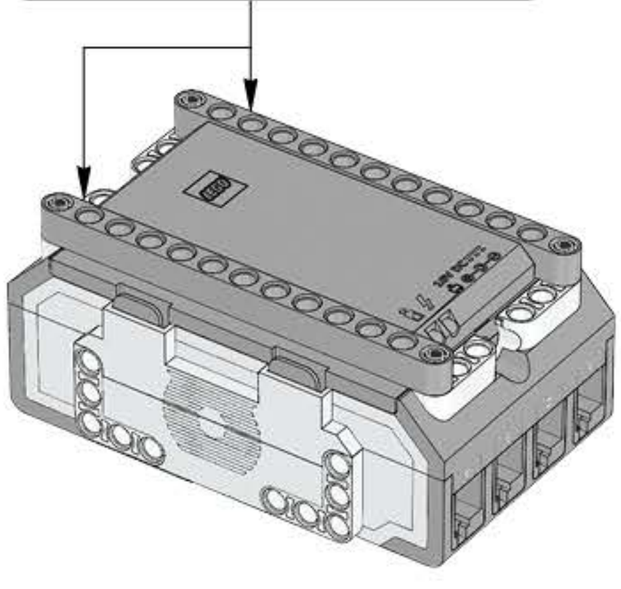

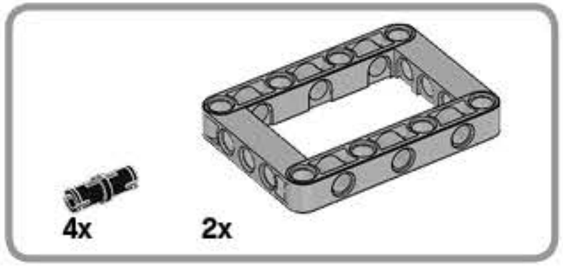

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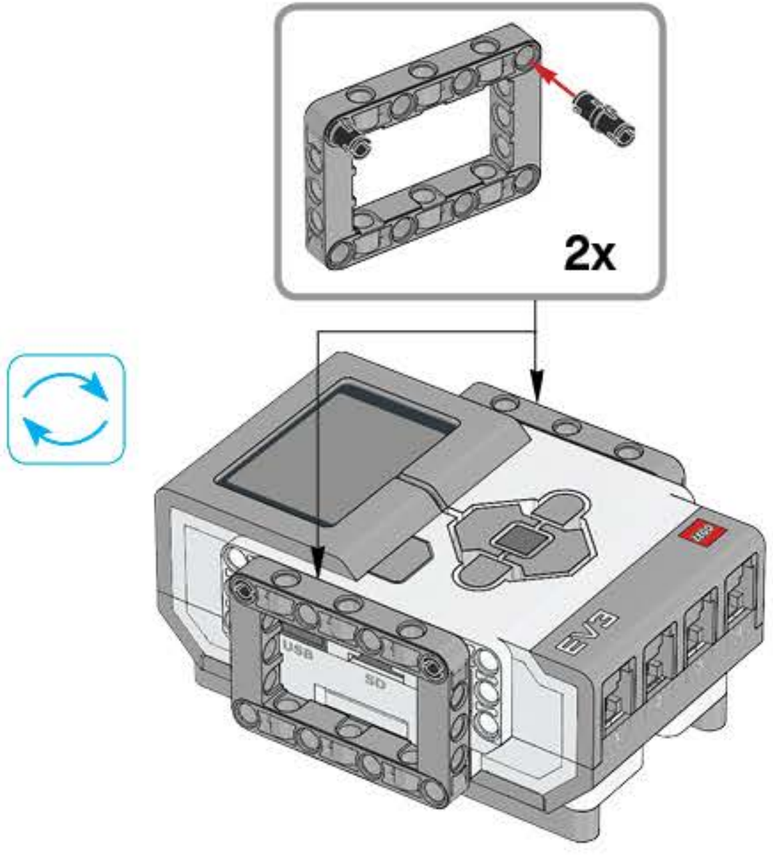

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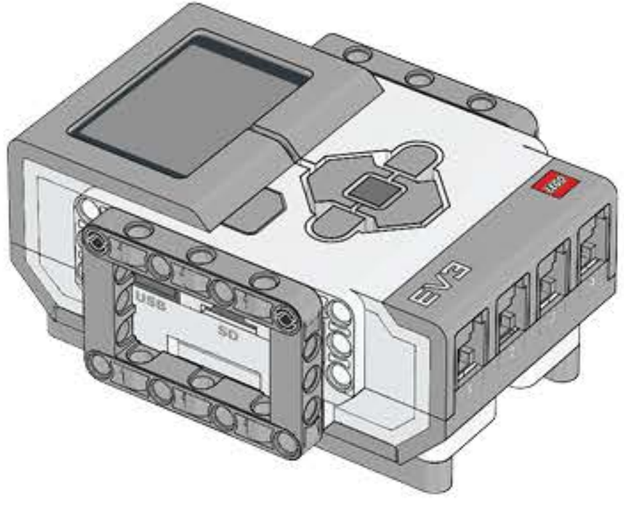

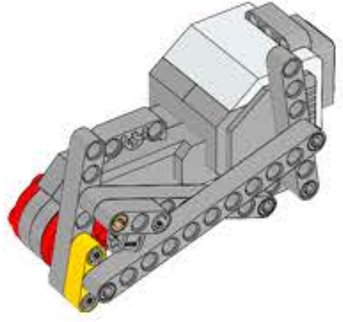

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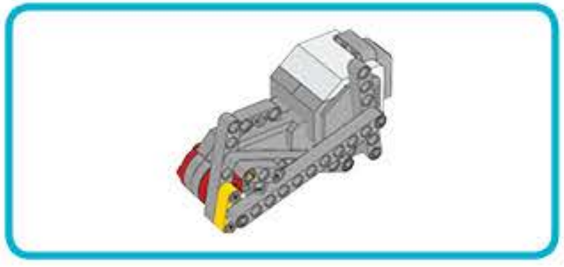

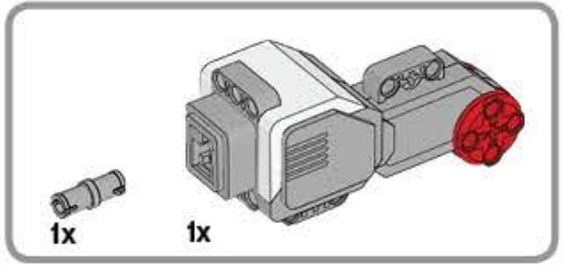

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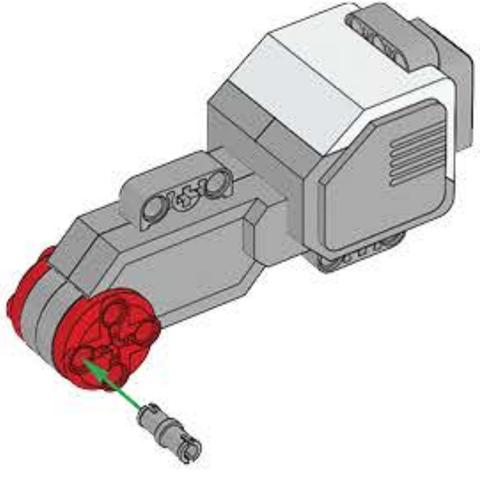

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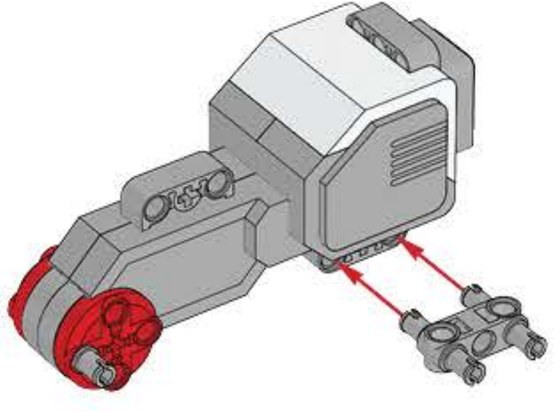

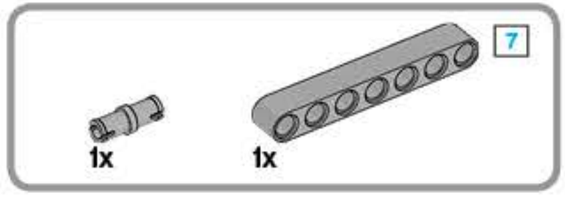

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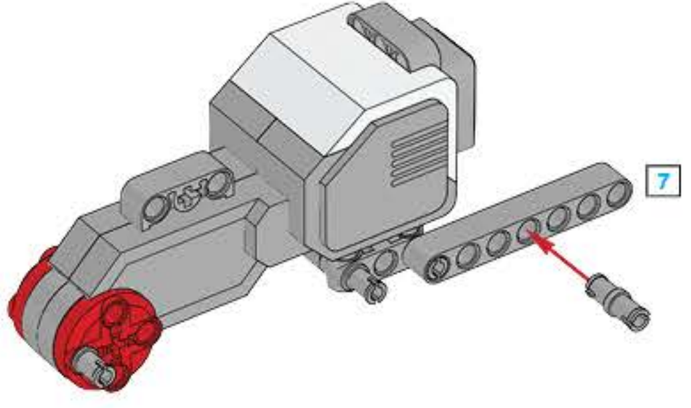

