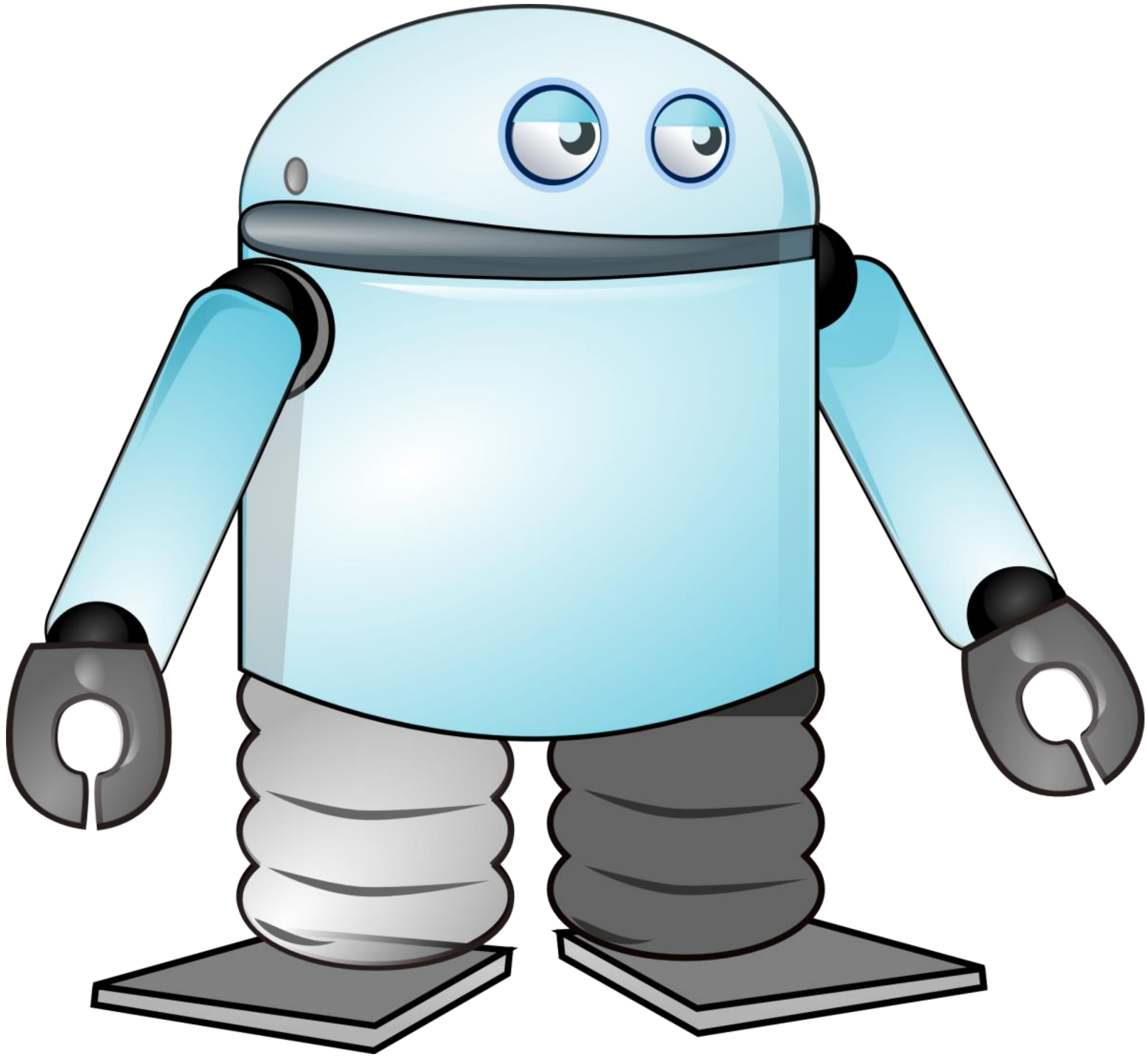


ROBOTICS BUILDING BLOCKS

4-H Youth Development, University of Nebraska–Lincoln

CURRICULUM MAP

Page	Title ....Section	Estimated Time (minutes)	Completed
1	**Robotics Building Blocks**	10	
2	**Imaginations Coming Alive**	5	
	................................Robots - Changing the World	5	
	................................Amazing Feat	15	
	................................Activity	10	
	Overview	15	
	................................Assemble Technics	15	
	................................EV3 Block is a computer	10	
	................................Installing EV3 Software	10	
	................................The Program	10	
	................................Congratulations	20	
	Solving Bigger Problems	5	
	................................Sturdy Structures	15	
	................................Getting Ready for Next Challenge	35	
	................................Challenge - Maze Navigation	15	
	................................Well Done	10	
	Getting in Gear	10	
	................................Synchronizing	10	
	................................Speed & Power Transmission	10	
	................................Challenge - Maze Fork	15	
	................................Compliments	5	
	Sensing	15	
	................................Are we there yet	20	
	................................How Far are We?	20	
	What's Next	10	

SUPPORT & NOTES

By the end of this curriculum youth will have the knowledge, skills, and hands on experience to help them in:

- understanding the steps involved in building robots
- understanding how scientists and engineers build and use robots for societal benefits
- knowing about what is the state of the art in the robotics industry
- understanding how to integrate their knowledge of math and science into real project settings to solve challenges that are important to them
- understanding the structure of computer programs
- increasing their curiosity to continue their interest in robotics whether it is just fun or some idea that they want to explore
- designing solutions to challenges like First Lego League (FLL)
- learning about gears and using gear drives to tap power from motors
- building robots that are based upon a concept of assemblies that can be attached on demand
- building robots that can respond to their environment using sensors such as touch and ultrasonic sensors
- gaining confidence of learning additional intermediate and advanced topics in robots

This curriculum teaches problem solving, using and building robots, and programming. Youth learn about the process of decision making and problem solving by integrating concepts that they have learned in their math and science curricula. This curriculum is best delivered as a group activity involving 3-4 youth team members and a mentor. The content, activities, and videos that are part of this curriculum should be sufficient to provide the contextual knowledge set towards the objectives of this course. A mentor in the learning team will provide the framework for enhancing the learning by their ability to provide support for developing the full potential of youth through social encouragement, motivation, persistence, and behavior control. The mentor's role could be provided by an in-school teacher, a parent, or a caregiver. **Among the strengths of this curriculum,**

the one that is important to note is that this curriculum provides a systematic introduction to questions such as where to start and how to start learning about robots, and what should be the next step in the learning process. In a nutshell, the older adults bring their valuable prior experience and success in life skills, child rearing, and youth development in the learning process whereas this curriculum guides through the content knowledge.

The time required by individual students to complete this curriculum may vary. However, as a starting point it will be good to estimate 2 hours per week for five weeks for students in grade 5 through grade 8.

ACTIVITY

< *What Bot Will You Make* >

Question: What kind of robot would you like to build and why**?**

Question: If you were to take inspiration from nature to build a robot then

What is that inspiration and Why?

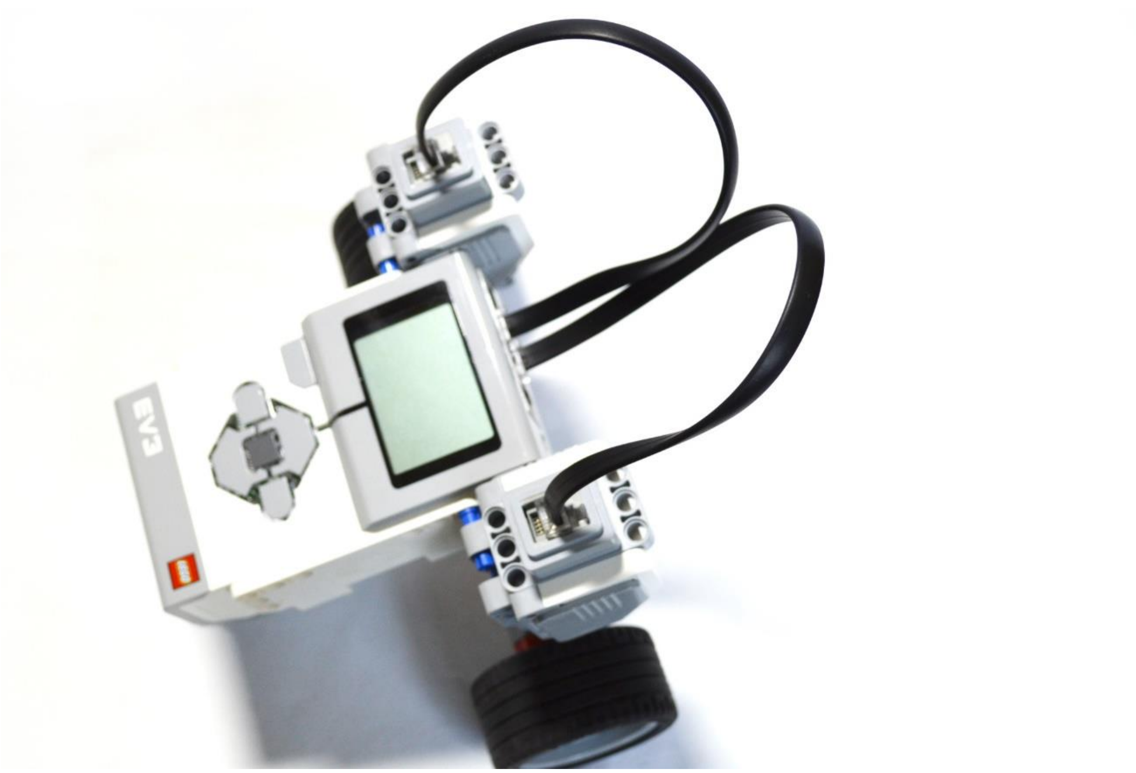
What will this robot do?

Draw how your robot might look

ACTIVITY

< *Build* ***Cycle*** **–** *parts list*>

In this activity, you will be preparing to build a bot that resembles the graphic below. Using a **pen/pencil** to write down the name of each part and the number of each part included in the kit by finding it in the elements list on pages 66-69 of the EV3 users guide (available at: https://www.lego.com/en-us/mindstorms/downloads).



Name ______________________________
X __________

Name ______________________________
X__________

Name ______________________________
X__________

Name ______________________________
X__________

[HINT: These are 5M in size]
Name ______________________________
X__________

Name(s) ______________________________
X__________

Name ______________________________
X__________

Name ______________________________
X__________

Name ______________________________
X__________

Name ______________________________
X__________

Name ______________________________
X__________

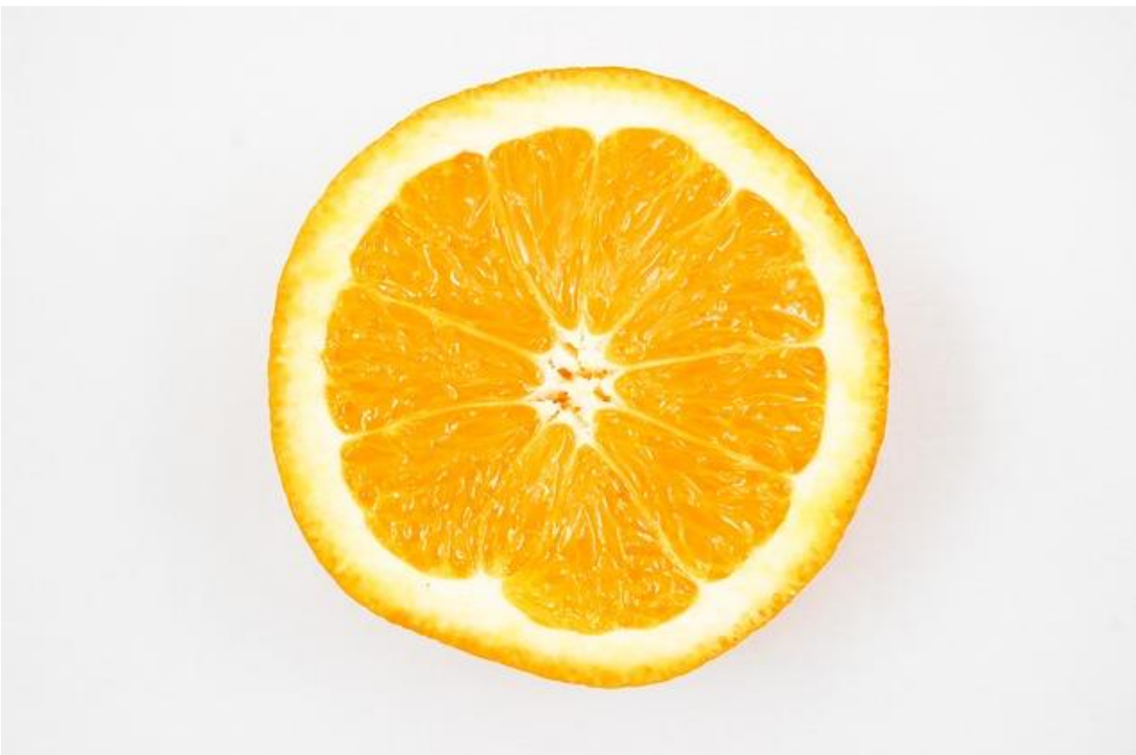
Name ______________________________
X__________

ACTIVITY

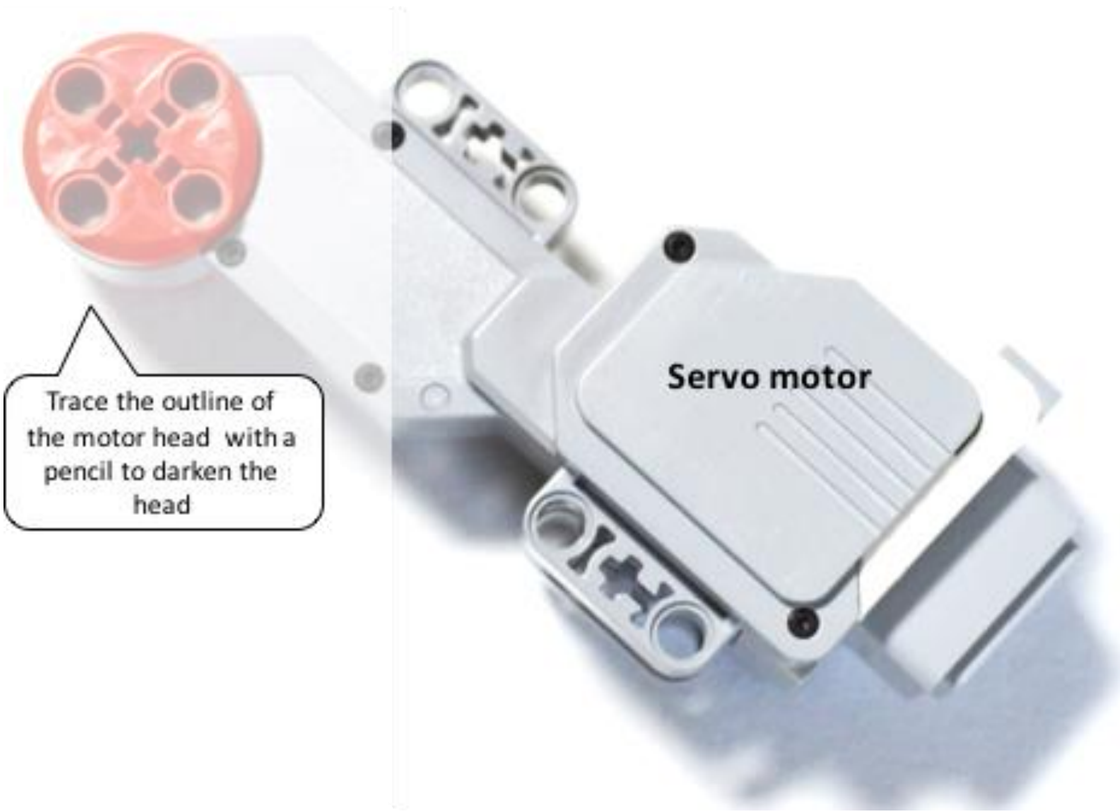
< *Axel cross section*>

In this activity, we will look at the axel cross section more closely.

Cross section is a view that would be obtained by making a straight cut through something, especially when the cut is at right angles to the axis. Here is an example of cross section of an orange.



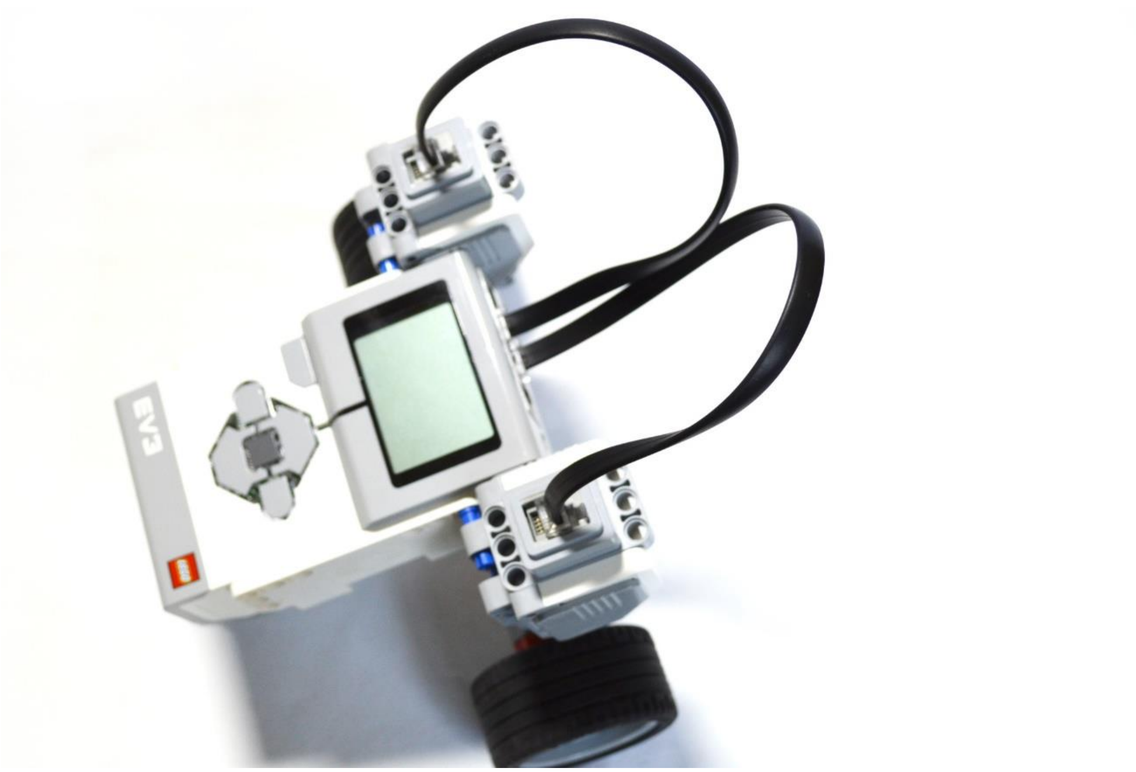

Trace the outline
with a pencil and
darken the axel


Servo motor
Trace the outline of
the motor head with a
pencil to darken the
head

ACTIVITY

< *Build Cycle* ***Bot*** >

In this activity, we will build a simple bot (simBot) that we can use as a starting point for other activities. This is a bare minimum design – feel free to be creative and design a bot that you want.



Find the following from your Mindstorms kit – you may follow the steps provided in the accompanying document.

☐ 1 X EV3 block ☐ 2 X large motors ☐ 2 X tires ☐ 2 X hubs ☐ 2 X 5M axles	☐ 1 X steel ball ☐ 1 X ball bearing ☐ 1 X 2M Connector with friction ☐ 2 X 1M bushing	☐ 4 X 3M connection peg with friction ☐ 2 X cables ☐ 1X ½ triangle beam ☐ 2 X 2M connector peg with friction/axle

Step 1

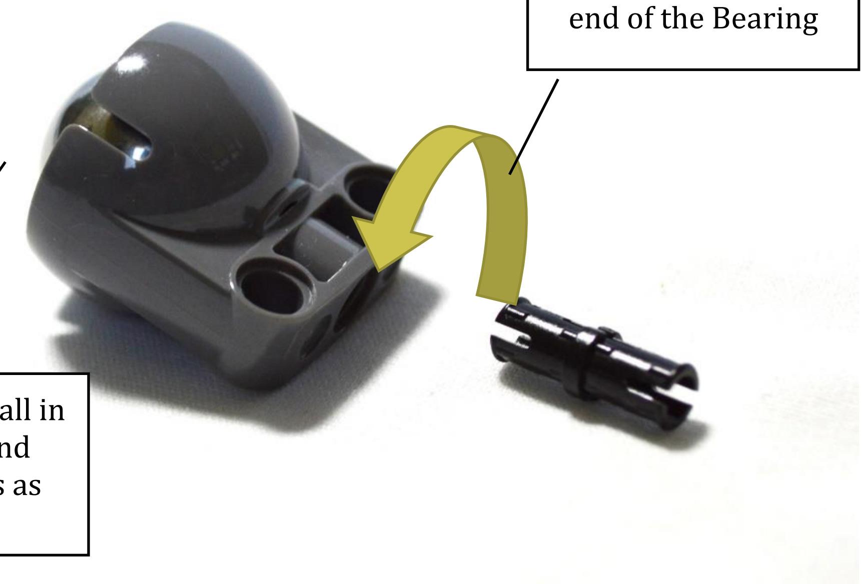
1

Place the Ball Bearing, Steel Ball, and the 2M peg as shown

Step 2

2

The peg will be pushed at the top end of the Bearing



1

Push the Steel Ball in the Bearing and place the parts as shown

Step 3

1

Push 2M peg on top of the Bearing

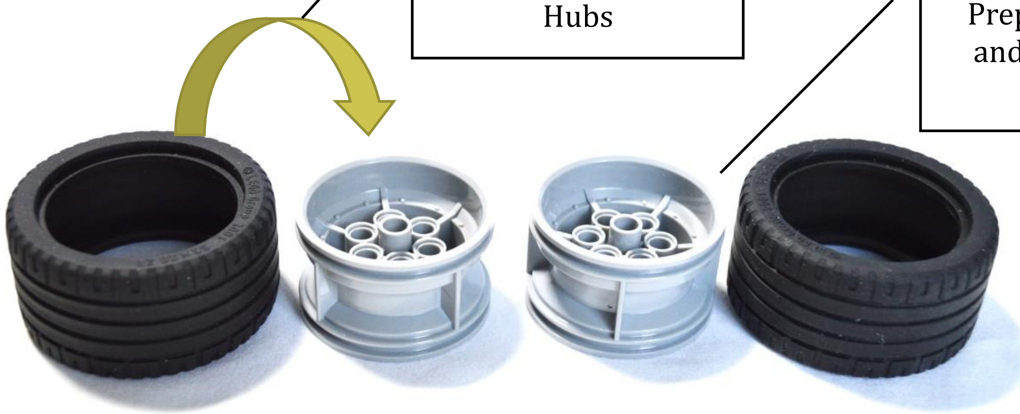
Step 4

1

The Tires will be slipped over the Hubs

1

Prepare the Hubs and the Tires for assembly



Step 5

1

The assembly must look like this

Step 6

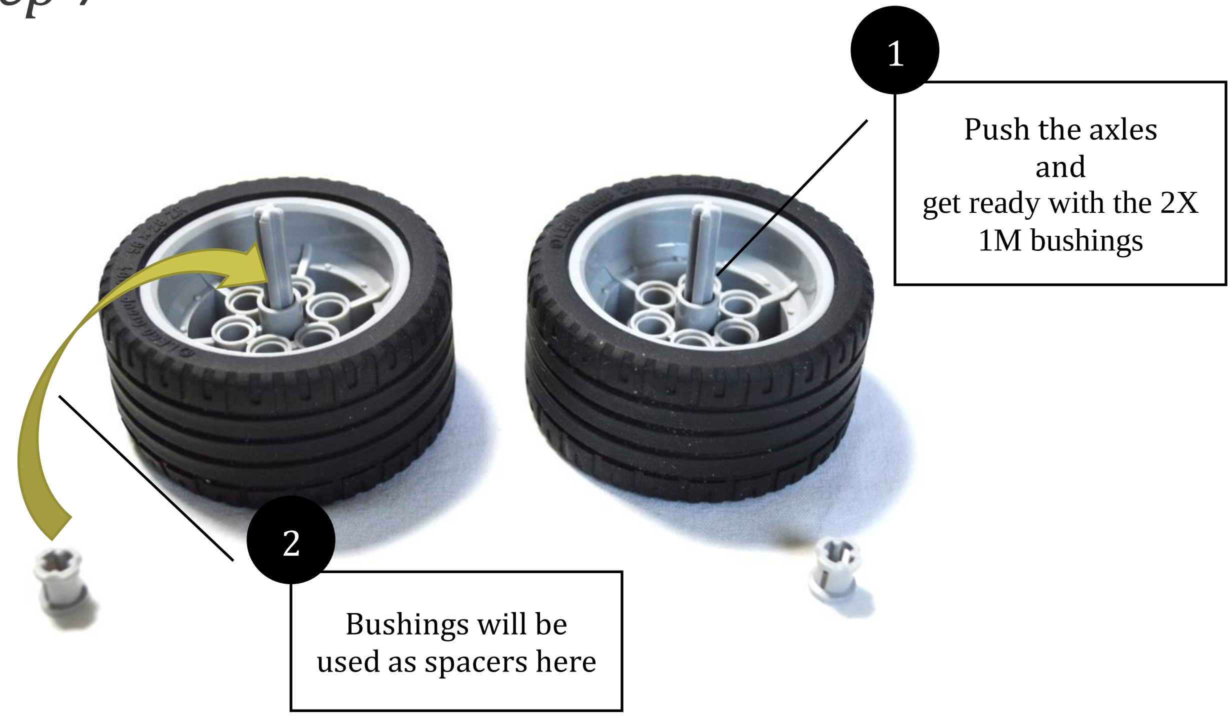
1

Flip the assembly so that the circular end shows on top

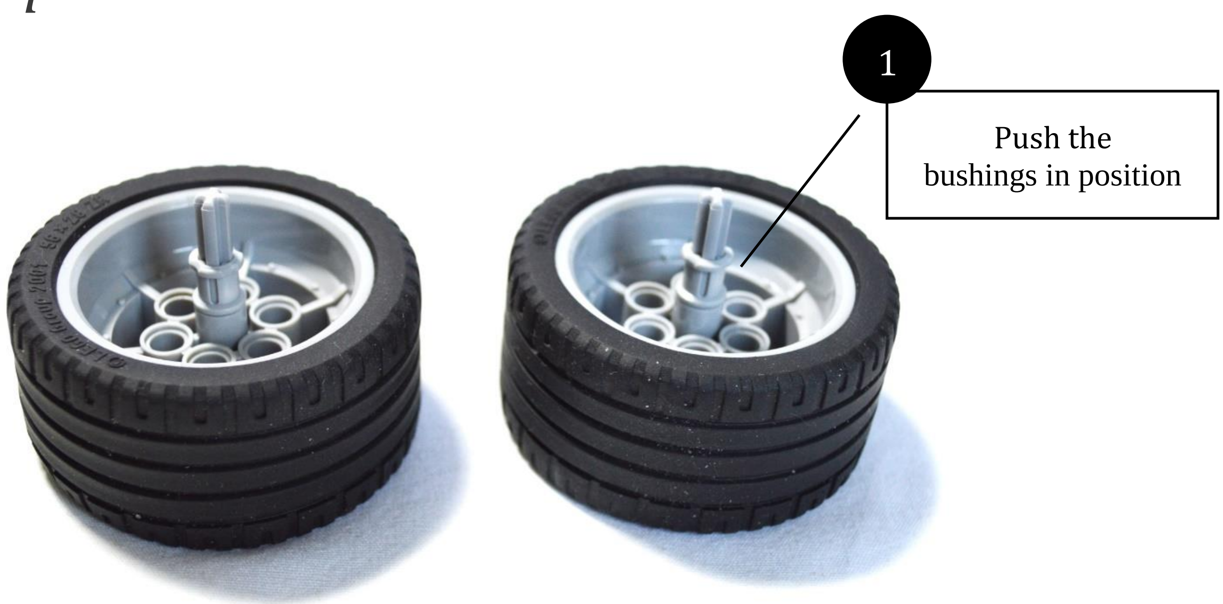
2

Place the axles for pushing them in the hub of the assembly

Step 7


1
Push the axles and get ready with the 2X 1M bushings
2
Bushings will be used as spacers here

Step 8


1
Push the bushings in position

Step 9

1

Prepare the EV3 Block and 4X 3M pegs for assembly

Step 10

1

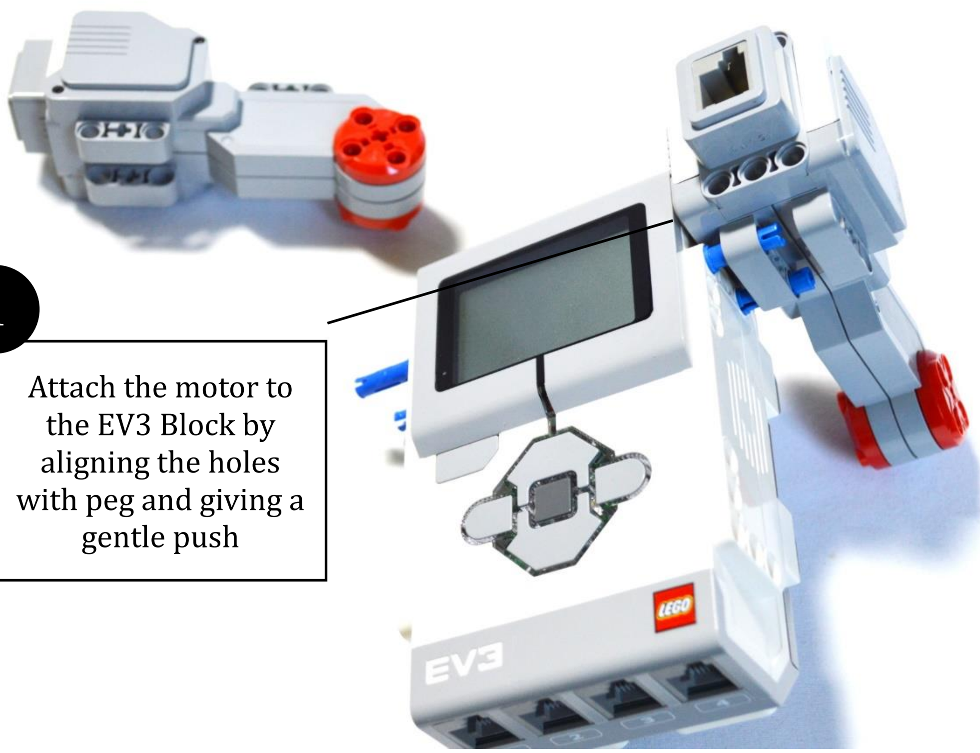
Push the pegs in the vertical holes. The EV3 assembly will look similar

Step 11

1

Place the EV3 Block and 2X large motors as shown

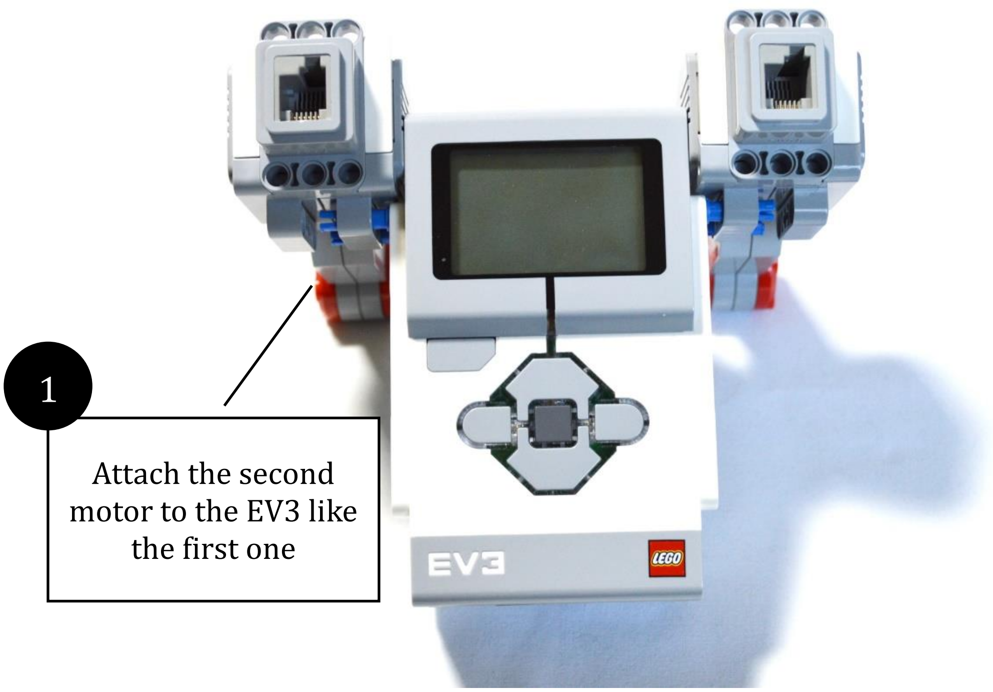
Step 12



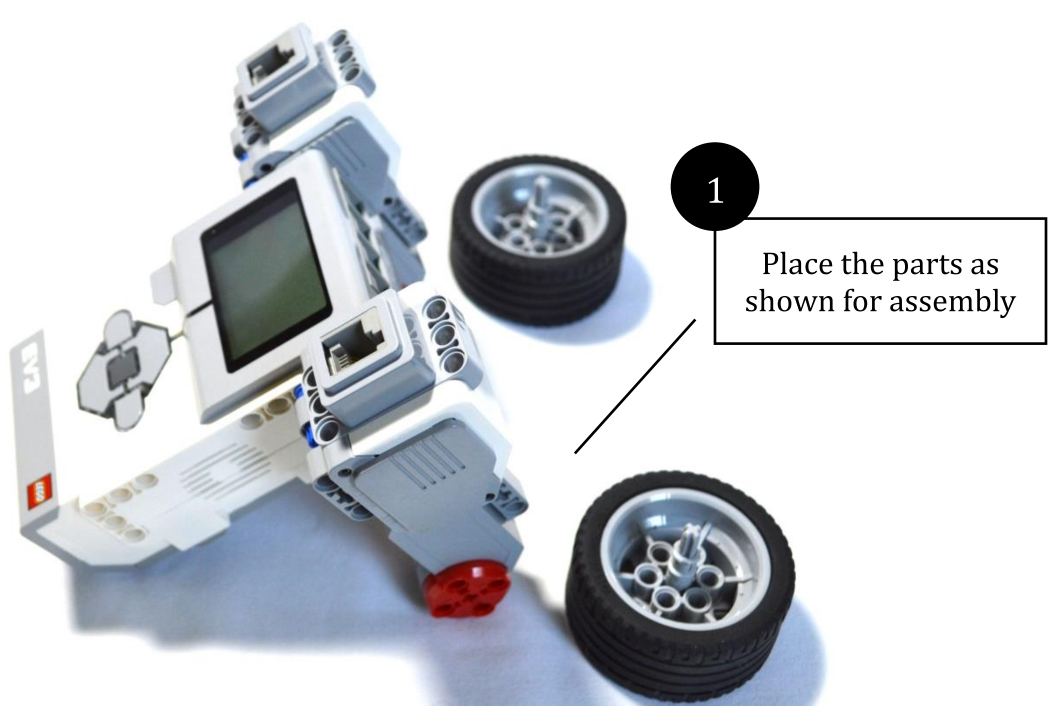
1

Attach the motor to the EV3 Block by aligning the holes with peg and giving a gentle push