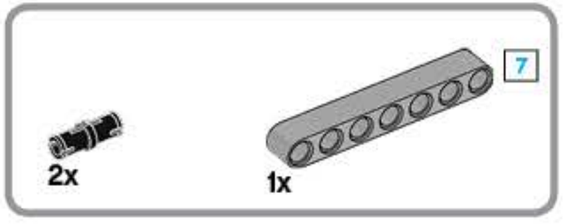

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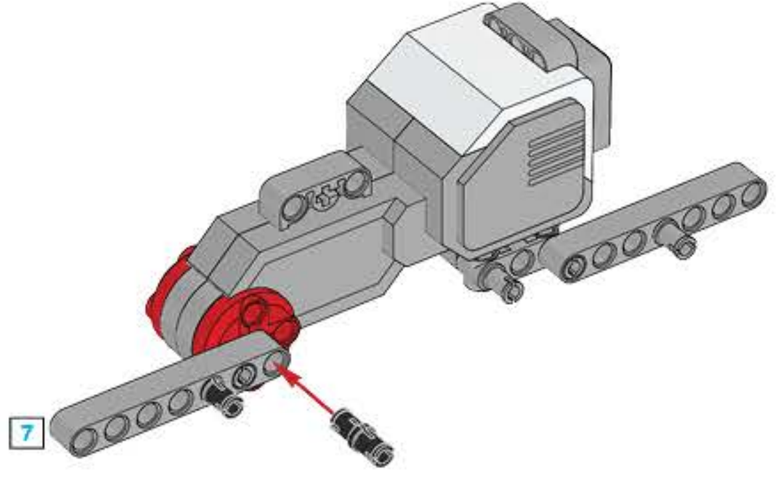

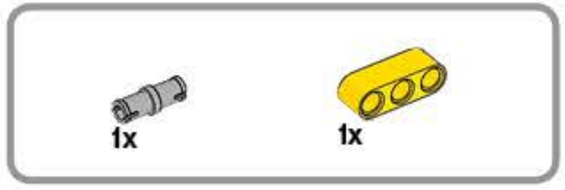

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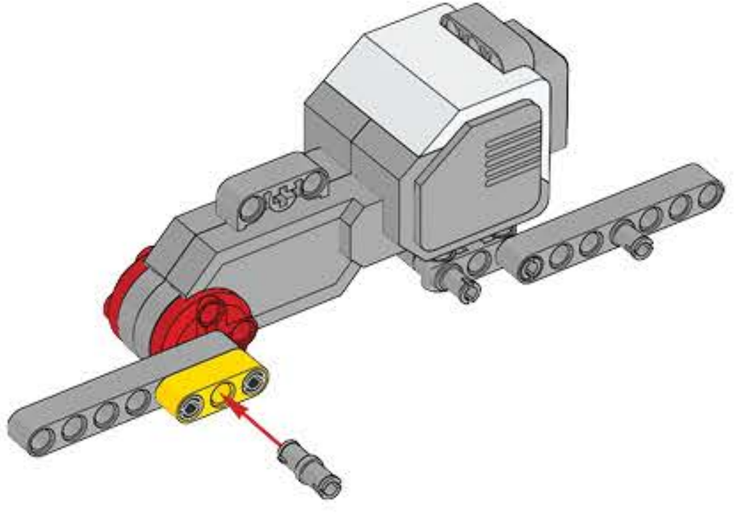

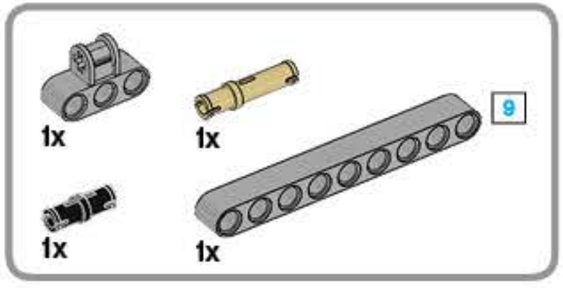

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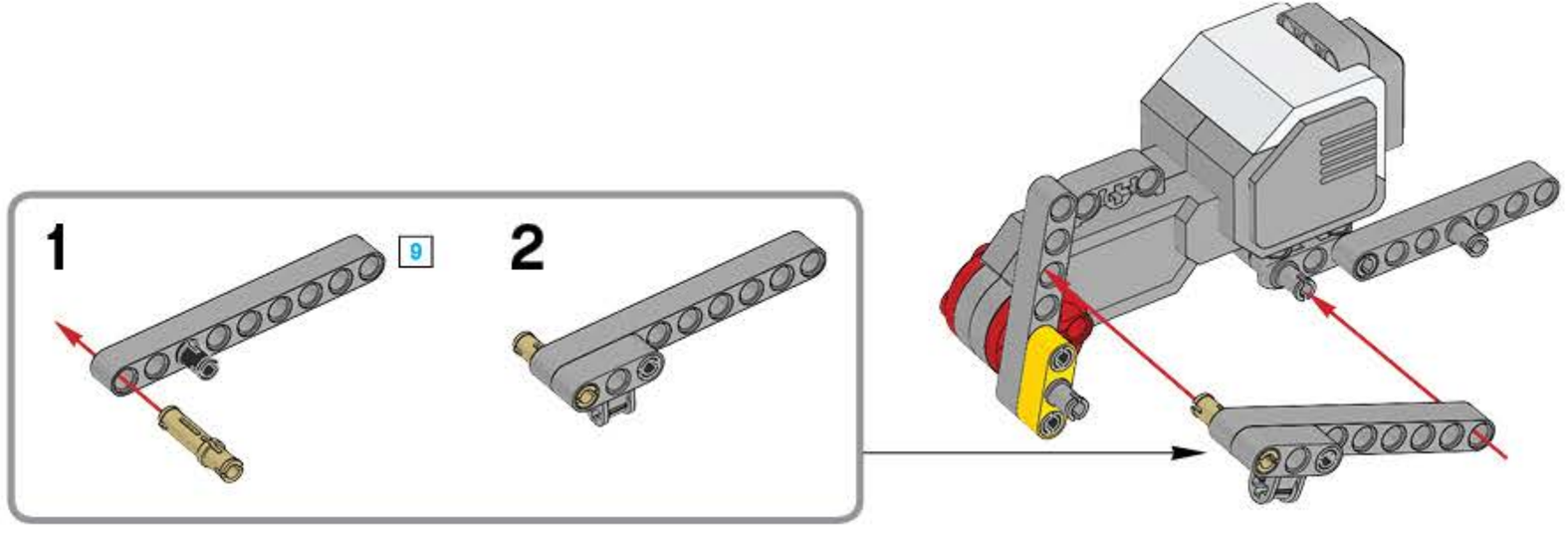

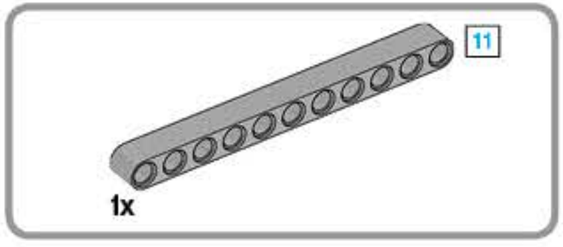

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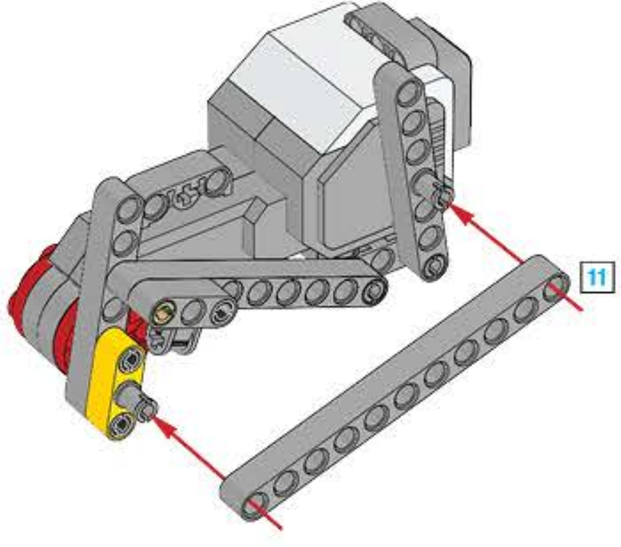

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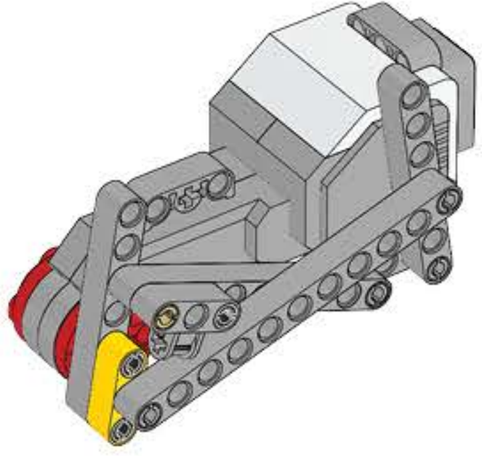

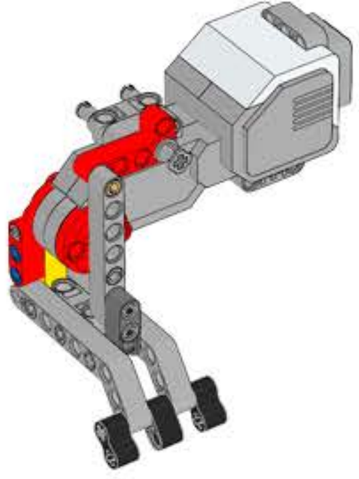

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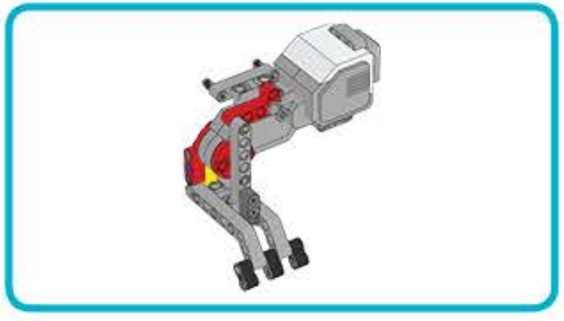

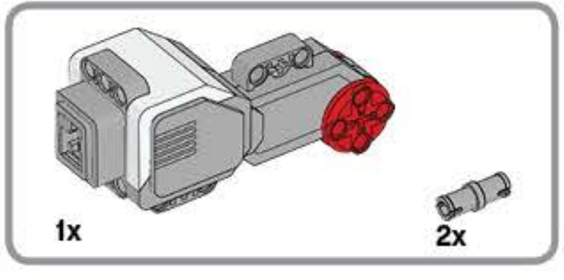

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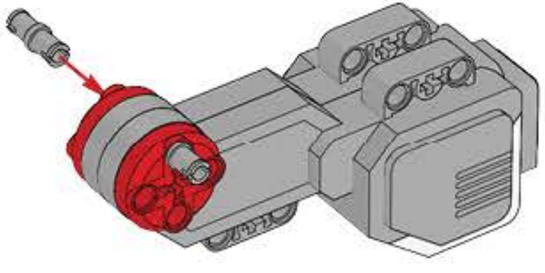