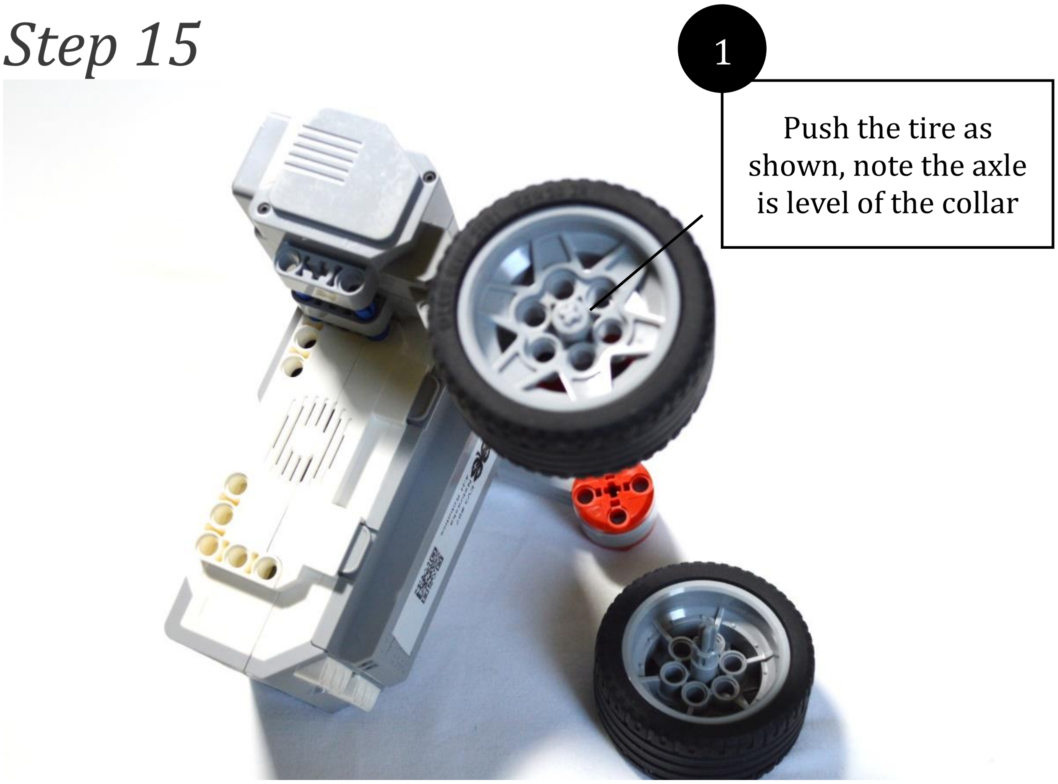
Step 13



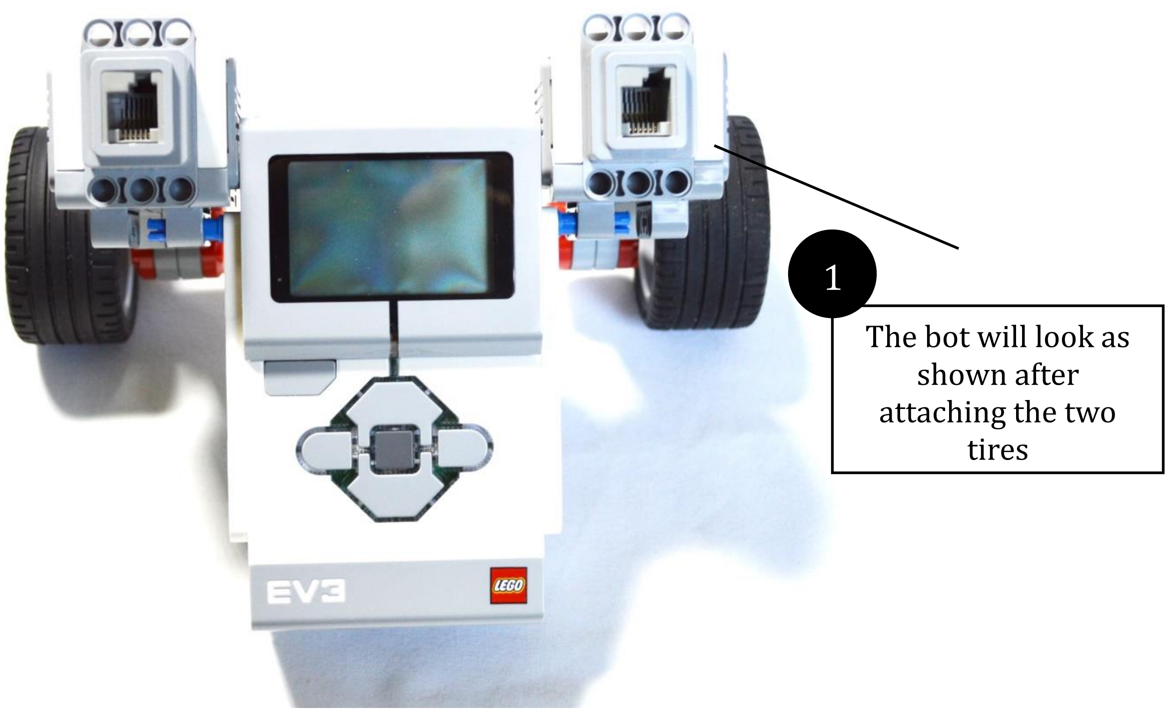
Step 14



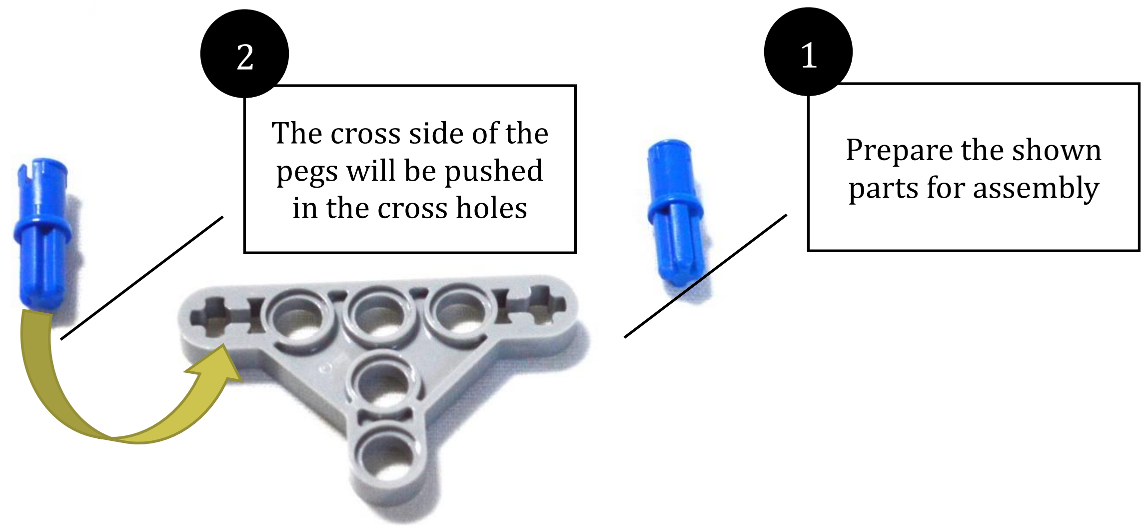
Step 15



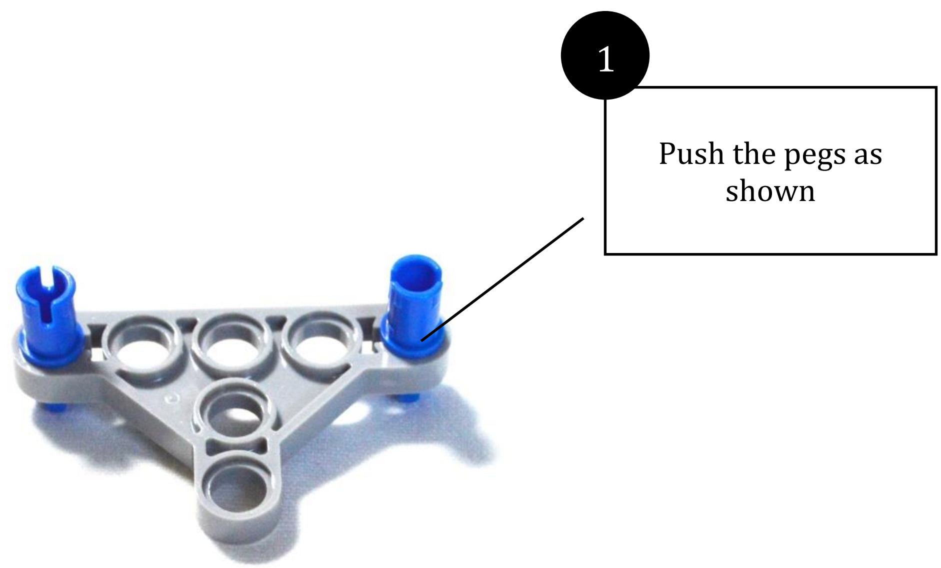
Step 16



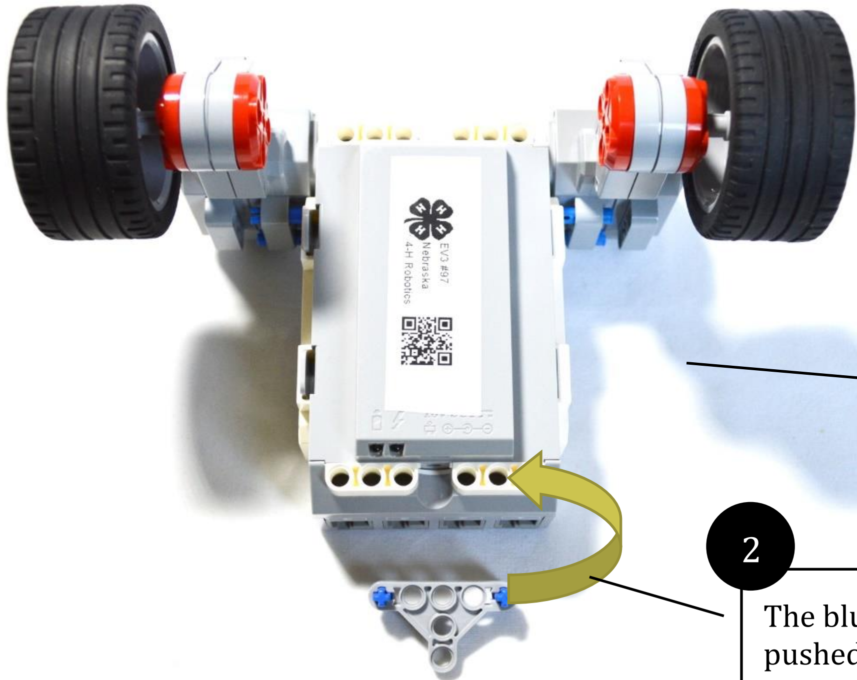
Step 17



Step 18



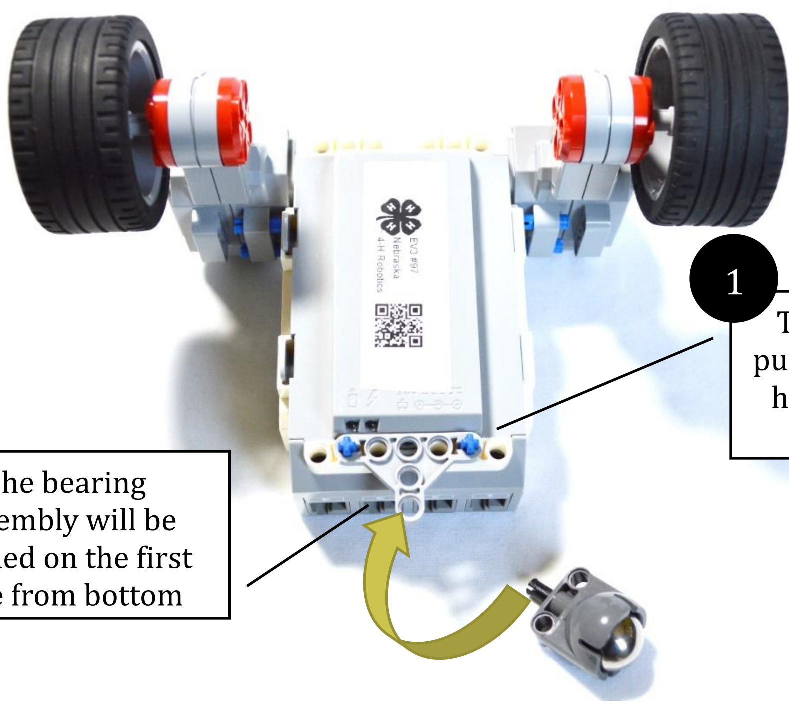
Step 19



1 Prepare the two components for assembly

2 The blue pegs will be pushed in the middle holes

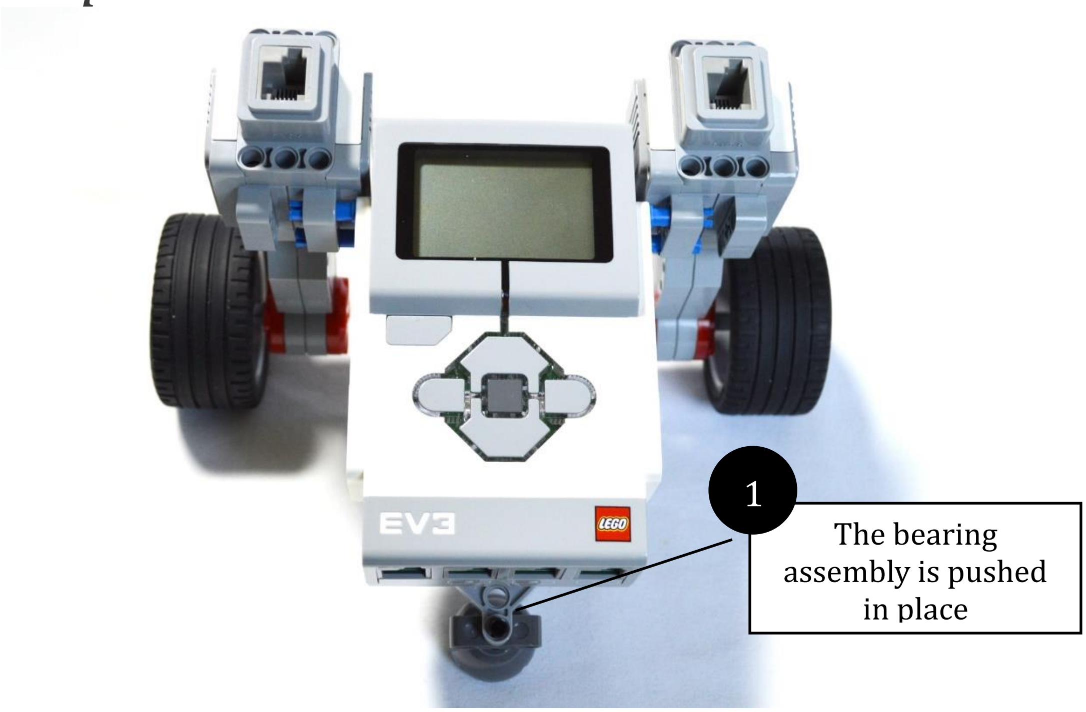
Step 20



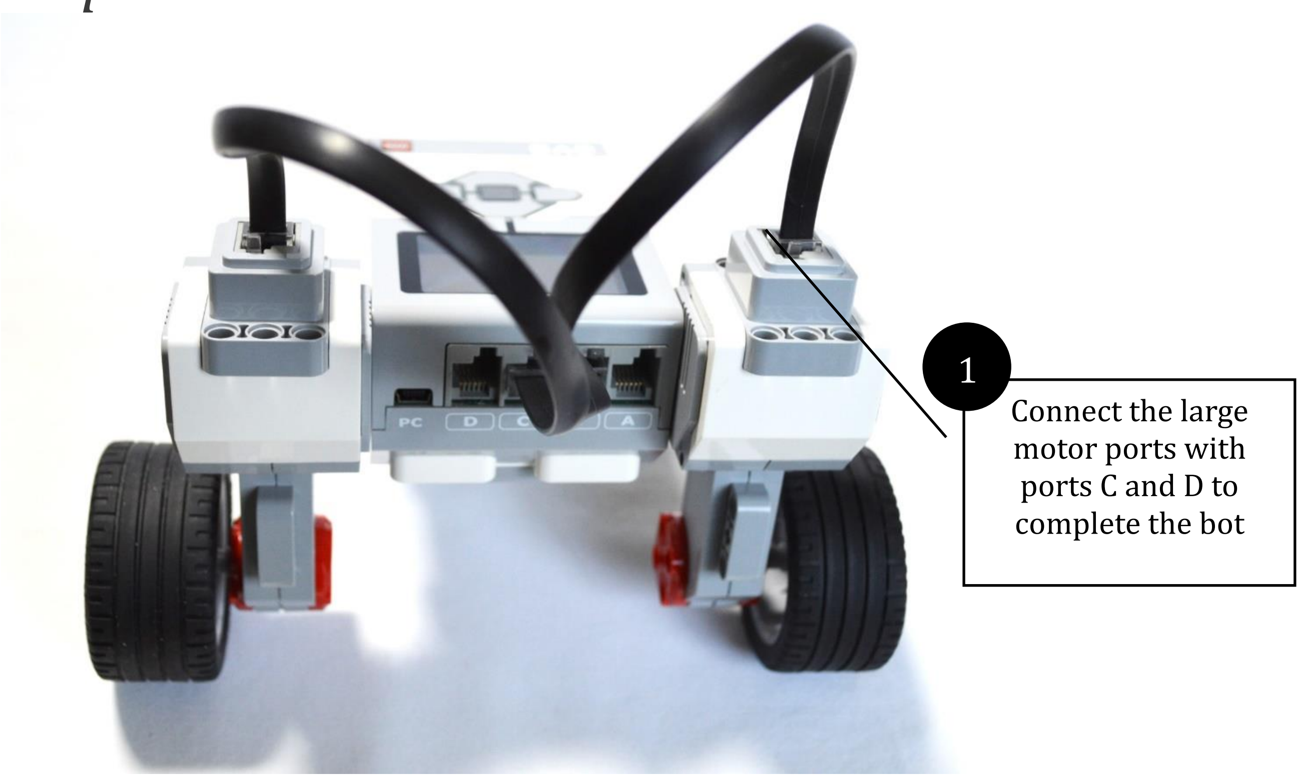
1 The blue pegs are pushed in the middle holes to attach the beam