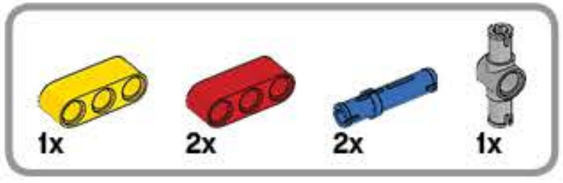

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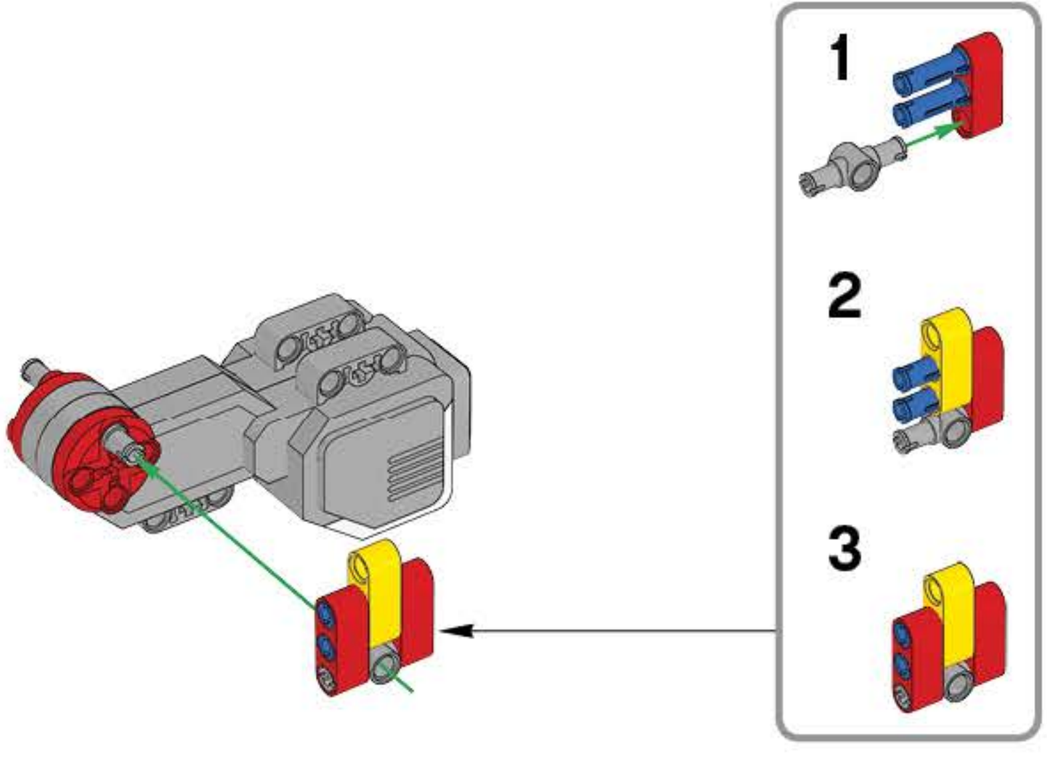

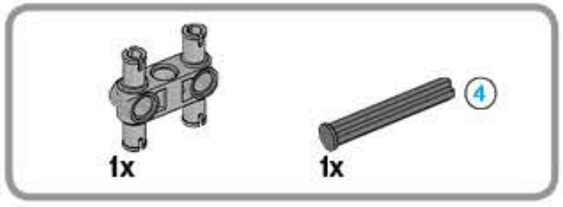

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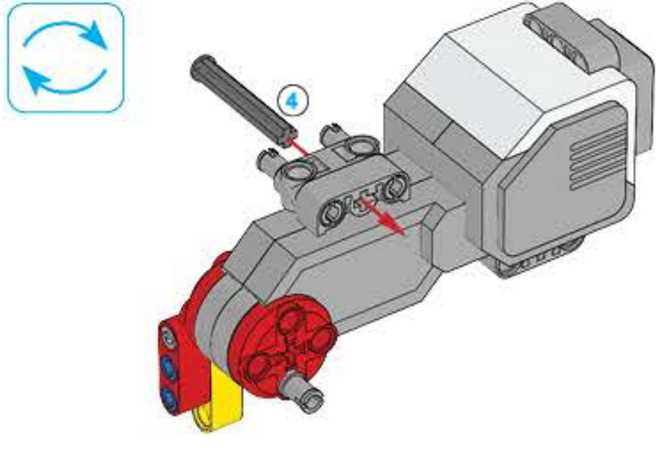

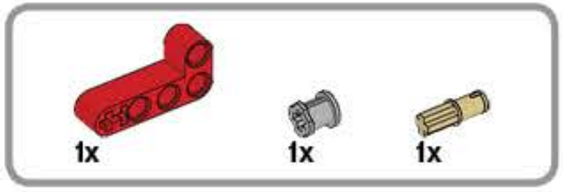

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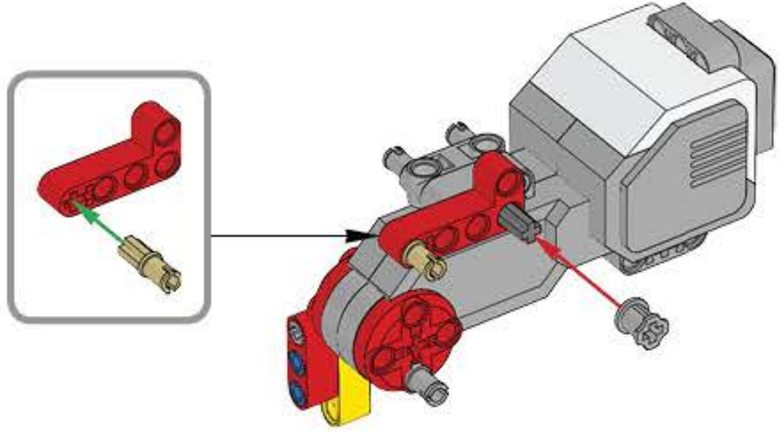

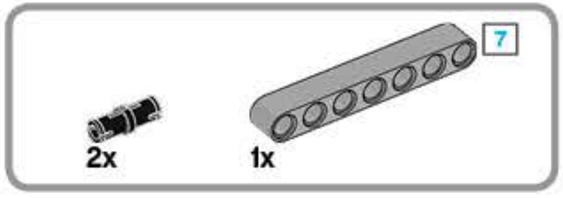

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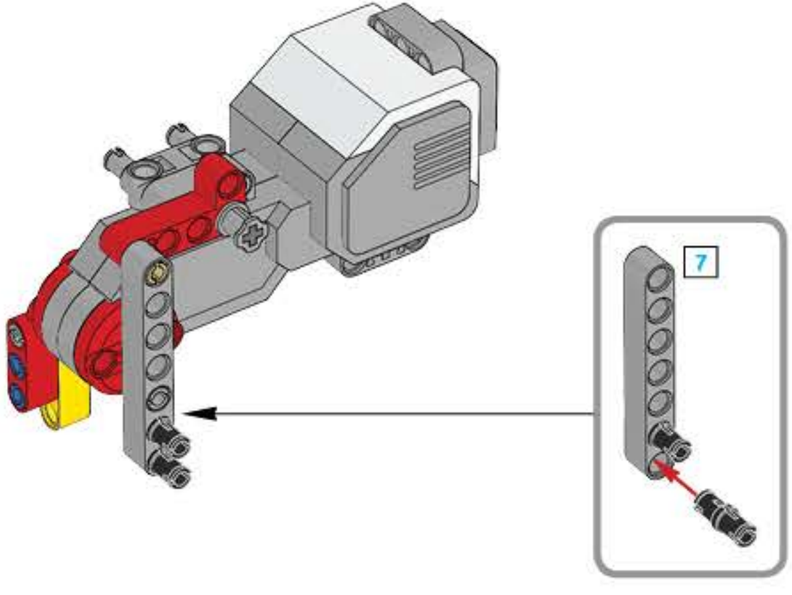

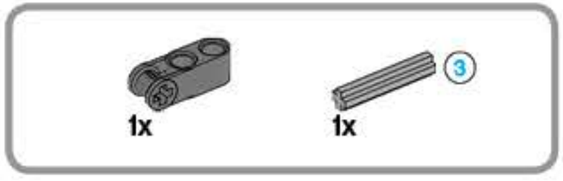

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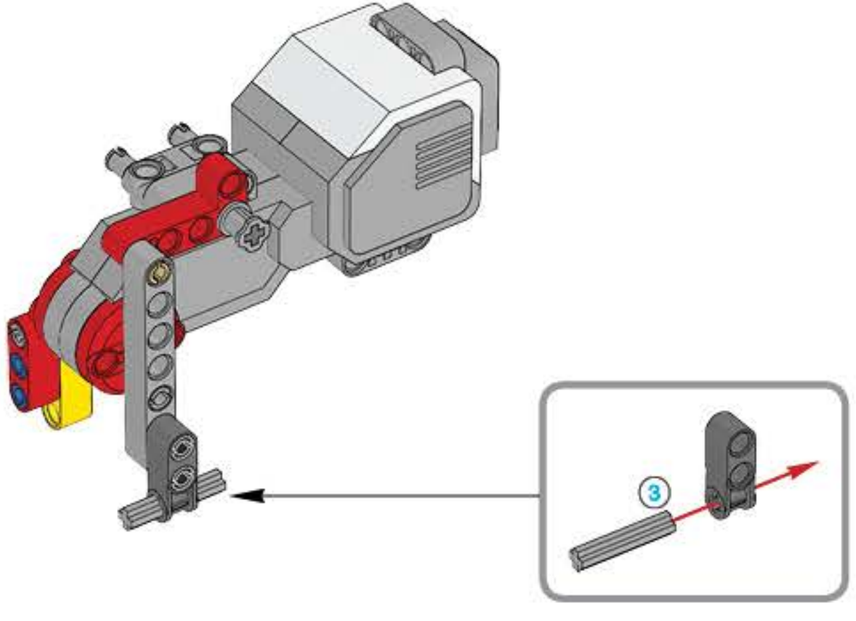

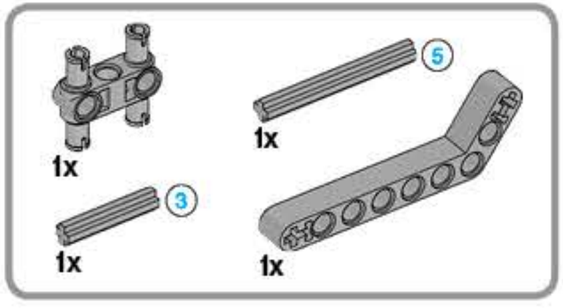

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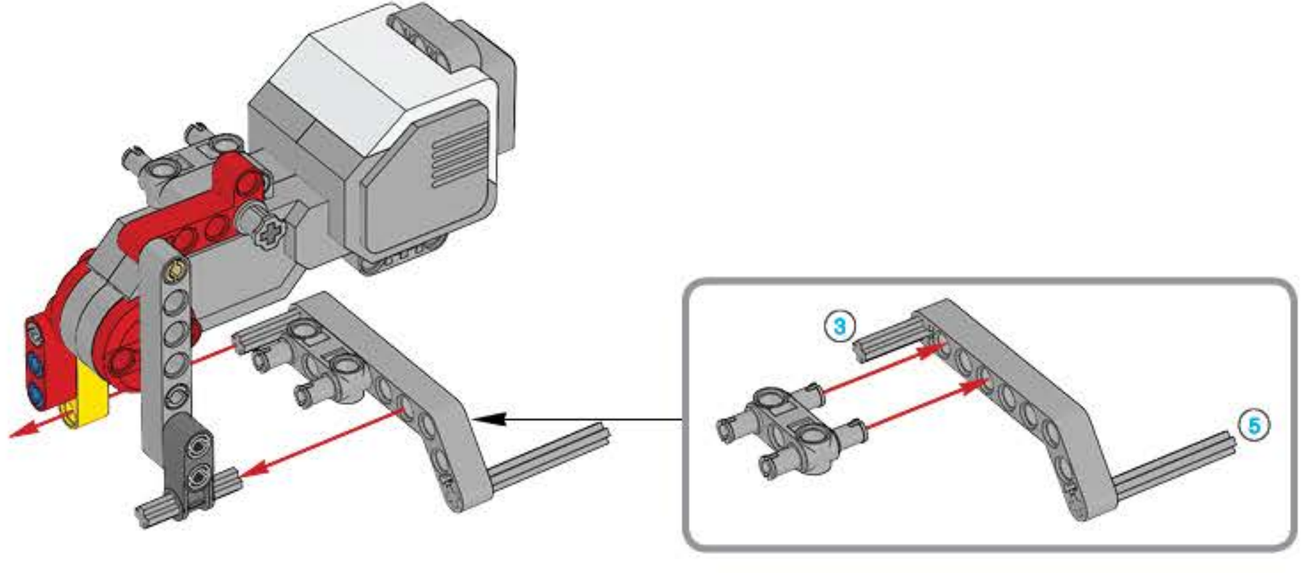

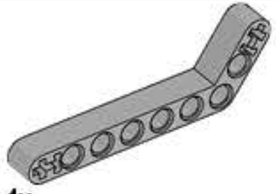

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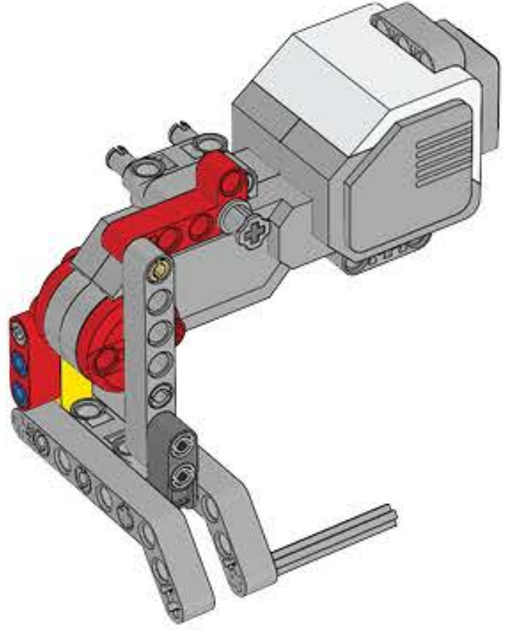

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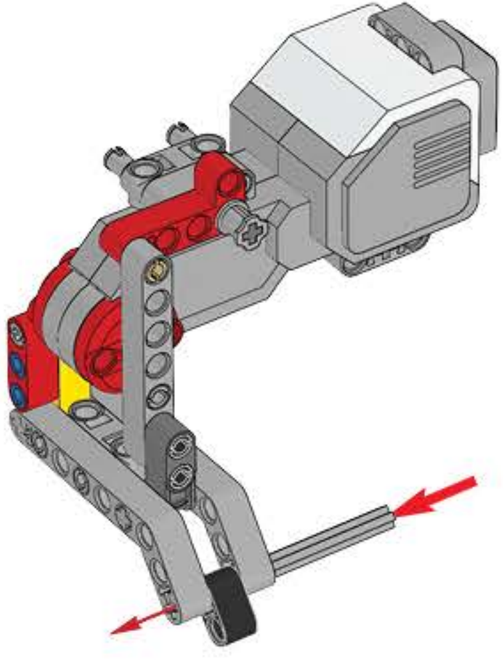

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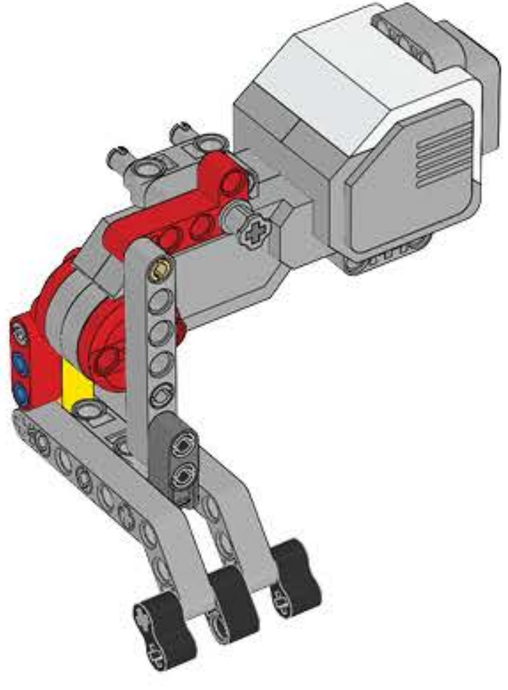

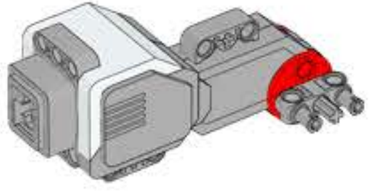

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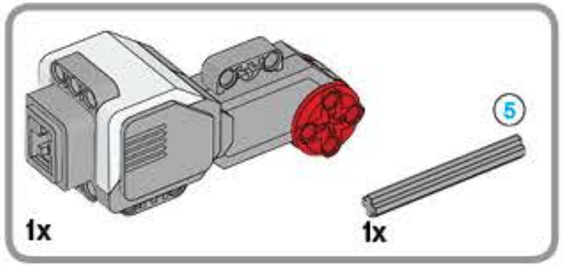

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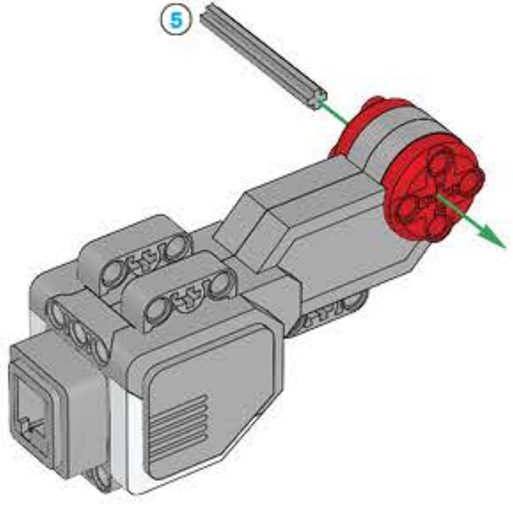

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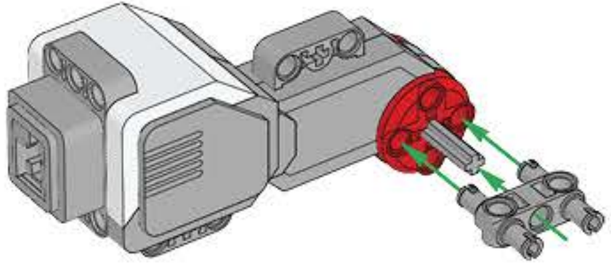

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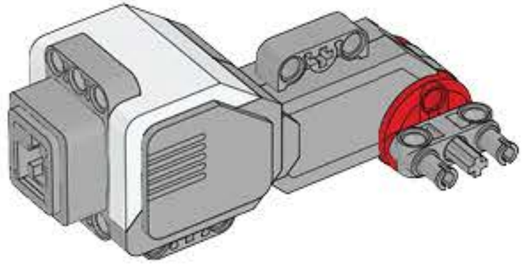

Make It Move Without Wheels

Make It Move Discussion

Watch the Make It Move video and answer the questions below:

Watch the Make It Move video and answer the questions below:

1. Look at the ways in which machines and robots move with and without wheels. Choose one example and trace how the movement transfers from one part to another.