2 The bearing assembly will be pushed on the first hole from bottom

Step 21



Step 22



ACTIVITY

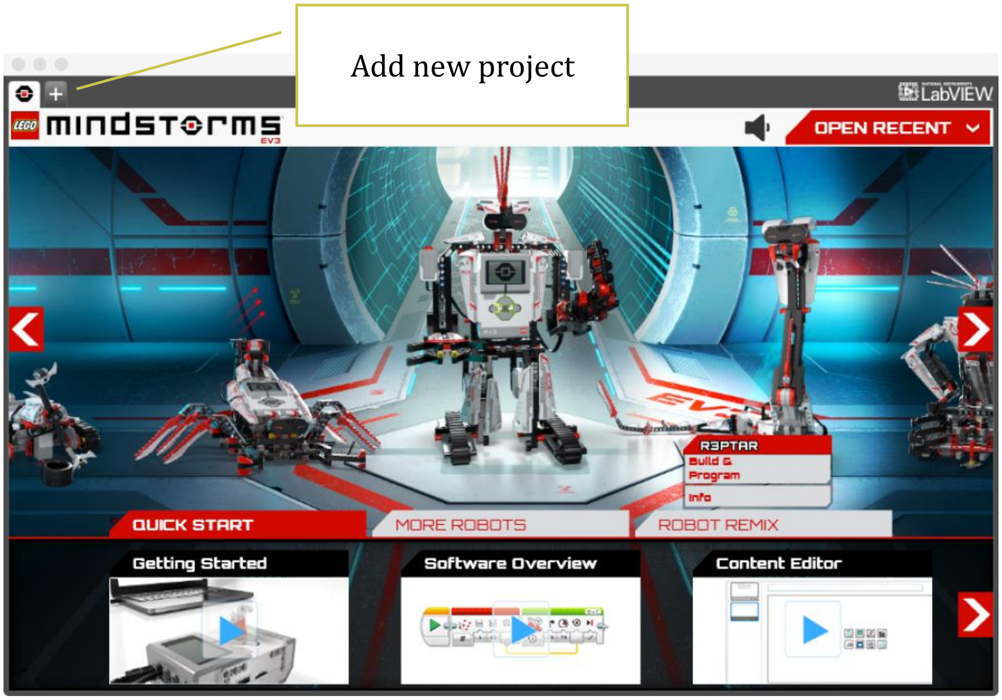
< *EV3 Software*>

In this activity, the goal is to be able to find the EV3 software, start it, save a file, and finally reopen it.

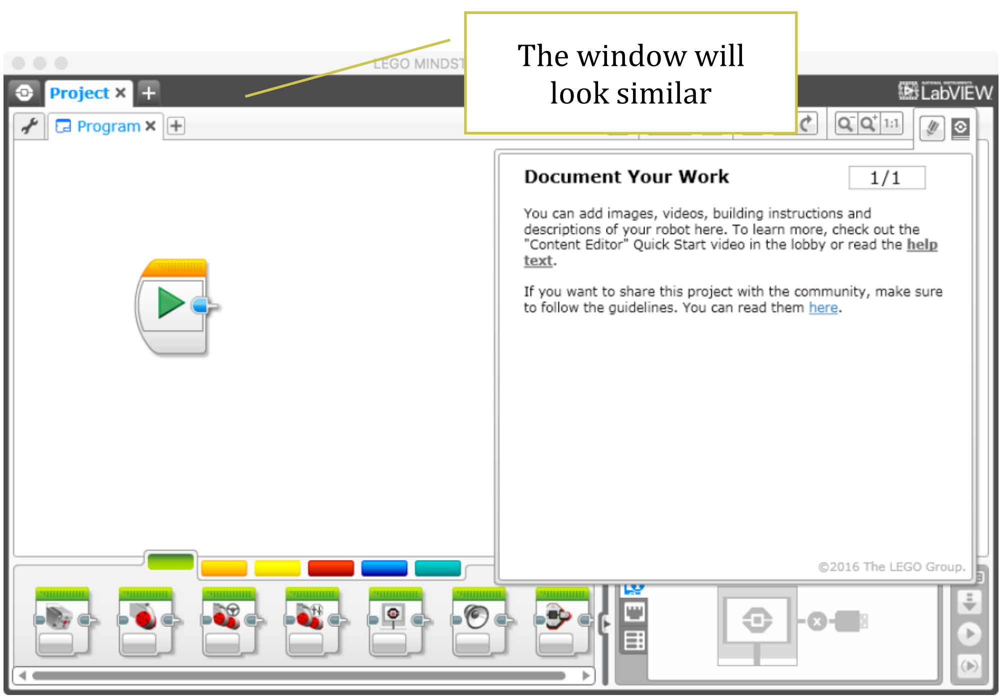
Step 1

Find the Lego Mindstorms Application from Start Menu and launch it

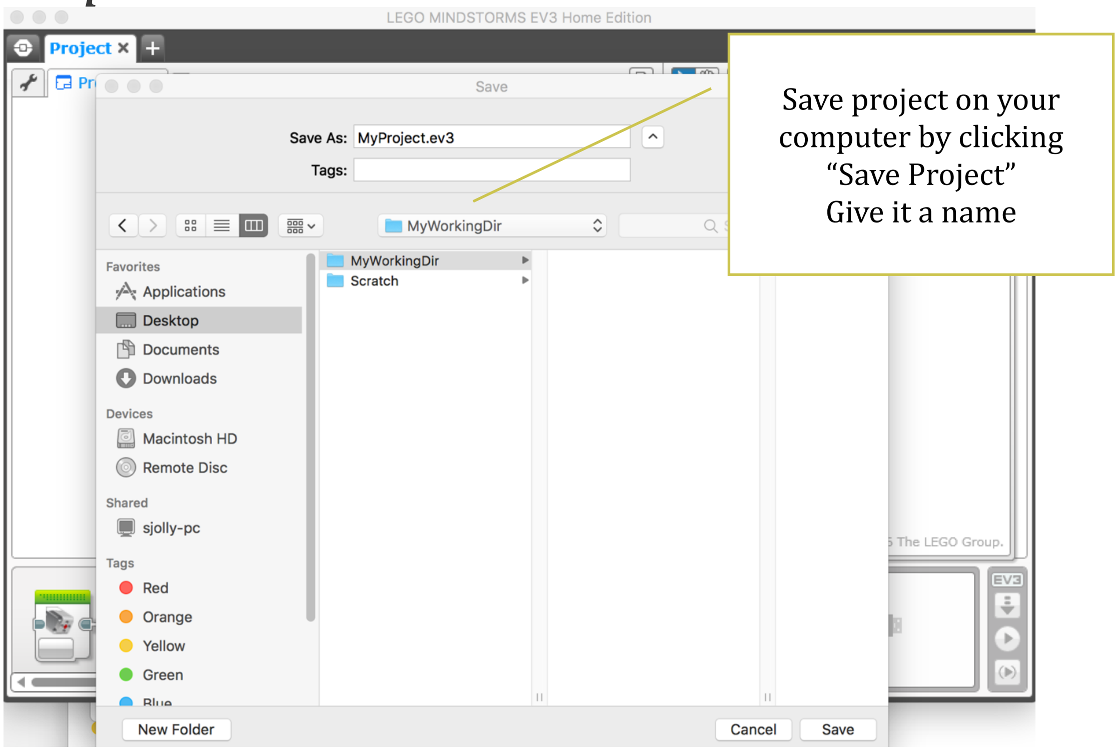
Step 2


Add new project
LabVIEW
MINDSTORMS EV3
OPEN RECENT
R3PTAR
Build &
Program
Info
QUICK START
MORE ROBOTS
ROBOT REMIX
Getting Started
Software Overview
Content Editor

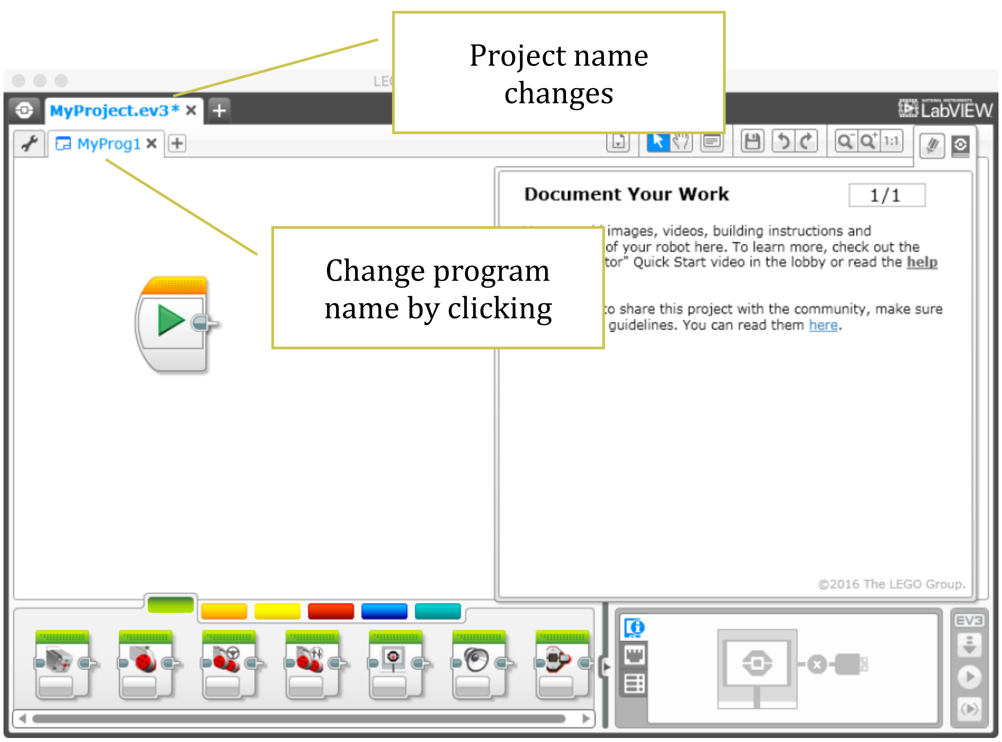
Step 3

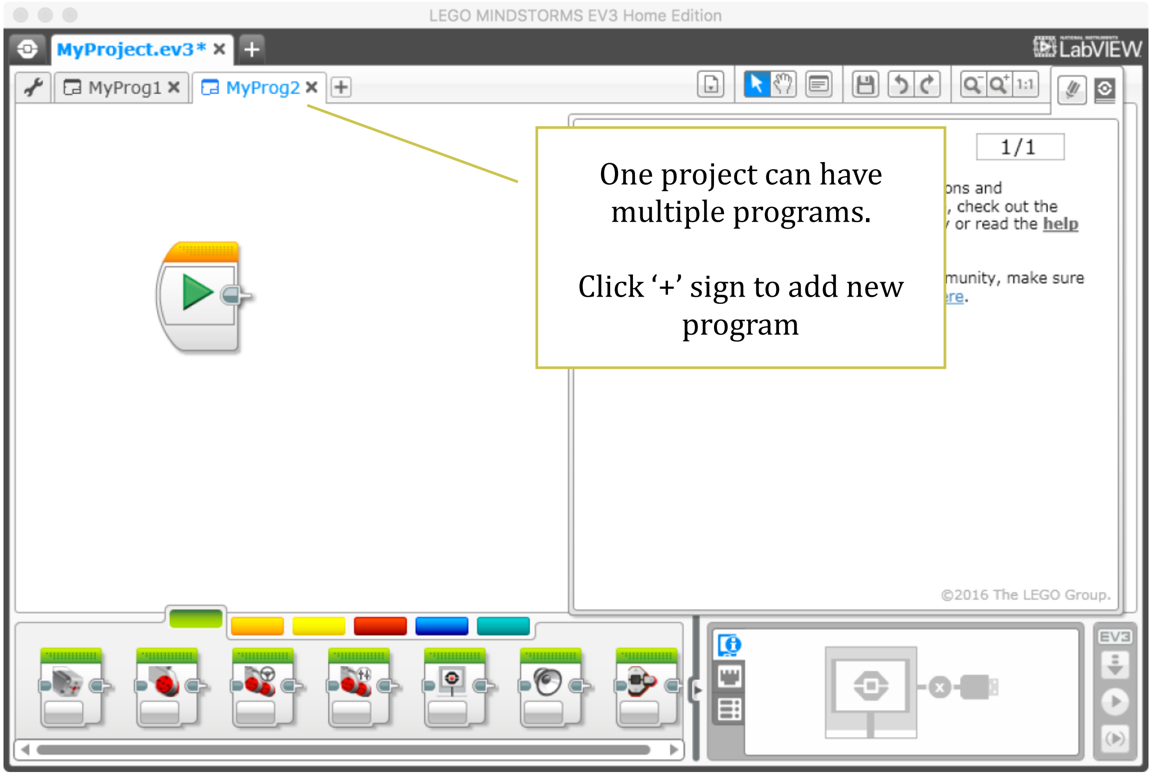

The window will look similar
Project
Program
LabVIEW
Document Your Work
1/1
You can add images, videos, building instructions and descriptions of your robot here. To learn more, check out the "Content Editor" Quick Start video in the lobby or read the help text.
If you want to share this project with the community, make sure to follow the guidelines. You can read them here.
©2016 The LEGO Group.

Step 4


LEGO MINDSTORMS EV3 Home Edition
Save
Save As: MyProject.ev3
Tags:
MyWorkingDir
Favorites
Applications
Desktop
Documents
Downloads
Devices
Macintosh HD
Remote Disc
Shared
sjolly-pc
Tags
Red
Orange
Yellow
Green
MyWorkingDir
Scratch
New Folder
Cancel
Save
Save project on your computer by clicking "Save Project"
Give it a name

Step 5


Project name changes
MyProject.ev3*
MyProg1
LabVIEW
Document Your Work
1/1
Change program name by clicking
©2016 The LEGO Group.



Step 6

Locate the file on your computer where you saved it and open it. It is a good practice to save your programs in a folder where you can locate them and refer to them or reuse them for future use.

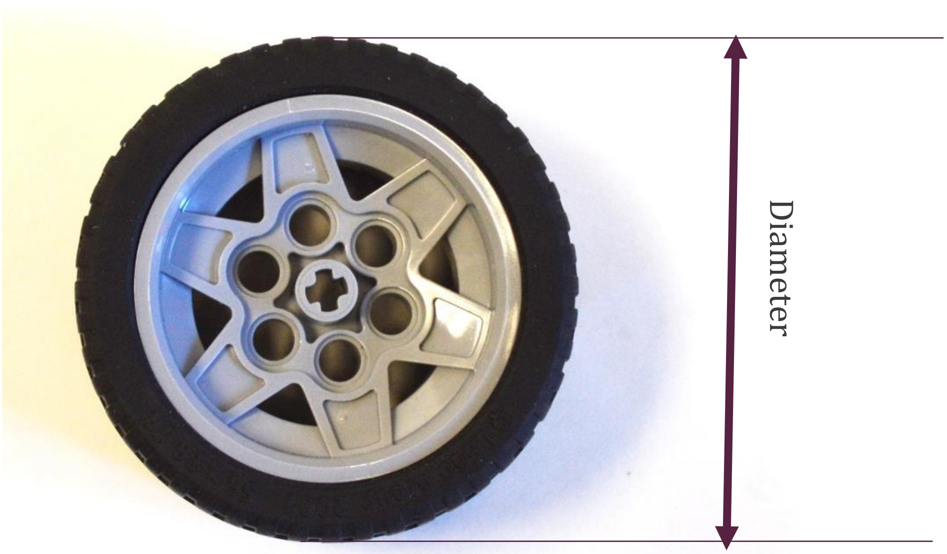
ACTIVITY

< *Calculating Distance Travelled* >

In this activity, our goal is to understand how to calculate the distance that our bot will travel for each revolution of the wheel. Next, we will calculate number of revolutions the bot wheel will be required to travel in order to achieve a certain distance.

Step 1

Measure the diameter of the wheel from your EV3 set. Use a scale that can measure in millimeters (mm)



Diameter = ____________________________

Step 2

Calculate a value (let's call it **Circumference**) by multiplying 3.14 with the **Diameter** you found in step 1 or **Circumference = Diameter X 3.14**

Thus **Circumference = _________________ X 3.14**

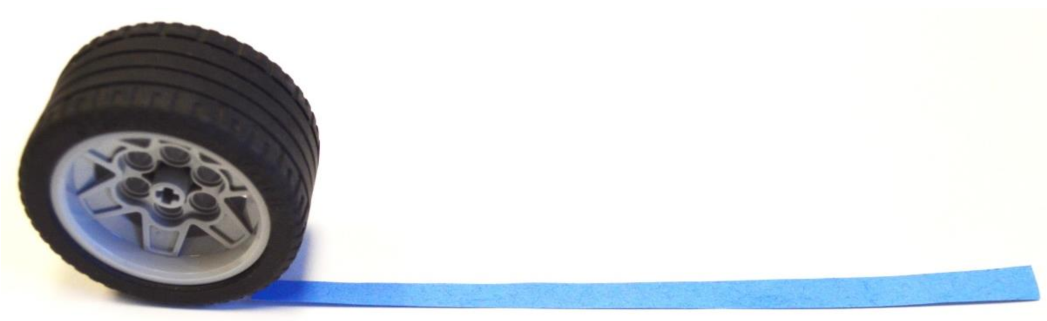
Circumference = ______________________

Step 3

Cut a narrow strip of paper which is 10 mm in width and has a length of the value you calculated for the **Circumference.**

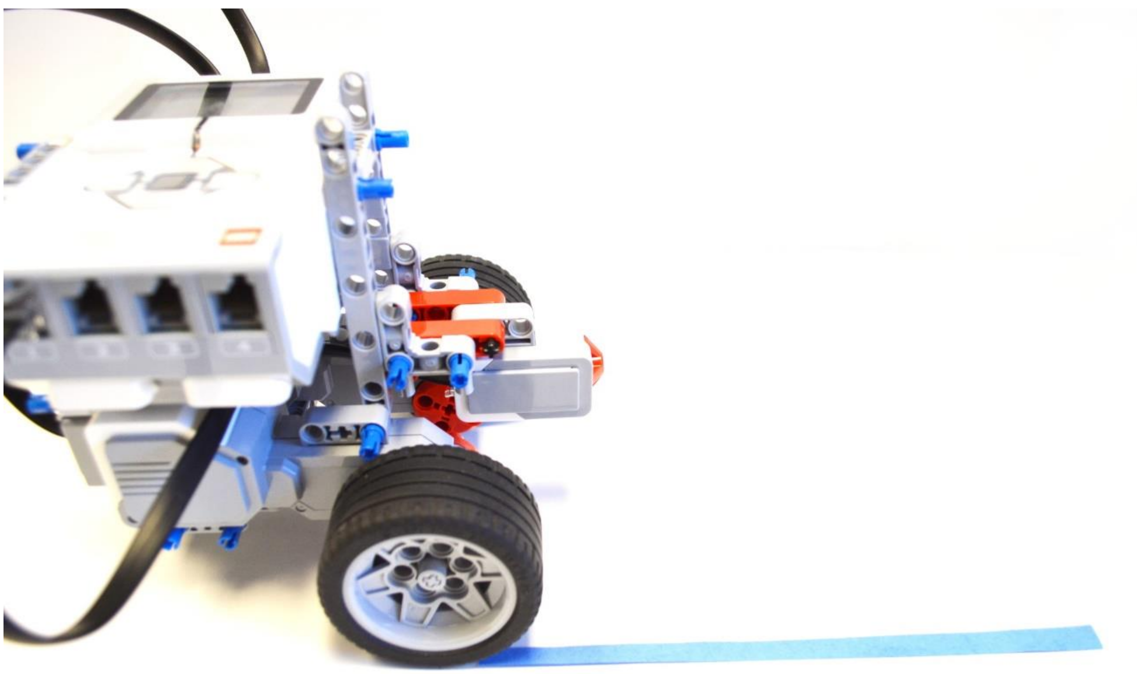
Step 4

Take the strip from previous step and wrap it around a wheel from the EV3 set as shown below



Step 5

You will notice that the strip that you had created wraps the wheel perfectly. Which means that when the wheel makes one revolution it travels the distance which is calculated by the **Circumference** of the wheel. See the image below to see if you agree.



Step 6

This also means that if the wheel makes two revolutions then the bot will travel by a distance = 2 X Circumference and similarly for 3 revolutions distance = 3 X Circumference and so on.

We also know that the Circumference is calculated by multiplying the value of pi which is 3.14 with the Diameter. We can see thus that

$$\boldsymbol{DistanceTraveledByBot = 3.14\ X\ \ Diameter\ X\ NumberOfWheelRevolutions}$$

We can also calculate the number of wheel revolutions required if we know the distance that must be traveled by the bot by simply rearranging the above formula to:

$$\boldsymbol{NumberOfWheelRevolutions = \frac{DistanceTraveledByBot}{3.14\ X\ Diameter}}$$

Step 7

Answer the following questions. You may plugin the values in the above formula for your answers

1. If you set the <u>number of revolutions for the wheel to be 3</u> and your robot has wheels with <u>diameter of 56 mm</u>, how far will your robot travel?

2. Set the values of your program to have 3 revolutions of the wheel and then measure the distance that the bot moves

a. How close was this answer as compared to previous one?

____

b. If it was different, what could have caused the difference?

3. Run the bot. If you want your bot to travel 200 mm and your robot has wheels with diameter of 56 mm, how many revolutions must your wheel make?

$$\boldsymbol{NumberOfWheelRevolutions} = \frac{\_\_\_\_\_\_\_\_\_\_\_\_}{\mathbf{3.14}\ \boldsymbol{X}\ \_\_\_\_\_\_\_\_\_\_\_\_}$$

4. If you want your bot to travel a distance of 500 mm and your robot has wheels with diameter of 56 mm, how many revolutions must your wheel make?

ACTIVITY

< Connectors Smooth or With Friction>

The technics parts have different type of pins. In this activity, your goal is to explore the different types. Selecting the correct pin for the type of joint is important for a sturdy robot

Step 1

Find the following from your Mindstorms Kit:

- ❑ 1 of 13M beam
- ❑ 1 of 2M black peg
- ❑ 1 of 2M gray peg
- ❑ 1 of 2M blue axel peg
- ❑ 1 of 2M gray axel peg
- ❑ 1 of 3M blue peg
- ❑ 1 of 3M gray peg

Step 2

Push one side of the 2M black peg in a hole in 13M beam and then try to rotate the peg – note if it rotates easily. Pull out the peg and now push the other side in a hole in 13M – note if it rotates easily. Mark your findings in the picture below if the side offers a frictional joint or offers a smooth joint.

Step 3

Repeat Step 2 with all other pegs that you selected in Step 1 and mark your findings on next page. Mark Friction/Smooth for both top and bottom side of the pins.

2M black peg

Friction
Smooth

Friction
Smooth

2M gray peg

Friction
Smooth

Friction
Smooth

2M blue axel peg

Friction
Smooth

Friction
Smooth

2M axel peg

Friction
Smooth

Friction
Smooth

3M blue peg

Friction
Smooth

Friction
Smooth

3M peg

Friction
Smooth

Friction
Smooth

ACTIVITY

< *Cross* ***Pinning*** >

In this activity, we will make rectangular frames - we will cross pin using (i) rectangular or square shape, and (ii) triangular shape. Your goal will be to test which one of the two cross pinning makes sturdy frames.

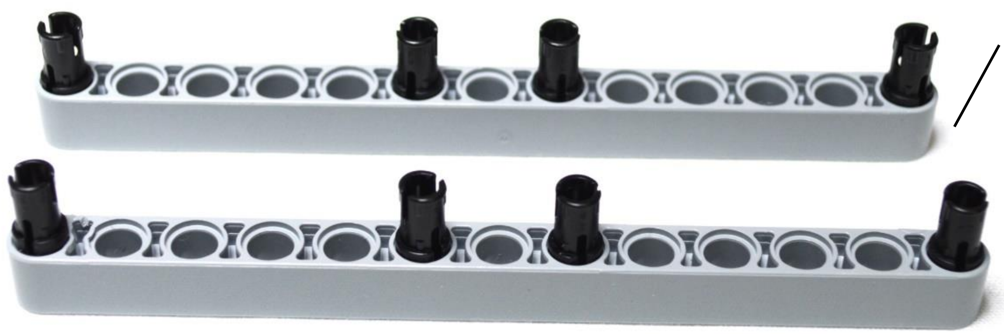
Find the following from your Mindstorms kit.

- ☐ 4 X 13M beams
- ☐ 8 X 7M beams
- ☐ 16 X 2M connection peg with friction

Step 1.1

1

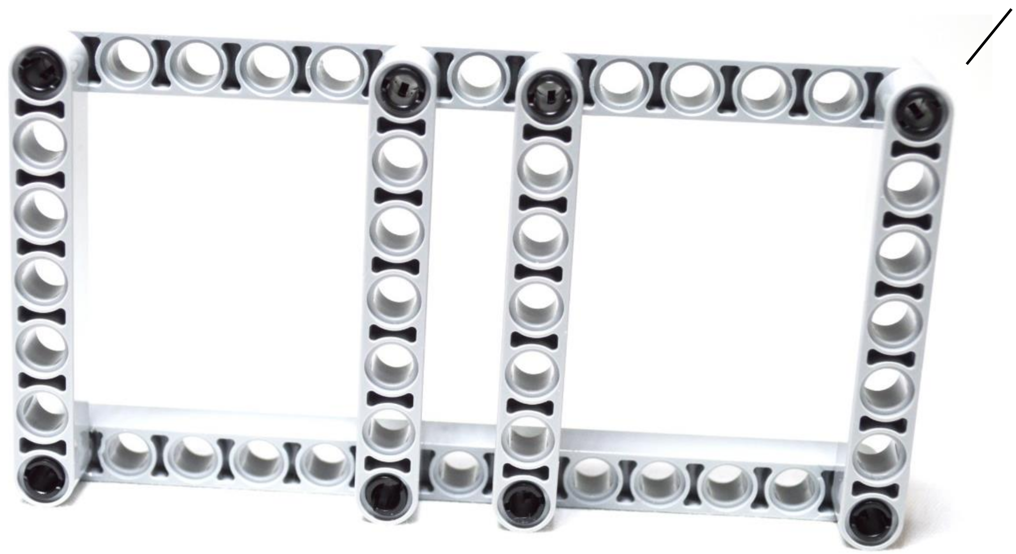
Plug 8 X 2M pegs in two 13M beams as shown



Step 1.2

1

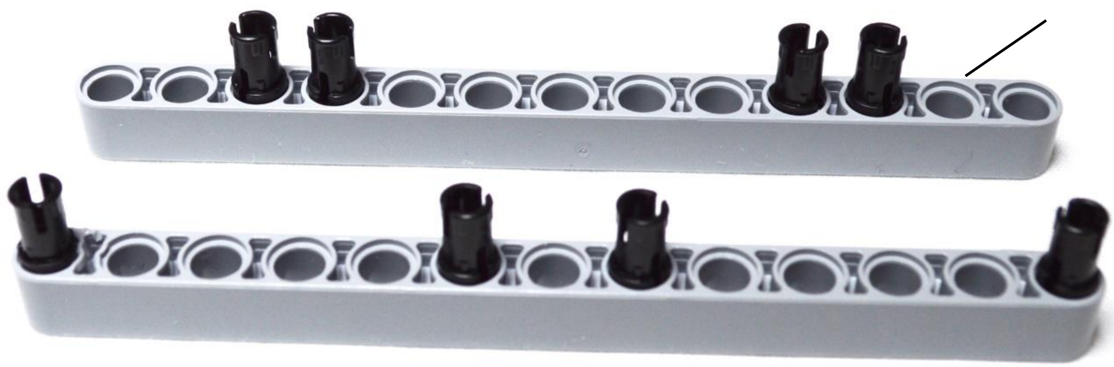
Complete the frame using 4 X 7 M beams



Step 2.1

1

Plug 8 X 2M pegs in two 13M beams as shown

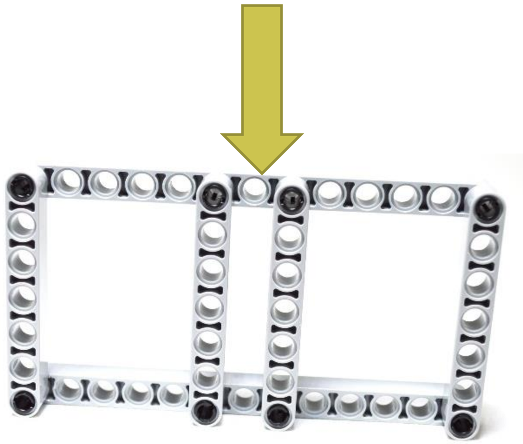


Step 2.2

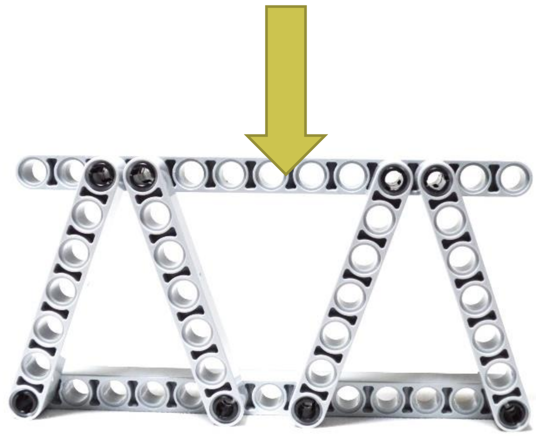
1

Complete the frame using 4 X 7 M beams

Step 3- Answer the questions below



Frame cross pinned using rectangular shape



Frame cross pinned using triangular shape

Which of the two frames are more stable when you apply force near the position of the arrows?

____

____

____

Support your previous answer by explaining what you think makes the frame you selected sturdy.

____

____

____

____

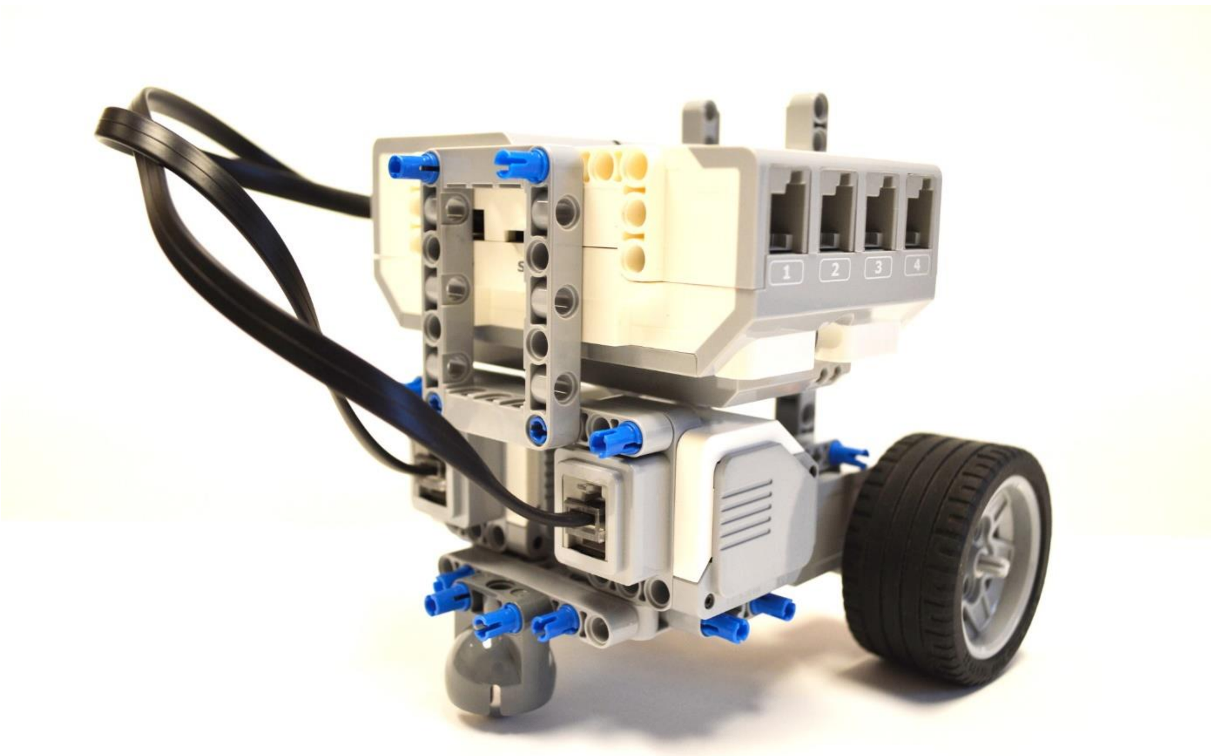
____

____

ACTIVITY

< *simBot* >

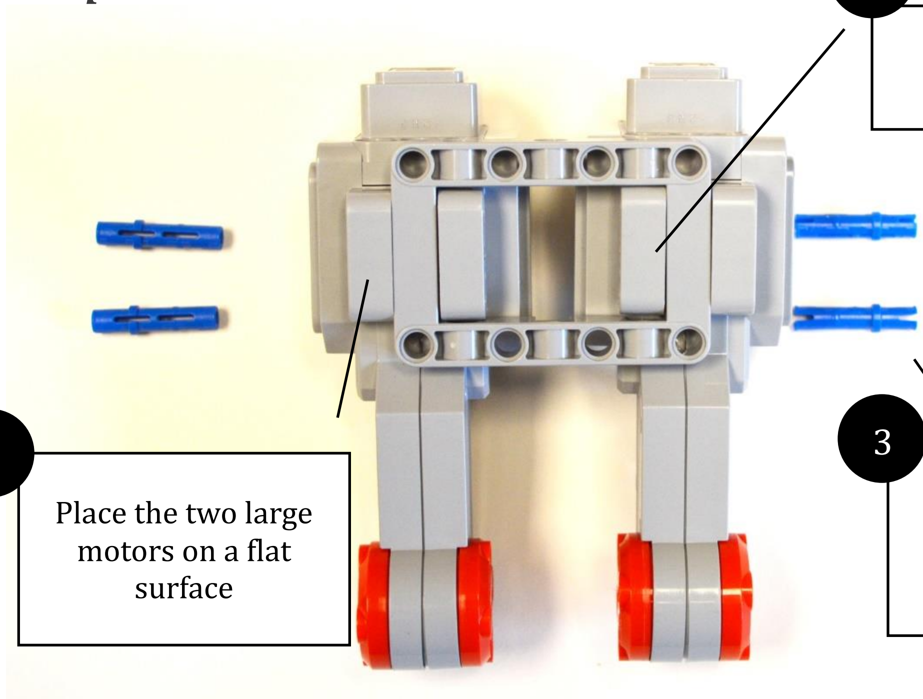
In this activity, we will build a simple bot (simBot) that we can use as a starting point for other activities. This is a bare minimum design – feel free to be creative and design a bot that you want to.