Your answer

2. Compare the way the two walking robots move. What do you notice about how they balance as they walk?

Your answer

3. Look at the ways in which machines and robots move up hills or other inclined surfaces. These robots require more power to move uphill. What are some features that help them climb uphill?

Your answer

4. Which robot(s) moves in a regular pattern? What does moving in the pattern accomplish?

Your answer

Make It Move Without Wheels

Design Brief

Design, build, and program a robot that can move itself a distance of at least 30 cm:

- Using at least one motor
- Using no wheels for locomotion

Make It Move Without Wheels

Brainstorm

Discuss different solutions to the design brief.

Think about how robots can move without wheels.

How will you:

- Connect the motor(s) to something to make the robot walk, crawl, or wiggle
- Program the robot to move

Which programming blocks will you use to:

- Turn on and turn off the motor or motors

Describe Your Idea

Brainstorm Idea #1

Your answer

Brainstorm Idea #2

Your answer

Brainstorm Idea #3

Your answer

Make It Move Without Wheels

Evaluate Design

Design Brief

Design, build, and program a robot that can move itself a distance of at least 30 cm:

- Using at least one motor
- Using no wheels for locomotion

Select the box that best describes how you did.

We successfully built and tested a Walker Bot using the Building Ideas: EV3 Frames, Leg 1, and then a mirror image of Leg 1.

☐ Bronze

We successfully used our own design ideas to build a robot that moved without using any wheels.

☐ Silver

We successfully used our own design ideas to build a robot that moved at least 30 cm without using any wheels.

☐ Gold

We successfully used our own design ideas to build a robot that moved at least 60 cm without using any wheels.

☐ Platinum

Make It Move Without Wheels

Evaluate NGSS Goals

NGSS Practice:

Designing solutions: Undertake a design project, engaging in the design cycle to construct and/or implement a solution that meets specific design criteria and constraints. Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and retesting.

Select the box that best describes how you did.

We completed a design project, engaging in the design cycle to construct and implement a solution.

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We creatively used the engineering design process to implement a solution that exceeded specific design criteria and constraints. We optimized performance of a design by using the following: prioritizing criteria, making tradeoffs, testing, revising, and retesting.

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Make It Move Without Wheels

Evaluate Creativity

Creativity:

Come up with inventive and creative solutions to problems. Consider multiple solutions.

Select the box that best describes how you did.

We started the project and have at least one possible solution that looks reasonable.

- [ ] Bronze

We brainstormed two to three ideas. Then we built and programmed a working model to solve the problems.

- [ ] Silver

We brainstormed more than three ideas. Then we built and programmed an effective model to solve the problem.

- [ ] Gold

We brainstormed many ideas. Then we built and programmed an original and effective model that solves the problem and adds features.

- [ ] Platinum

Make It Move Without Wheels

Evaluate Collaboration

Collaboration:

Work is shared effectively and the team encourages and helps each other.

Select the box that best describes how you did.

We sometimes worked well together, but some team members did more work than others, or we needed help from the teacher to resolve some disagreements.

- [ ] Bronze

We generally worked well together, providing help and support to each other. The work was shared fairly evenly among the group members.

- [ ] Silver

We worked well together, providing help and support to each other. The work tasks were shared evenly. We addressed issues that arose.

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We worked unusually well together, overcoming unexpected obstacles by working together as a team. We actively helped and supported each other. We addressed issues that arose with honest, constructive feedback.

- [ ] Platinum

Make It Move Without Wheels

Select the Best Solution

Describe the solution that you have agreed to build and program.

Think about ideas from your brainstorm discussion, then explain why you chose this solution for the design brief.

Your answer

Make It Move Without Wheels

Build and Program

Now you are ready to start building and programming your solution!

As you work on your solution, use this log page to describe:

One part of your design that worked especially well

Your answer

One design change that you had to make

Your answer

What you will try next

Your answer

Make It Move Without Wheels

Test and Analyze

As you test your design solution, use this page to record your findings.

How well does your solution satisfy the design brief? (e.g., Distance Moved, and Observations)se this page to record your data. You may also want to add summary information, such as the range of distances measured, and the average distance.

Your answer

#Test 1 (Distance Moved)

Your answer

#Test 2 (Distance Moved)

Your answer

#Test 3 (Distance Moved)

Your answer

Make It Move Without Wheels

Review and Revise

Take a moment to reflect on your robot solution. Think about:

Is the robot using something other than wheels to move? Trace the movement from the motor axle to the mechanism(s) that drives the robot forward, backward, or sideways. Wheels can be used to stabilize the robot, but not to drive it.

Your answer

Is it accurate? How do you know?

Your answer

Describe two ways you could improve your robot.

Your answer

Make It Move Without Wheels

Communicate

Document Your Solution Using Google Docs. Remember to include your photos and videos.

Make It Move Without Wheels

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Make It Move Without Wheels

Congratulations! What will you design next?

Make It Move Without Wheels

Brainstorm

Discuss different solutions to the design brief.

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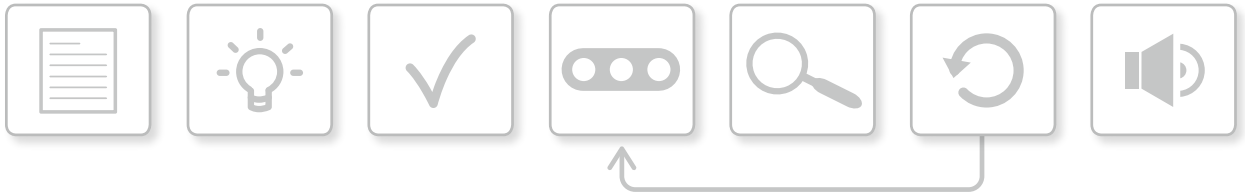
The Engineering Process

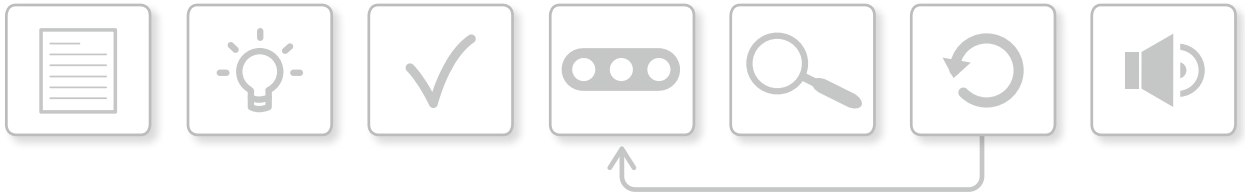


The Engineering Process involves seven practices:

- **Design Brief**
- **Brainstorm**
- **Select the Best Solution**
- **Build and Program a Solution**
- **Test and Analyze**
- **Review and Revise**
- **Communicate**

The process is **iterative**. That means it repeats. There is feedback to help you improve the solution.

The Design Brief

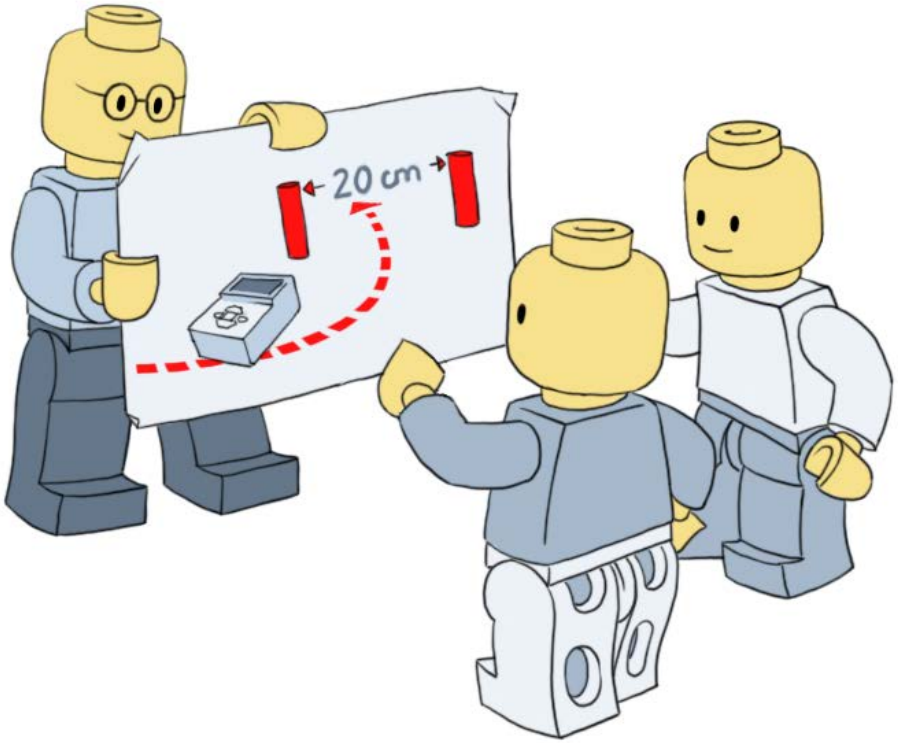


What is needed?

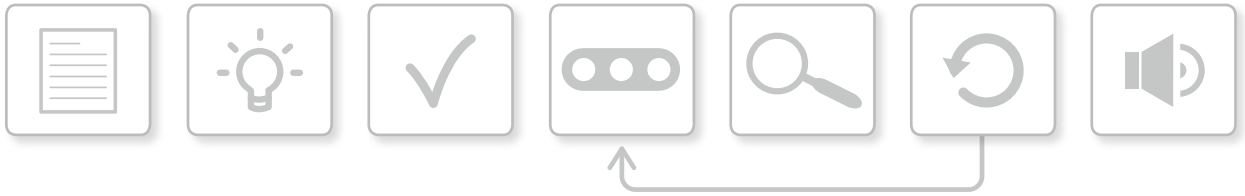
The design brief tells you what is needed. It also describes the **criteria** and **constraints**.

Criteria
The standards or rules describing how well the robot must perform.

Constraints
The limits (e.g., how far, how fast, how many times).