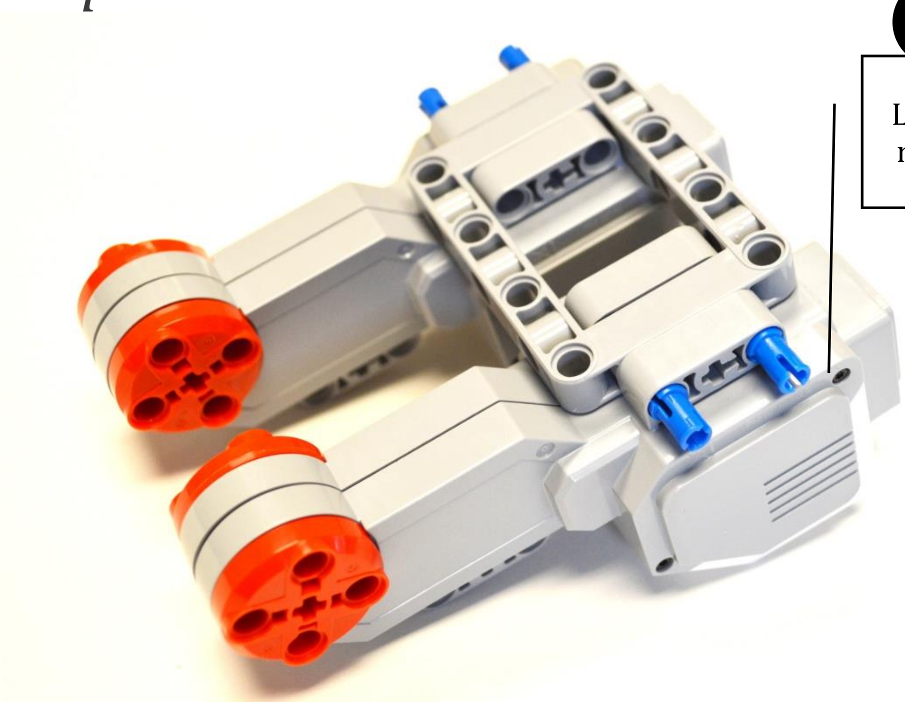
Find the following from your Mindstorms kit – you may follow the steps provided in the accompanying document.

☐ 1 X EV3 block ☐ 2 X large motors ☐ 2 X tires ☐ 2 X hubs	☐ 2 X 5M axles ☐ 1 X steel ball ☐ 1 X ball bearing ☐ 2 X 1M bushing	☐ 18 X 3M connection peg with friction ☐ 2 X 5x7M frames ☐ 1 X 5x11 frame

Step 1


1
Place the two large motors on a flat surface
2
Place the 5X7 M Frame as shown
3
Take 4 blue 3M connector pegs for locking the frame onto motors

Step 2


1
Lock the frame onto motors with 4 pegs

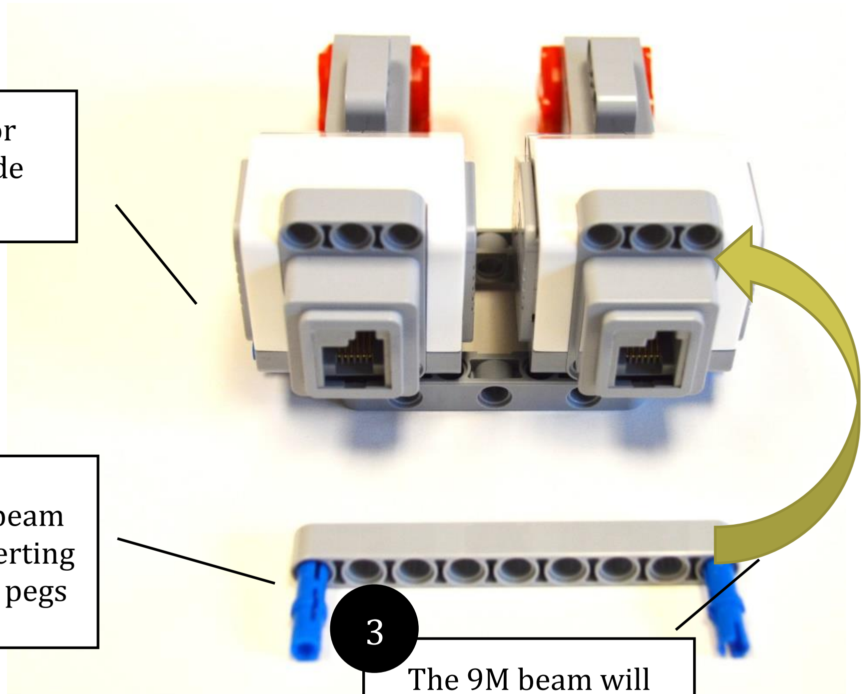
Step 3

1

Turn the motor assembly upside down

2

Prepare a 9M beam by partially inserting 2 3M frictional pegs



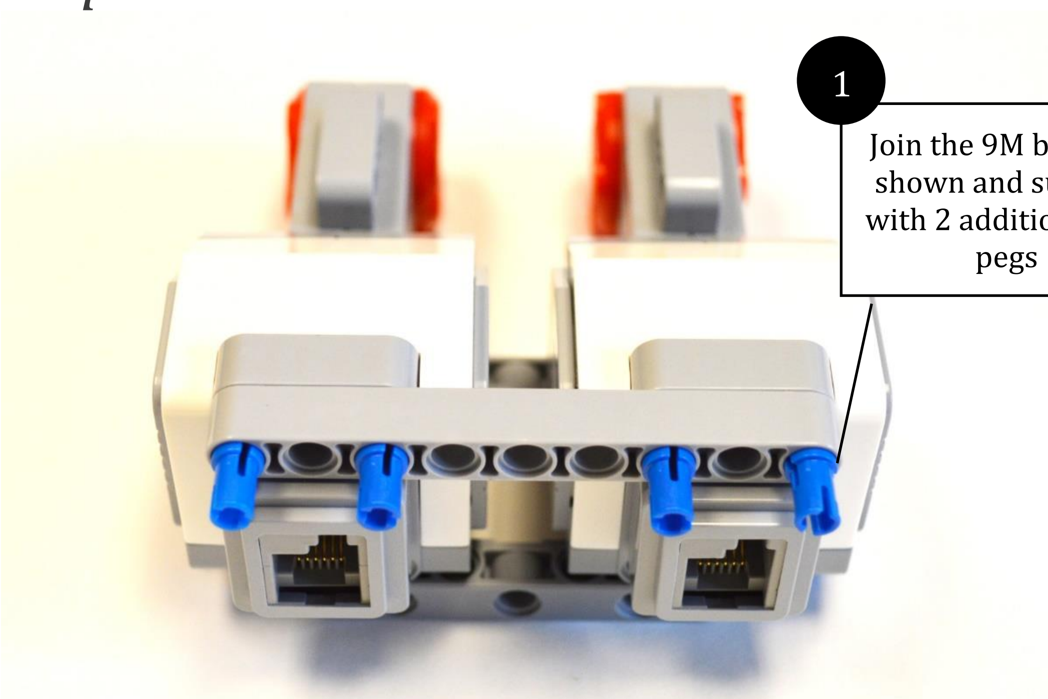
3

The 9M beam will help support the two motors for a sturdy join

Step 4

1

Join the 9M beam as shown and support with 2 additional 3M pegs



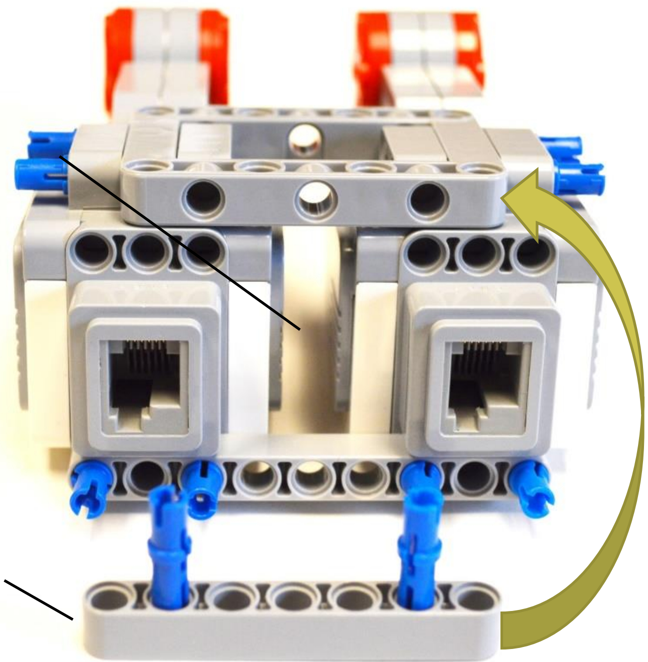
Step 5

1

Rotate the assembly upside down again

2

Prepare a 7M beam by partially inserting 2 3M frictional pegs – this will hold the third wheel built with steel ball and the bearing



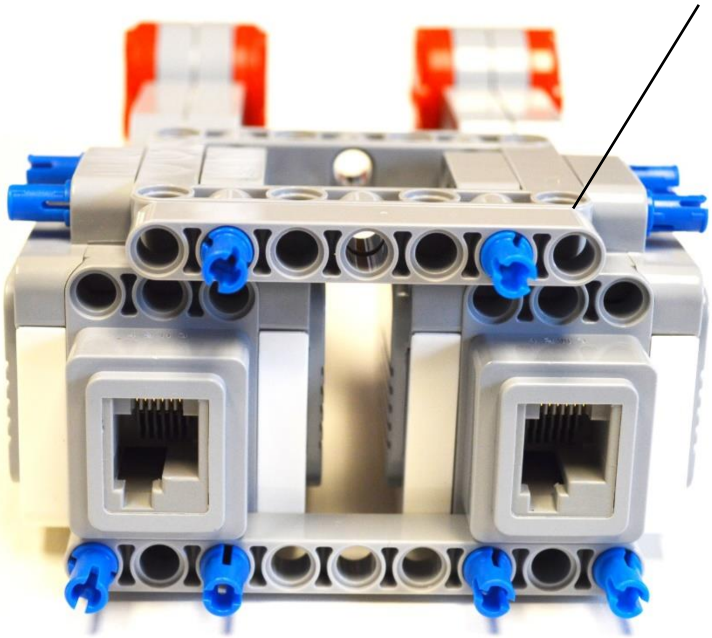
3

The 7M beam will be attached to the 5X7M frame to hold the third wheel built with steel ball and the bearing

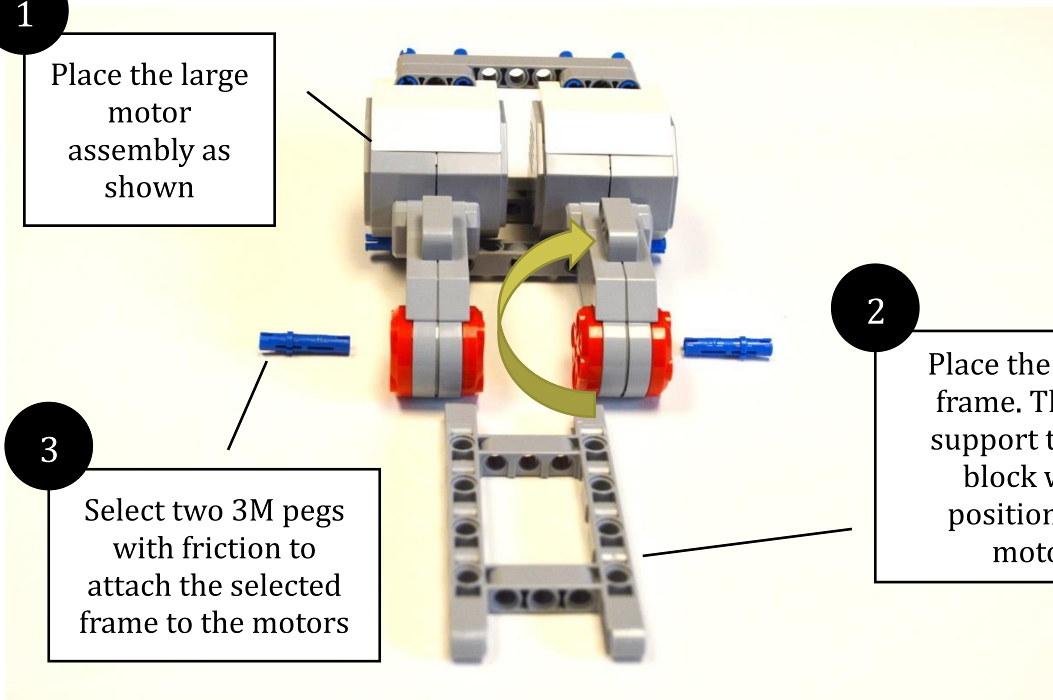
Step 6

1

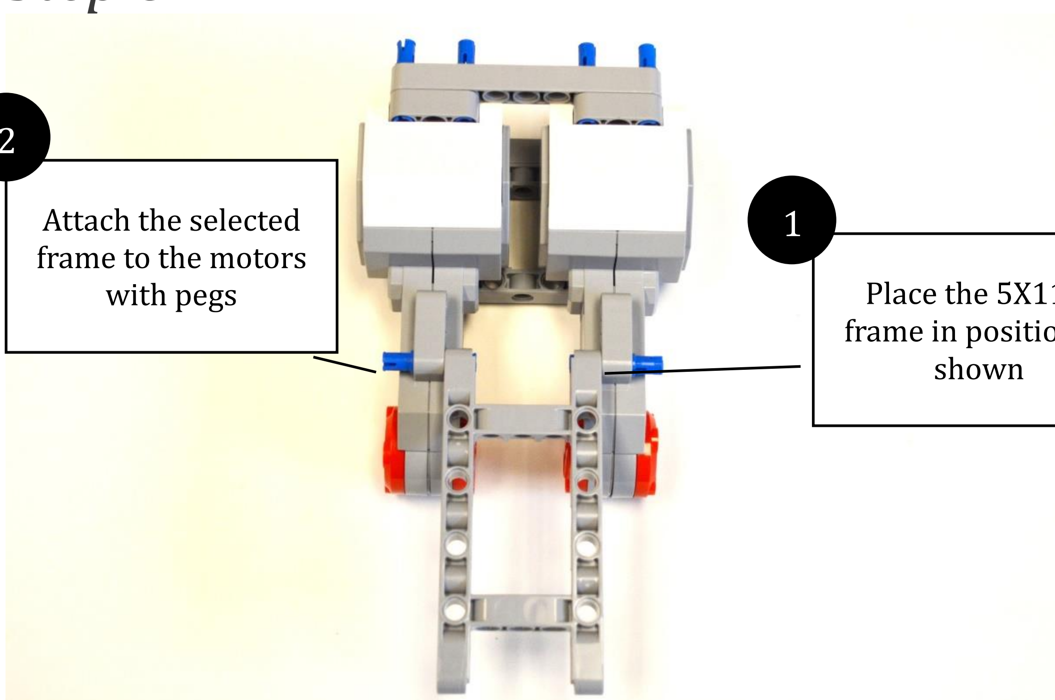
Attach the 7M beam and press the pegs into position