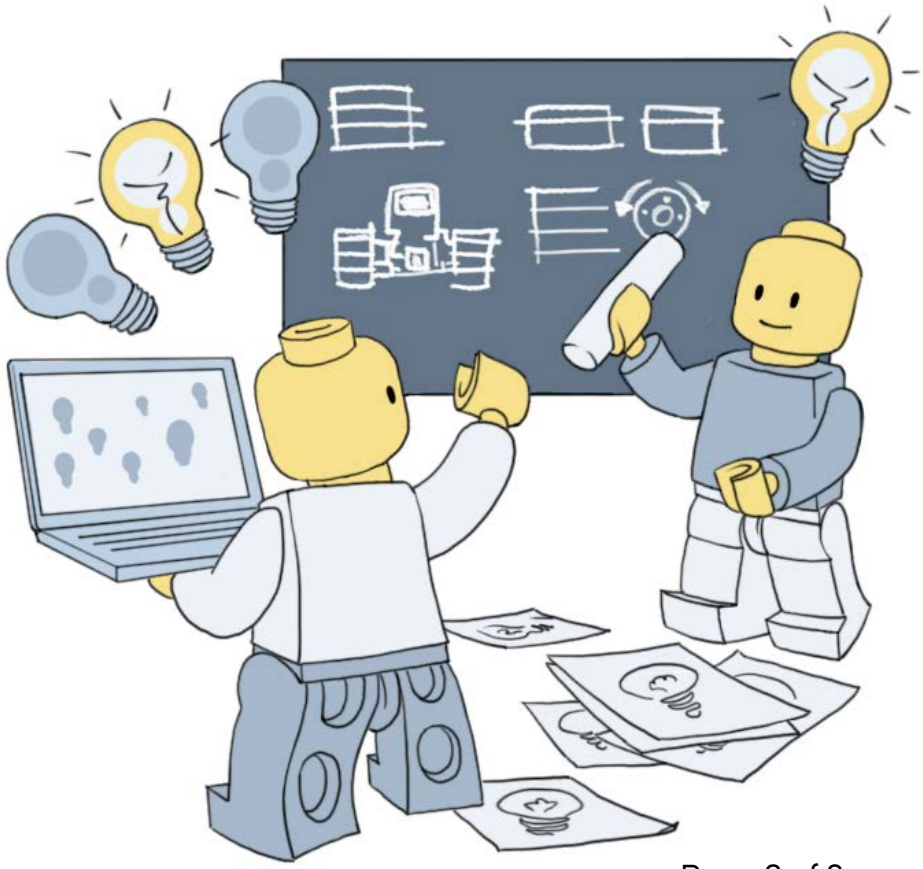
Brainstorm



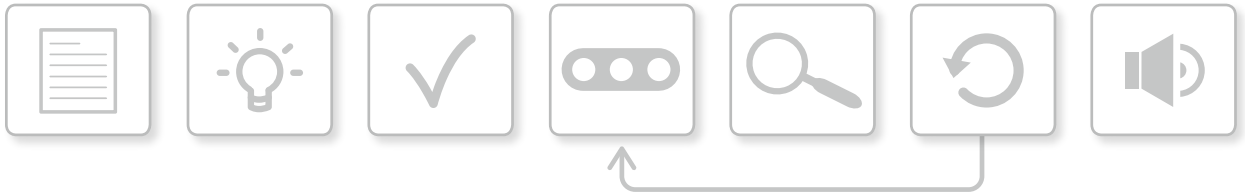
Research, explore, and share ideas for solving the design brief task.

What movement does the robot need to do?
How do I program the robot to do that?

Think about:
How do machines and robots do these tasks now?
Watch the *Make It Move*, *Make It Smarter*, and *Make a System* videos of real robots for inspiration and information.



Select the Best Solution

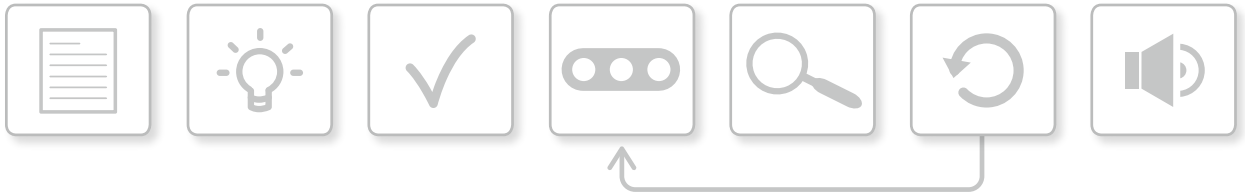


Your team must choose one idea.
Discuss the pros and cons, then choose one.

Remember:
Engineering is **iterative**. Test and revise as you go.
It won't be perfect the first time.

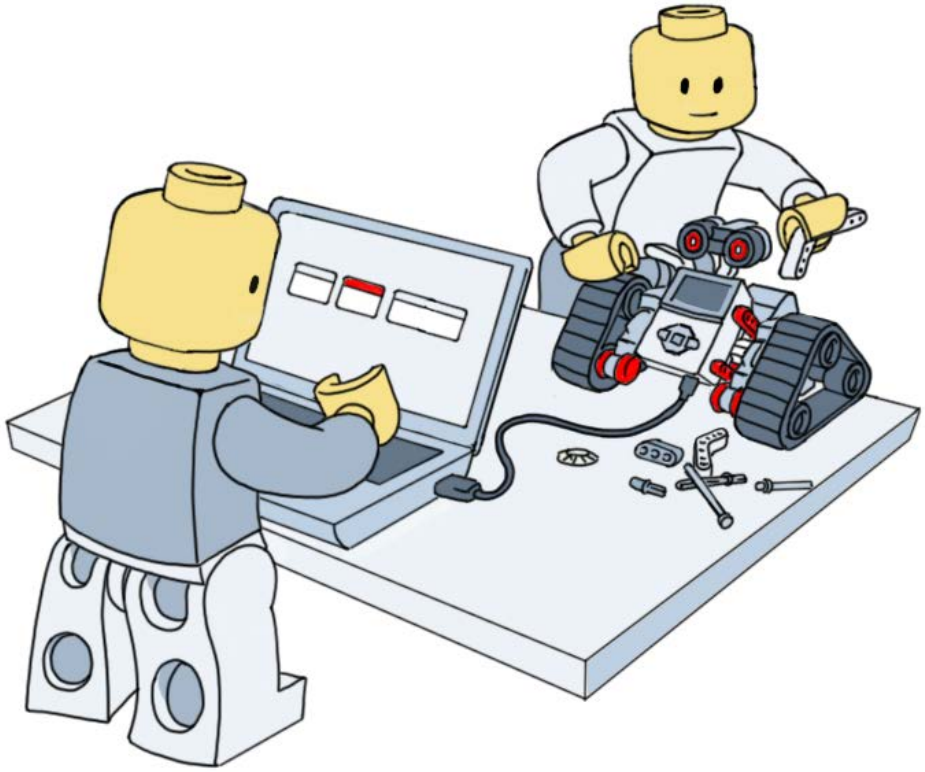
Get started...

Build and Program

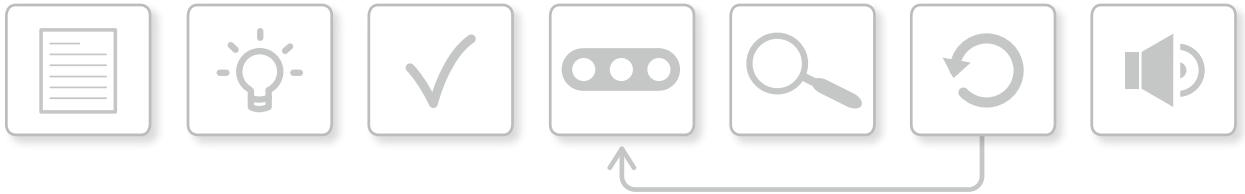


Log your progress as you create your own solution.

Find programming ideas in the EV3 Programming App Robot Educator Tutorials.



Test and Analyze

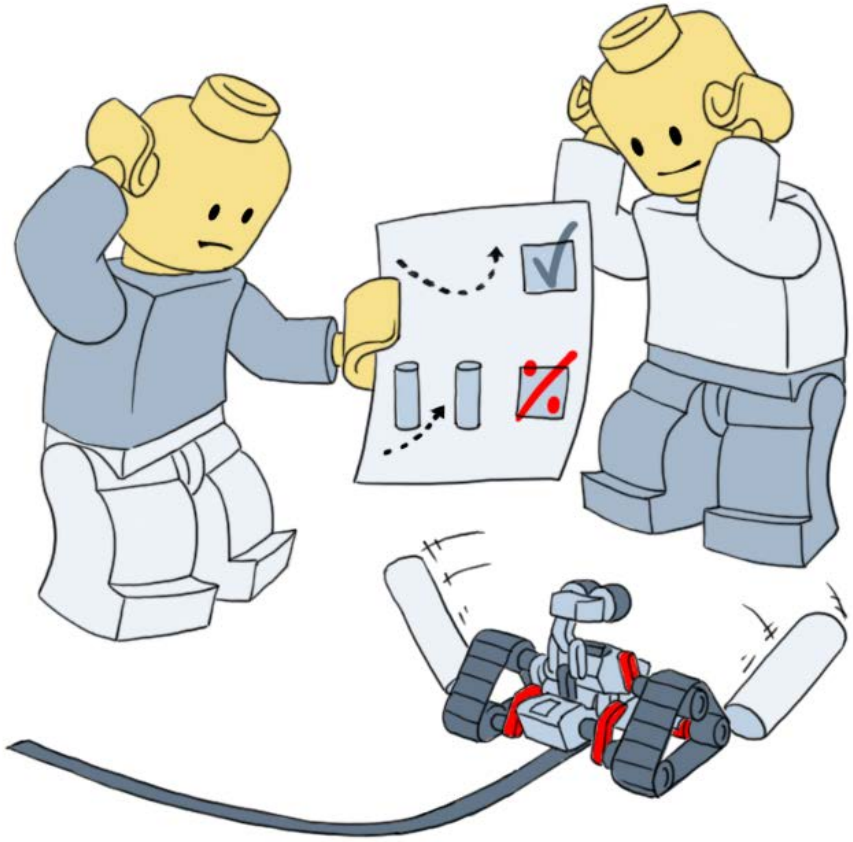


How well does your robot work?

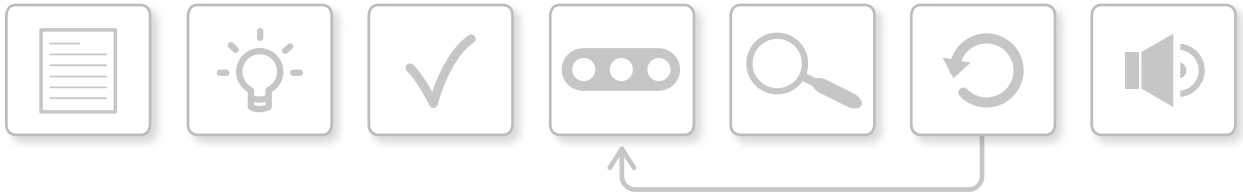
To find out, collect data and record observations in an organized way.

For example:

- Measure, record, or graph your data to see how accurate your robot is.
- Test multiple times so you have an average result.
- Test so you can show how well your robot is completing the task.

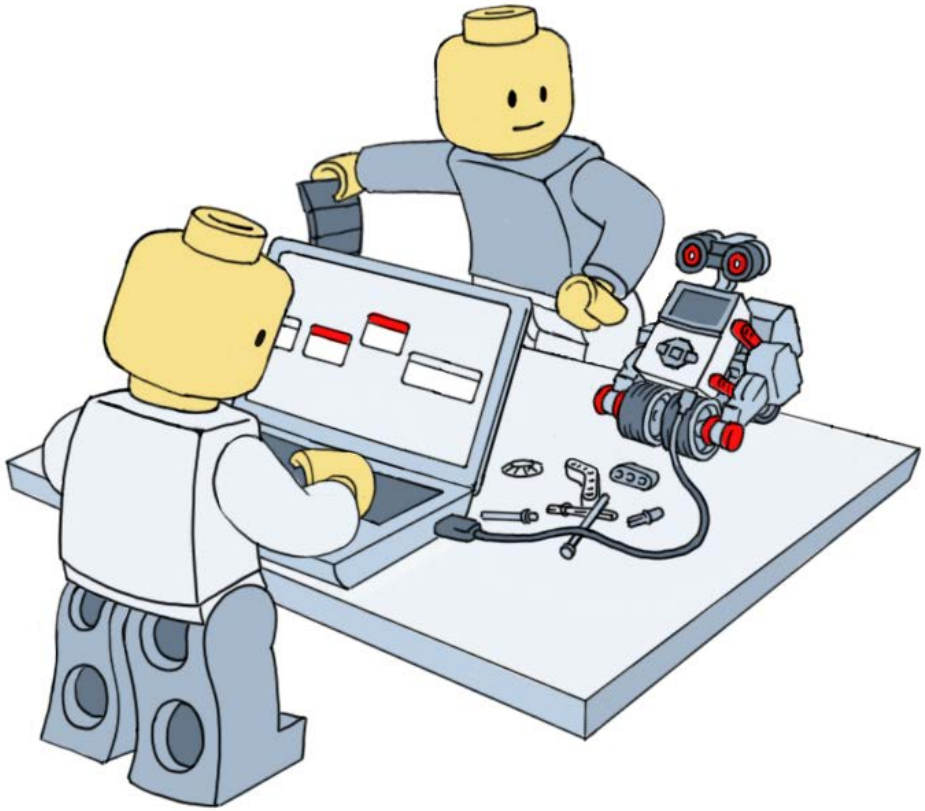


Review and Revise

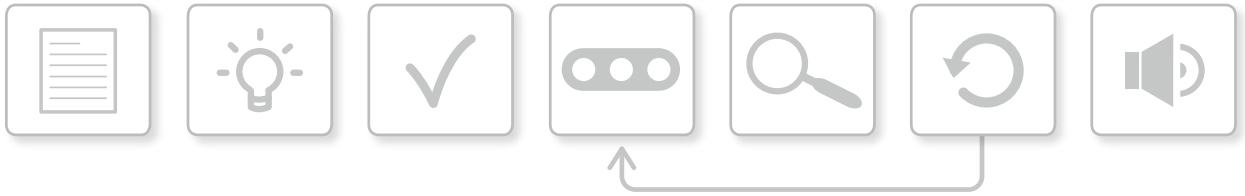


Look at your results.

- What can you say about your robot and its performance based on the data?
- Did your robot satisfy the design brief?
- What could your robot do better?

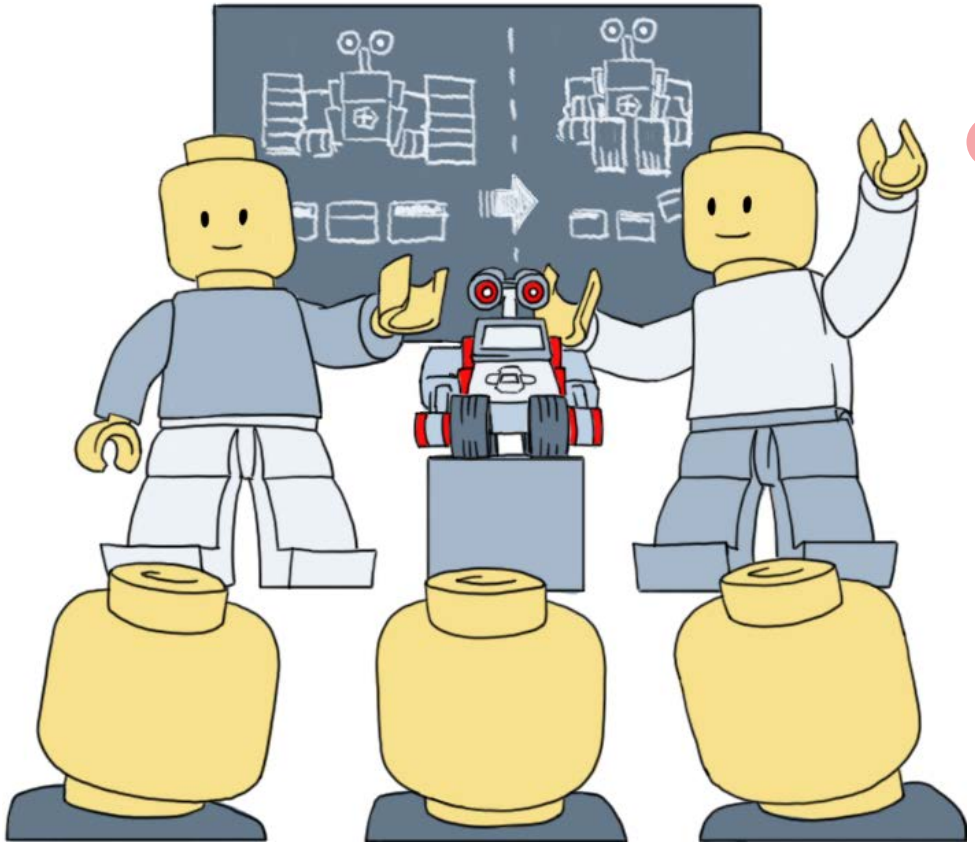


Communicate



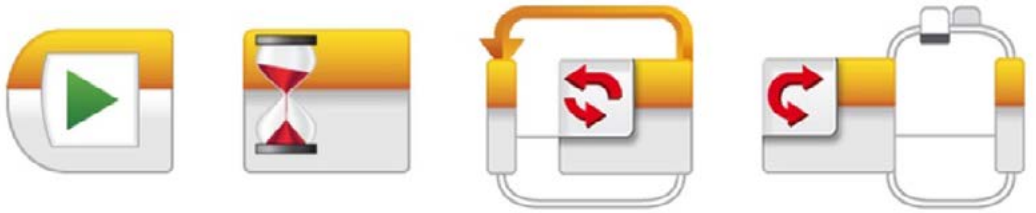
Some advice for communicating your ideas:

- Share your work with everyone you can.
- Include everyone on your team.
- Describe your robot solution.
- Show how your robot solves the problem... how about a video?
- Explain your program logic and your results.
- Did your robot mess up? Show that too... sharing mistakes can be helpful!



Robot Logic

When you download a program to an EV3 robot, you are making the robot smarter. Your programs tell the robot how to sense its surroundings, move, collect data, and make decisions.



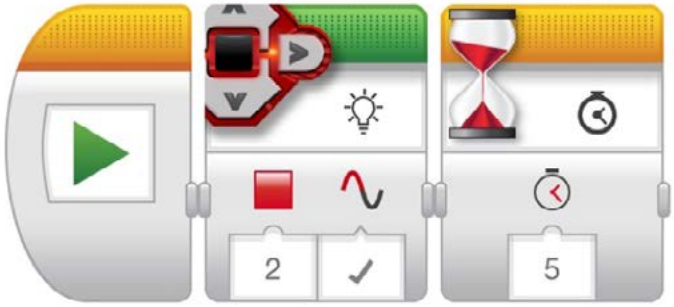
To program decision making, use these blocks on the Flow palette: **Start**, **Wait**, **Loop**, and **Switch**.

These blocks are built on true/false logic. The logic built into programs allows robots to think. It is how robots know how to make decisions.

Wait

Logic describes the control or decision-making flow of the program.

Wait is one way to control program logic.



Try this:
Use the EV3 Programming App to write and run the program.

Did you see the red EV3 Brick Status light turn on?