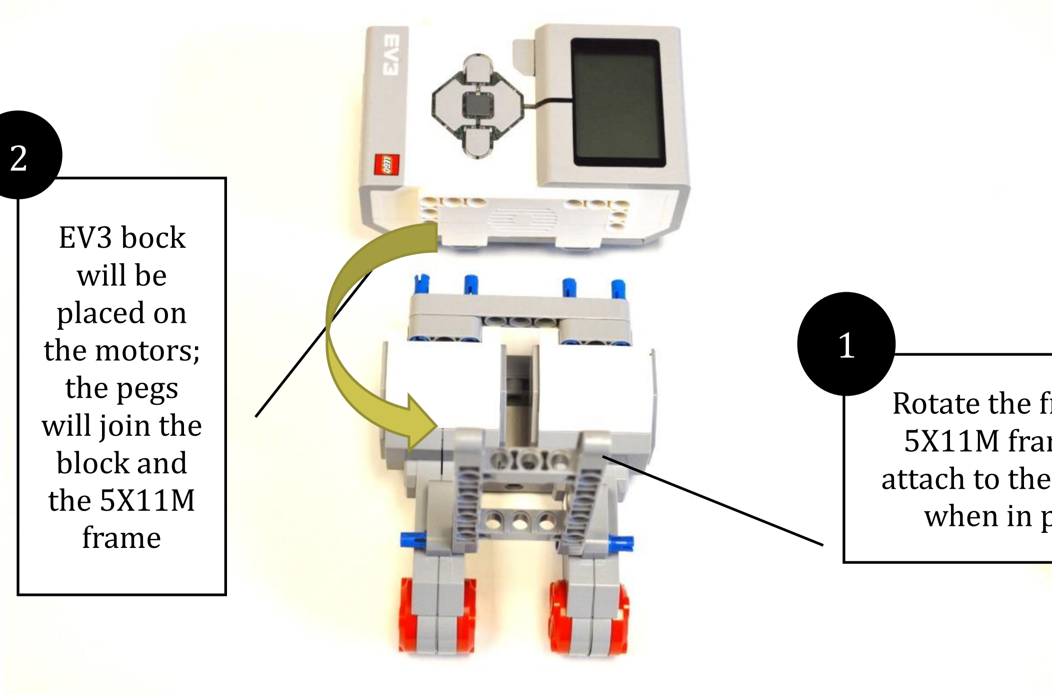
Step 7


1
Place the large motor assembly as shown
2
Place the 5X11M frame. This will support the EV3 block when positioned on motors
3
Select two 3M pegs with friction to attach the selected frame to the motors

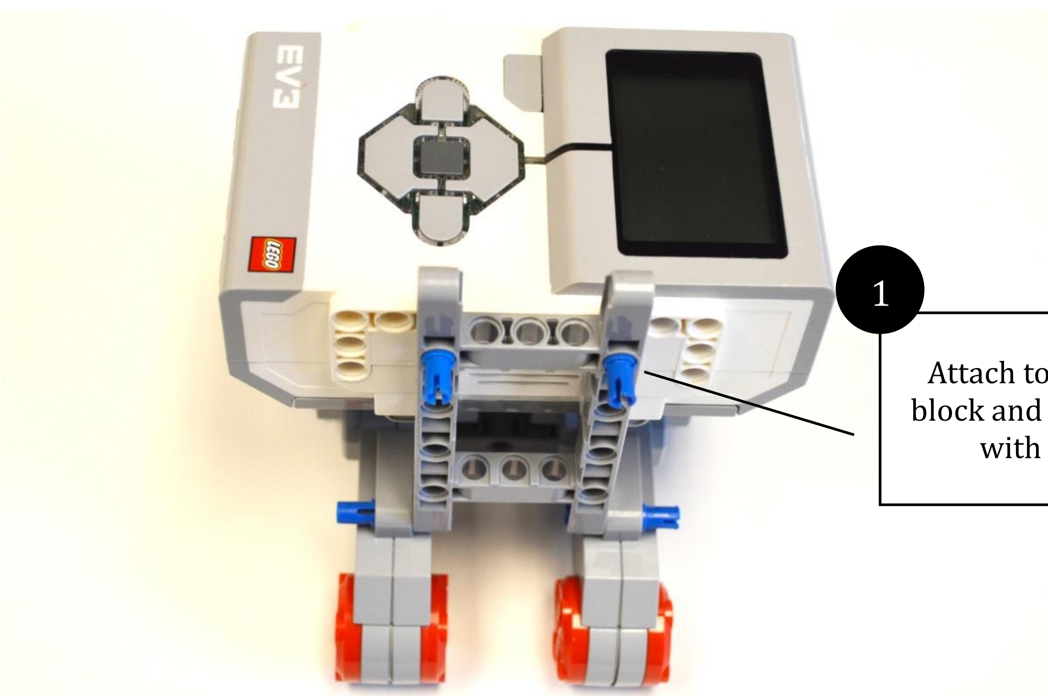
Step 8


2
Attach the selected frame to the motors with pegs
1
Place the 5X11M frame in position as shown

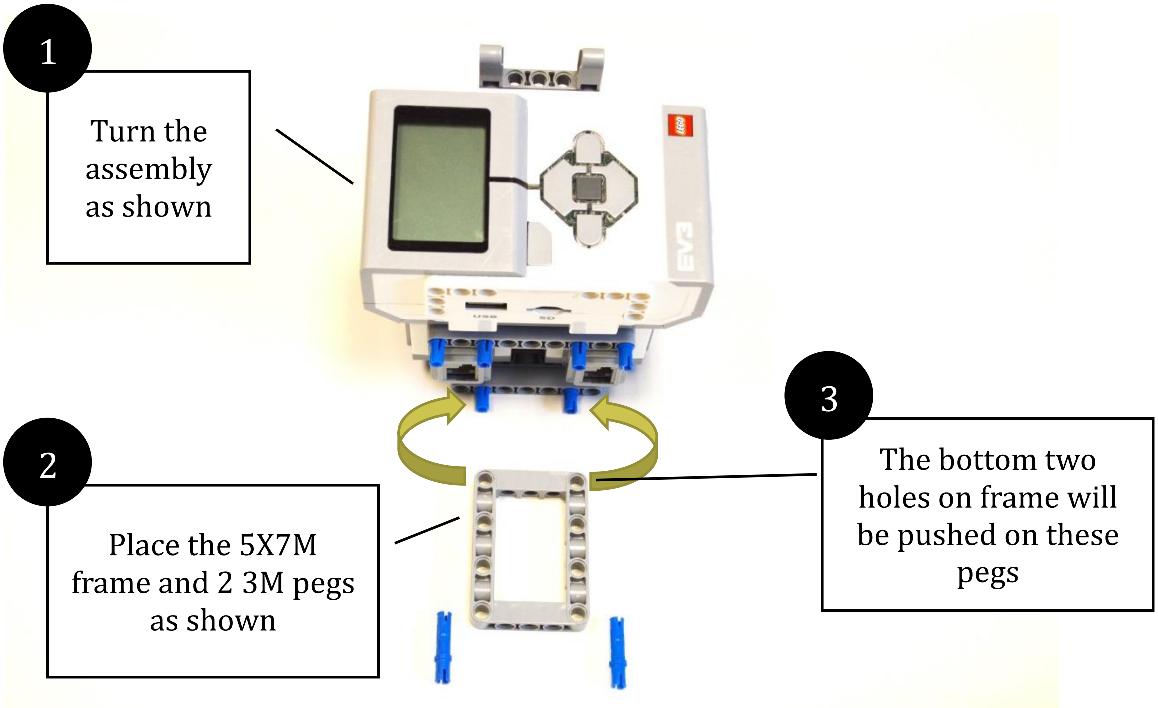
Step 9



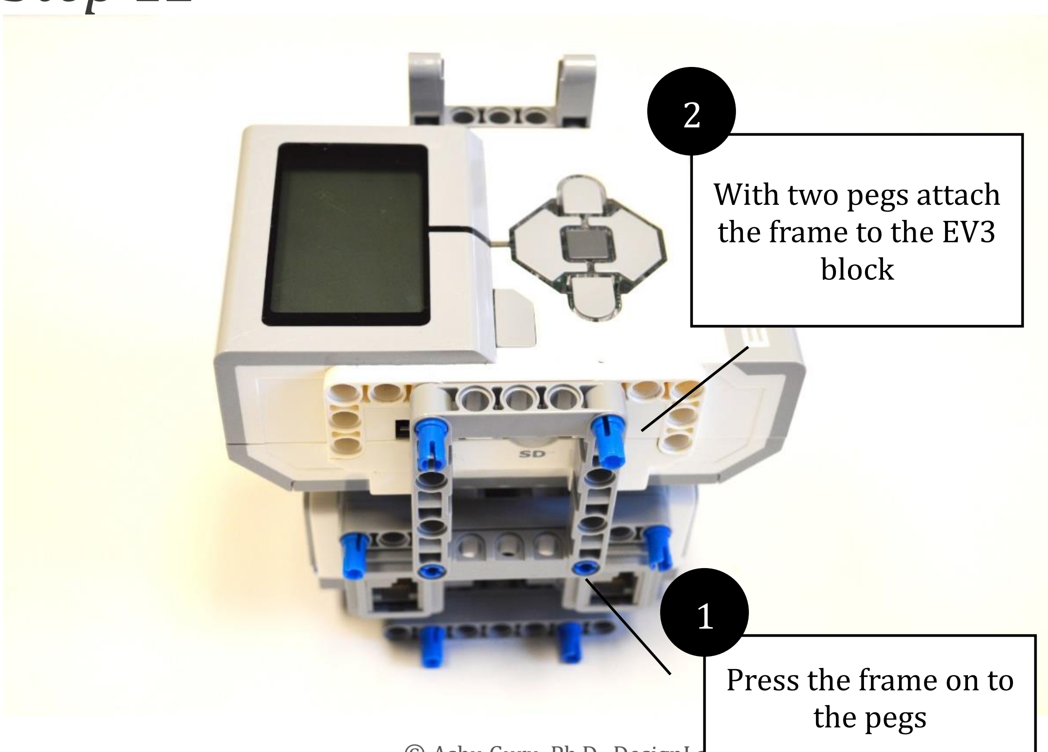
Step10



Step 11



Step 12



Step 13

1

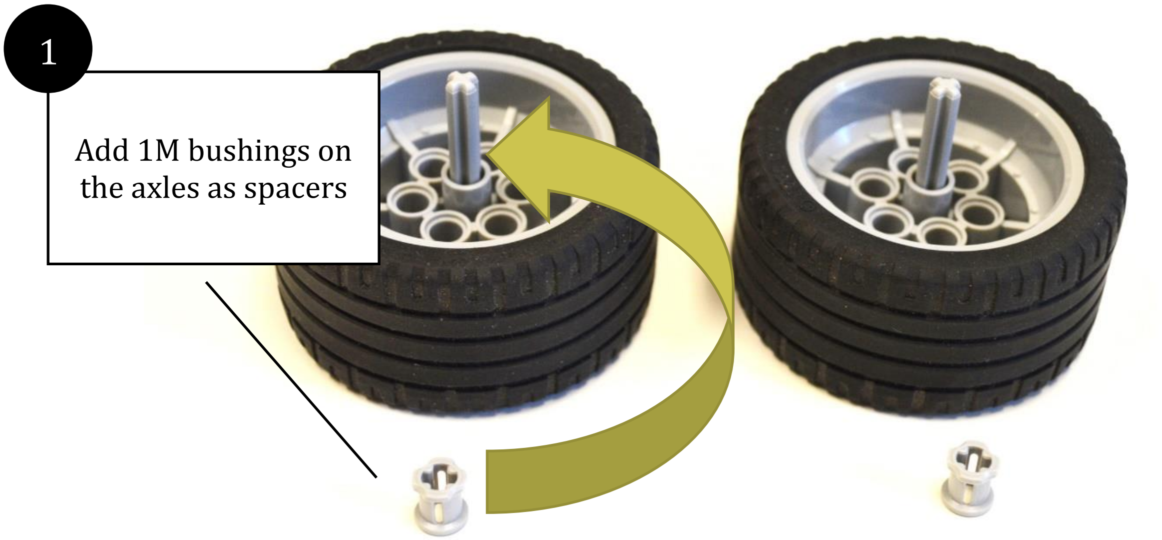
Get the hubs and the tires ready for assembly