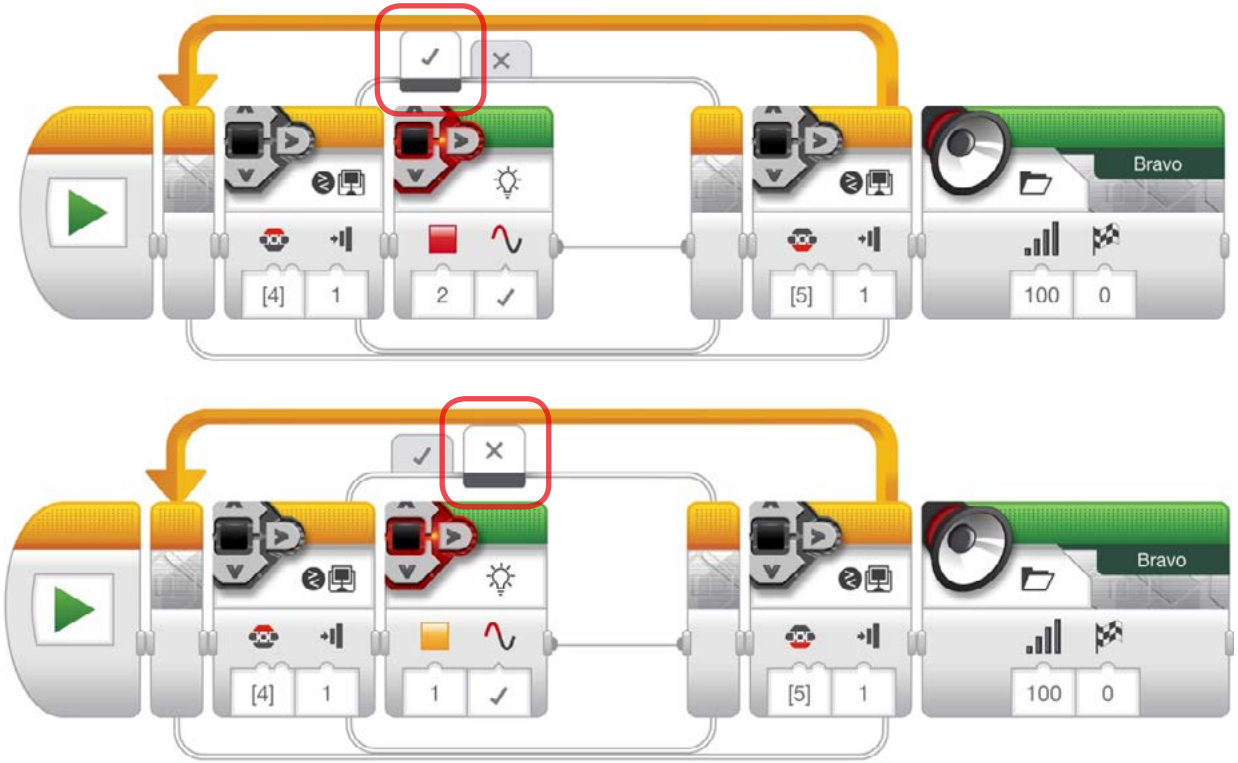
Loop

A **Loop** can mean, “do this function until something is true.”

Try this:
Use the EV3 Programming App to write and run the program.

What should be true to make the red light turn on?

What should be true to play the “Bravo” sound?



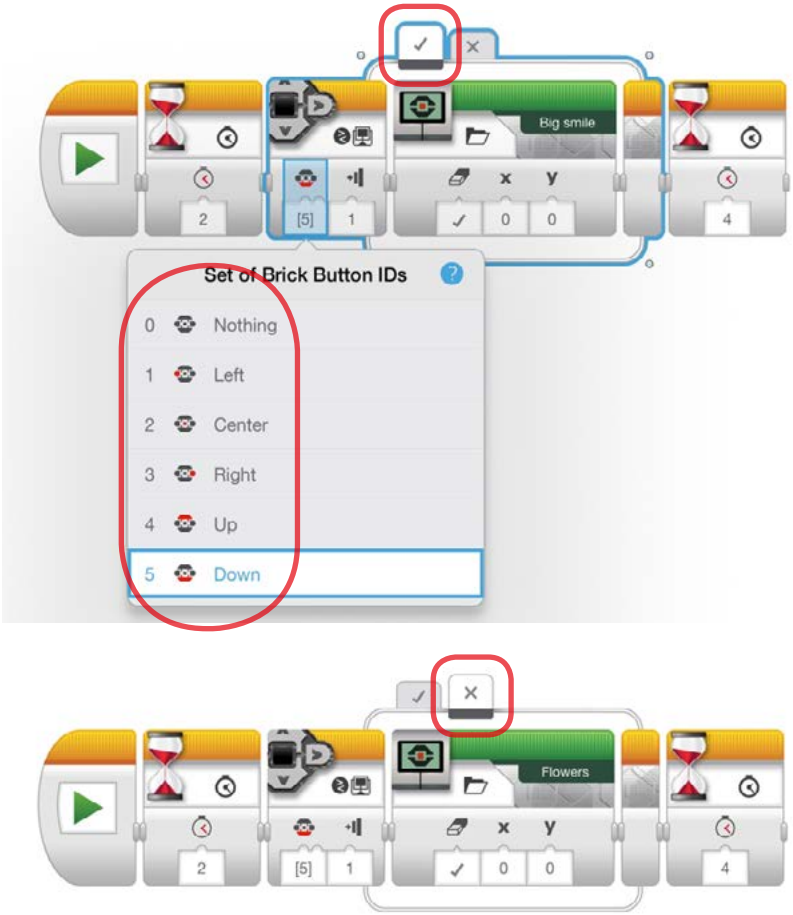
Switches: If Then

If statements are frequently used in program logic.
Switches are **If** statements.

The statements are either **true** or **false**.

Try this:
Use the EV3 Programming App to write and run the program.

- Which image is displayed?
- Which statement is true when the program runs?
- How can you make the other image display?



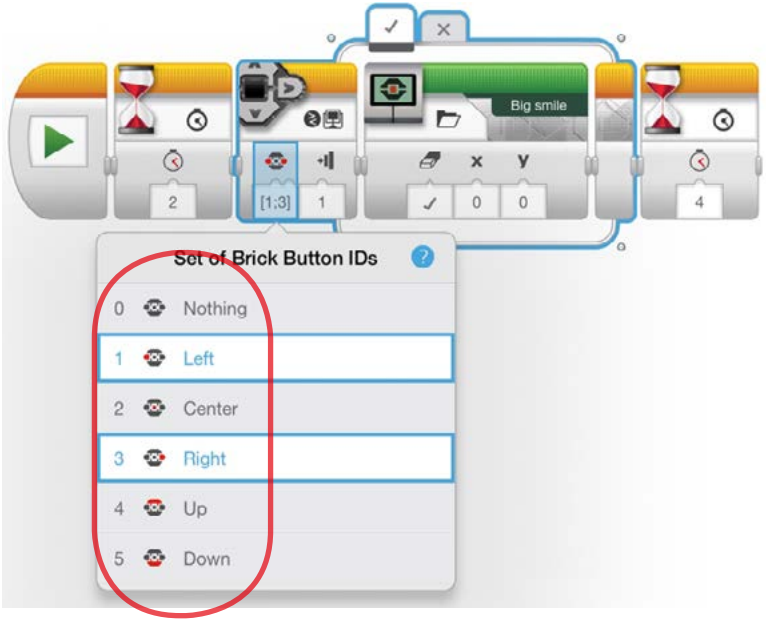
Switches: OR

Logic statements can be combined using operators. **OR** is an important operator.

The program to the right is an example of using **OR**.

Try this:
Use the EV3 Programming App to write and run the program.

- Which image is displayed?
- Which statement is true when the program runs?
- How can you make the other image display?

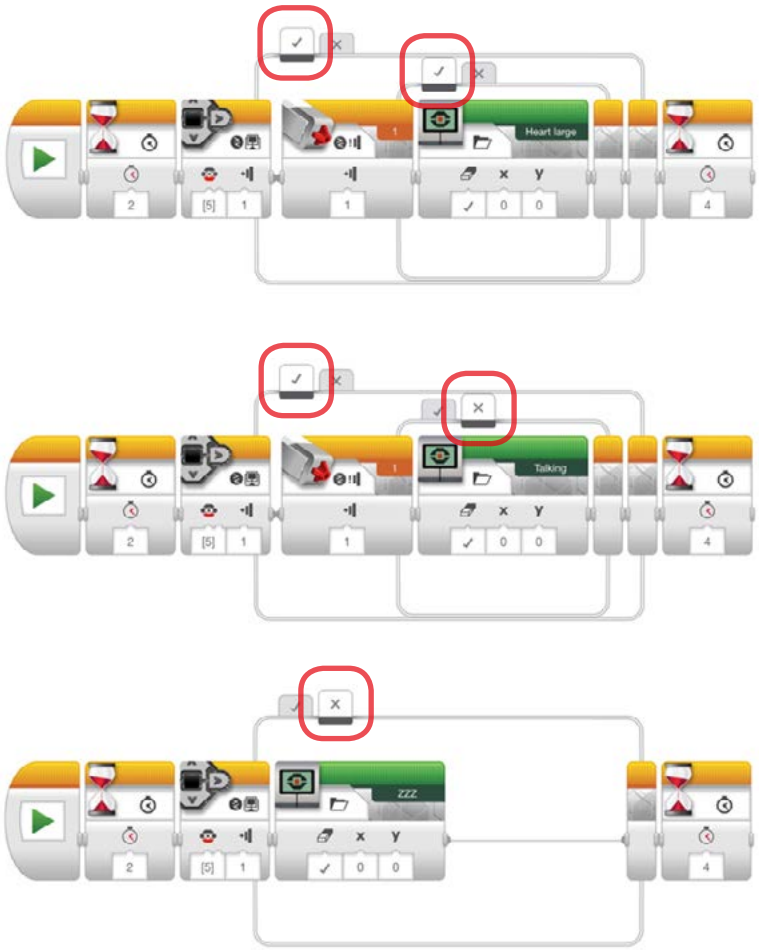


Switches: AND

The program below is an example of a logical **AND**.

Try this:
Use the EV3 Programming App to write and run the program.

- Which image is displayed?
- Which statement is true when the program runs?
- How can you get all three images to display?
- Explain why this program is an example of an **AND** operation.



Logic Examples in Robot Educator

See the Robot Educator tutorials in the EV3 Programming App for other examples of programs using logic concepts.

Other Robot Educator examples:

- Stop at Line uses Wait for Color Sensor Block
- Stop at Angle uses Wait for Gyro Sensor Block
- Follow a Line uses Switch and Color Sensor to change motor settings within a Loop