Step 14

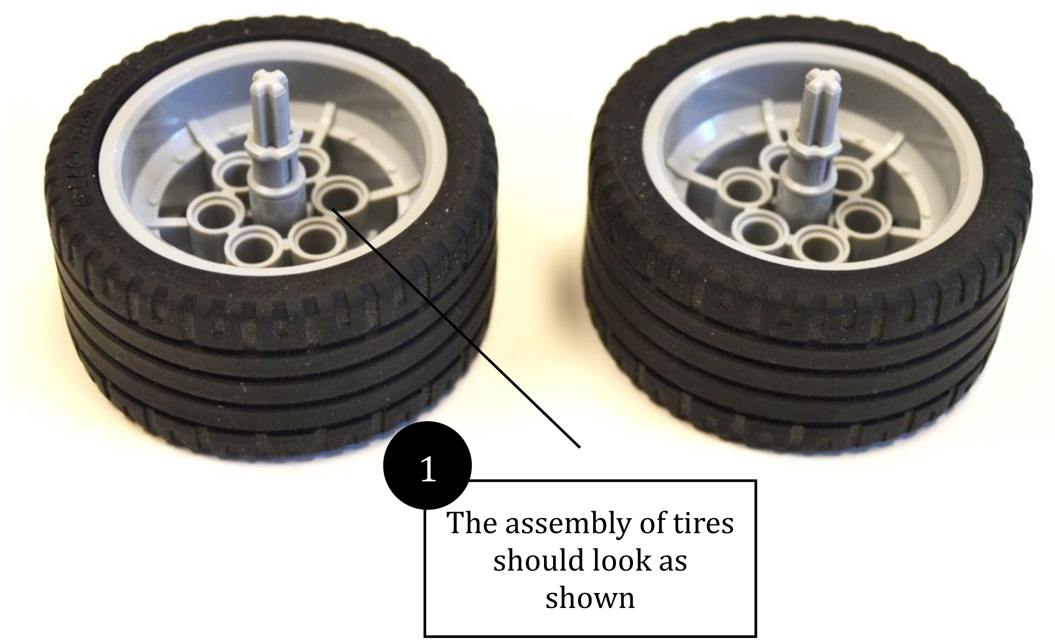
1

Insert the 5M axles from the circular hole side of the hub

Step 15



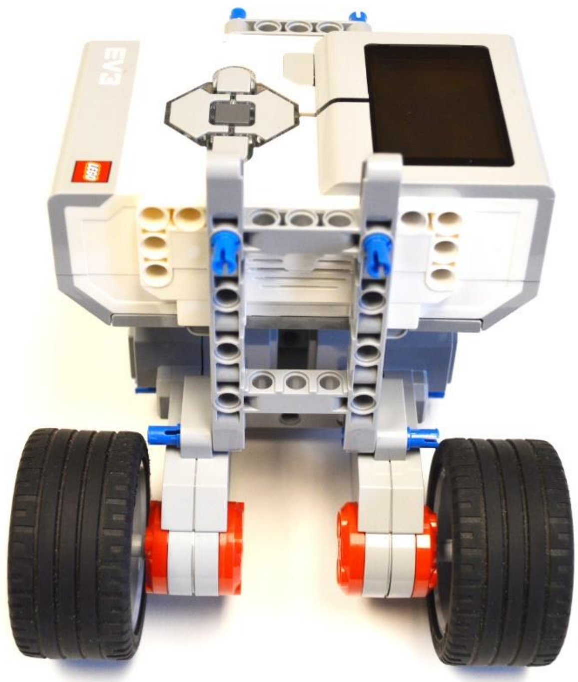
Step 16



Step 17

1

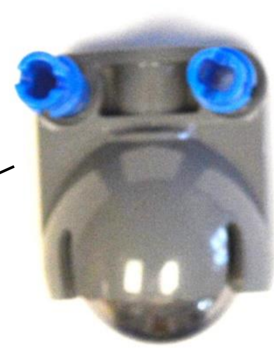
Attach the tires to the motors



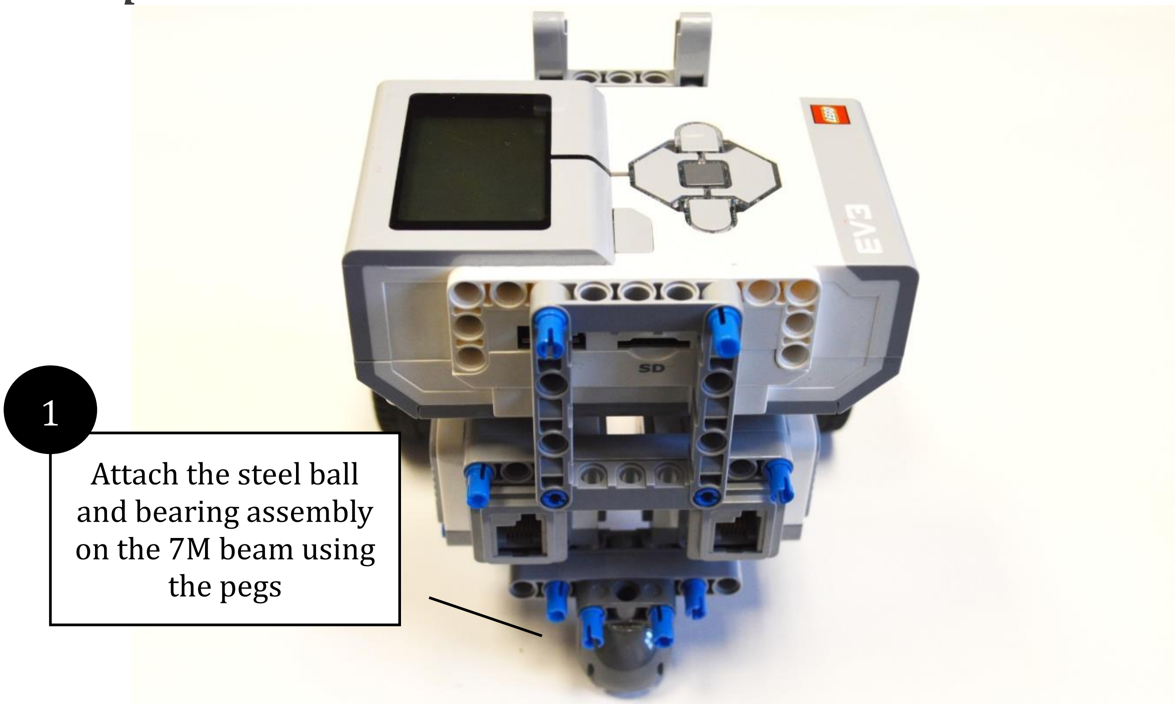
Step 18

1

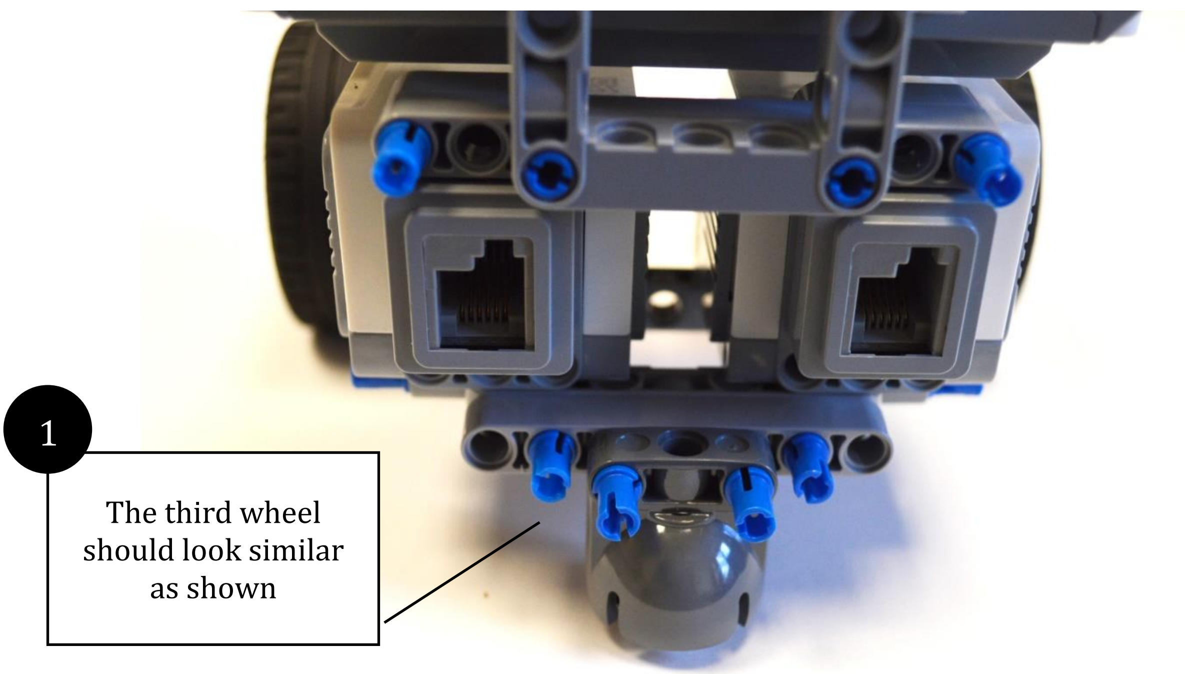
Get the steel ball and bearing assembly ready



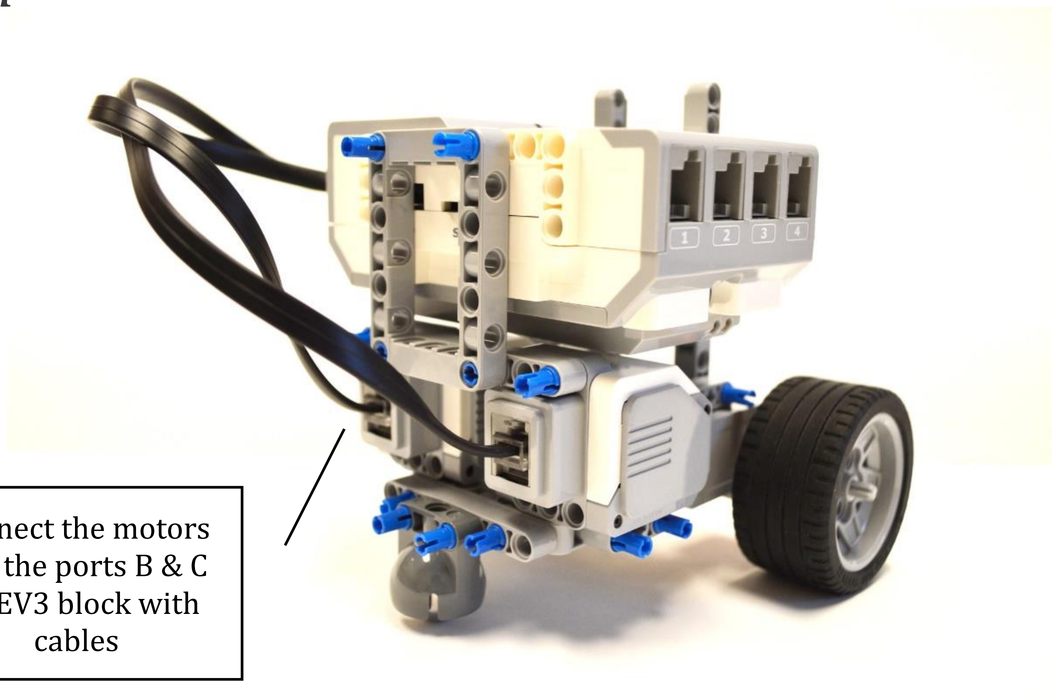
Step 19



Step 20

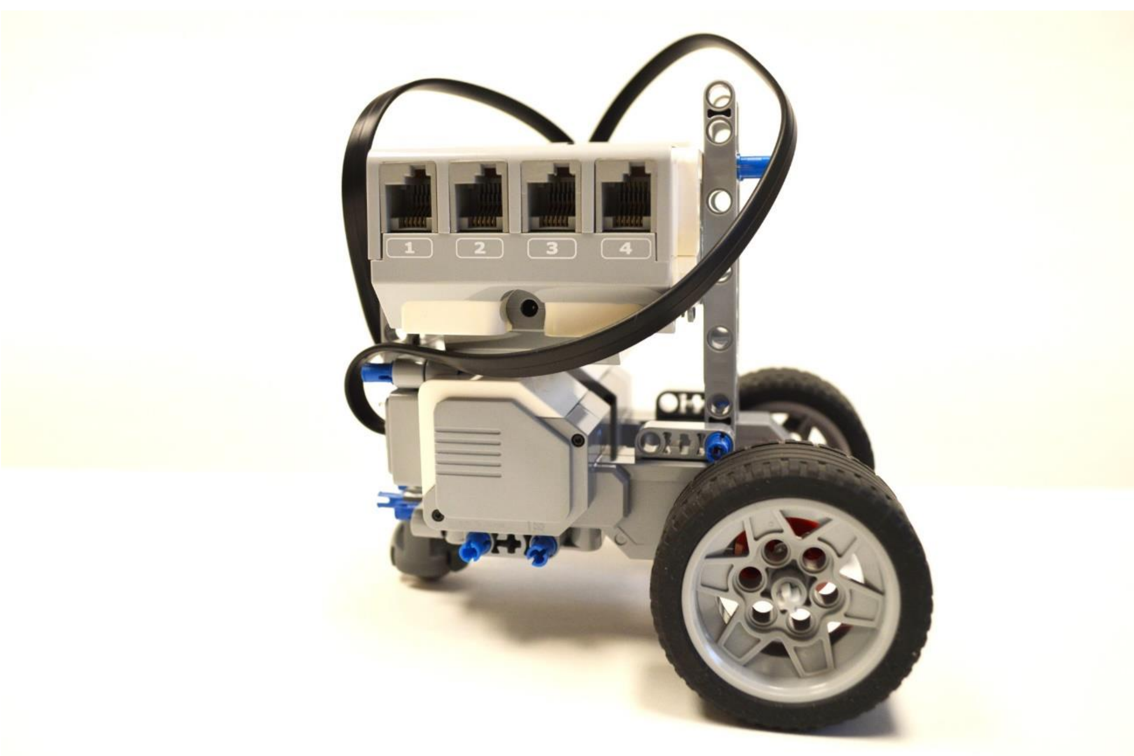


Step 21



1

Connect the motors and the ports B & C on EV3 block with cables



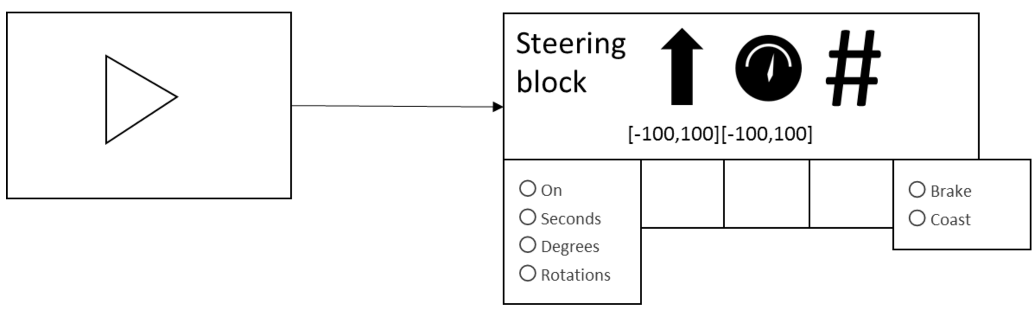
ACTIVITY

< Move Steering >

Section 1

In this section, you will first look at the drawing and try to answer what do you expect the bot will do. In the next step you will answer what did you find by programming your bot.

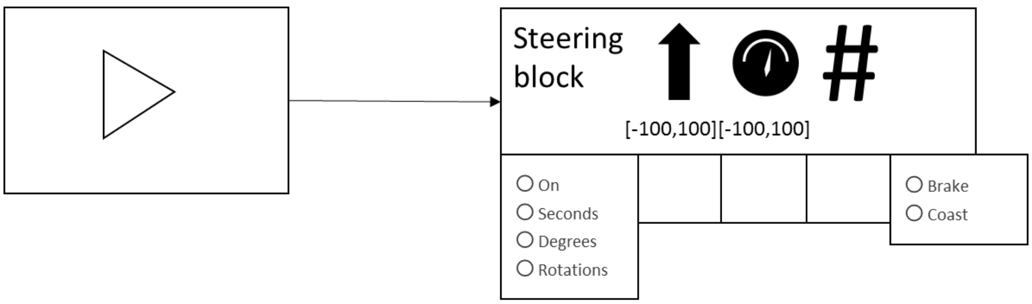
Activity 1



What do you expect?	What did you find?
The bot will move ☐ Forward ☐ Backward ☐ Left ☐ Right	The bot moved ☐ Forward ☐ Backward ☐ Left ☐ Right
The distance travelled by the bot is controlled by: ○ Wheel rotation ○ Time	The distance travelled by the bot was controlled by: ○ Wheel rotation ○ Time
The power is: ○ Low ○ Medium ○ High	The power was: ○ Low ○ Medium ○ High

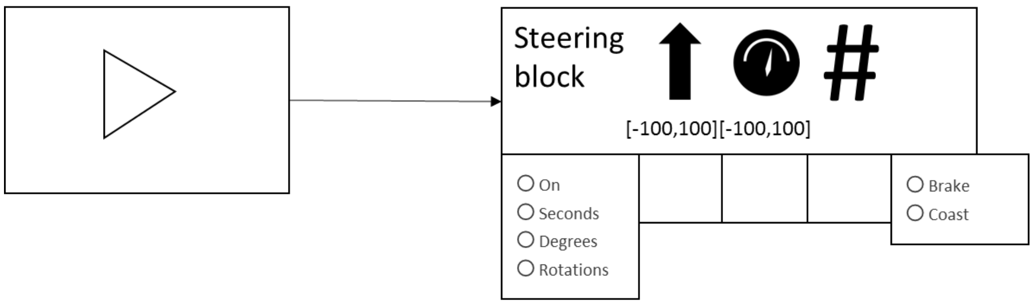
What will bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum	What did bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum

Activity 2



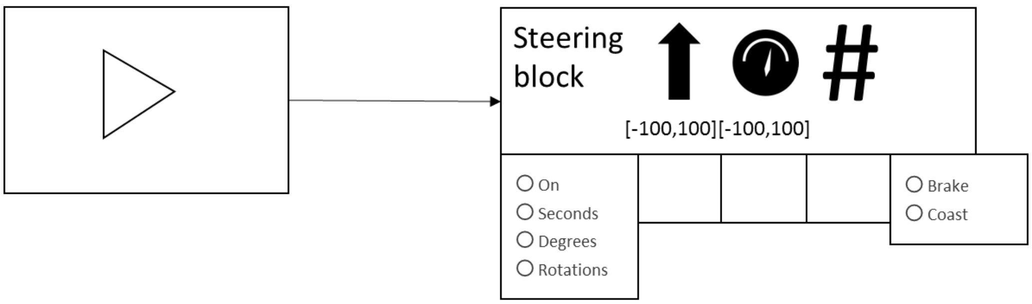
What do you expect?	What did you find?
The bot will move ☐ Forward ☐ Backward ☐ Left ☐ Right	The bot moved ☐ Forward ☐ Backward ☐ Left ☐ Right
The distance travelled by the bot is controlled by: ○ Wheel rotation ○ Time	The distance travelled by the bot was controlled by: ○ Wheel rotation ○ Time
The power is: ○ Low ○ Medium ○ High	The power was: ○ Low ○ Medium ○ High
What will bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum	What did bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum

Activity 3



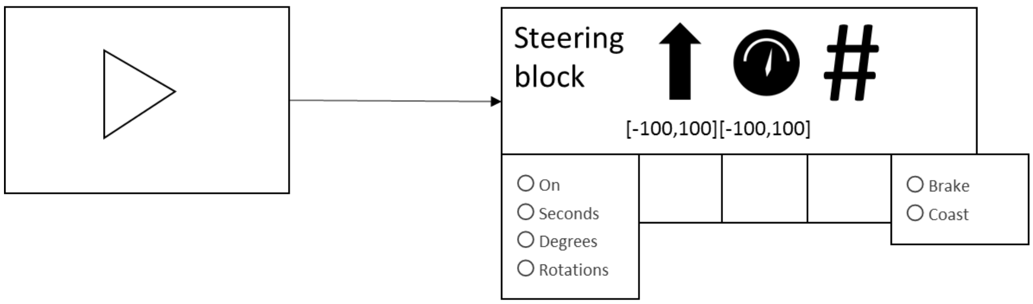
What do you expect?	What did you find?
The bot will move ☐ Forward ☐ Backward ☐ Left ☐ Right	The bot moved ☐ Forward ☐ Backward ☐ Left ☐ Right
The distance travelled by the bot is controlled by: ○ Wheel rotation ○ Time	The distance travelled by the bot was controlled by: ○ Wheel rotation ○ Time
The power is: ○ Low ○ Medium ○ High	The power was: ○ Low ○ Medium ○ High
What will bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum	What did bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum

Activity 4



What do you expect?	**What did you find?**
The bot will move ☐ Forward ☐ Backward ☐ Left ☐ Right	The bot moved ☐ Forward ☐ Backward ☐ Left ☐ Right
The distance travelled by the bot is controlled by: ○ Wheel rotation ○ Time	The distance travelled by the bot was controlled by: ○ Wheel rotation ○ Time
The power is: ○ Low ○ Medium ○ High	The power was: ○ Low ○ Medium ○ High
What will bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum	What did bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum

Activity 5



What do you expect?	What did you find?
The bot will move ☐ Forward ☐ Backward ☐ Left ☐ Right	The bot moved ☐ Forward ☐ Backward ☐ Left ☐ Right
The distance travelled by the bot is controlled by: ○ Wheel rotation ○ Time	The distance travelled by the bot was controlled by: ○ Wheel rotation ○ Time
The power is: ○ Low ○ Medium ○ High	The power was: ○ Low ○ Medium ○ High
What will bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum	What did bot do after performing the steering instruction? ○ Braked immediately ○ Slowly stopped as it lost momentum

EXTENSION

Section 2

In this section, you are given a scenario and your goal is to program the bot to make that action.

Scenario 1:

The bot moves <u>Forward</u> by <u>3 wheel rotations</u> and then <u>stops by braking</u>

Scenario 2:

The bot moves <u>Forward</u> by <u>3 wheel rotations</u> and then <u>stops by braking</u>

Scenario 3:

The bot moves <u>Forward</u> by <u>3 wheel rotations</u> and then <u>stops by braking</u>

Scenario 4:

The bot moves <u>Forward</u> by <u>3 wheel rotations</u> and then <u>stops by braking</u>

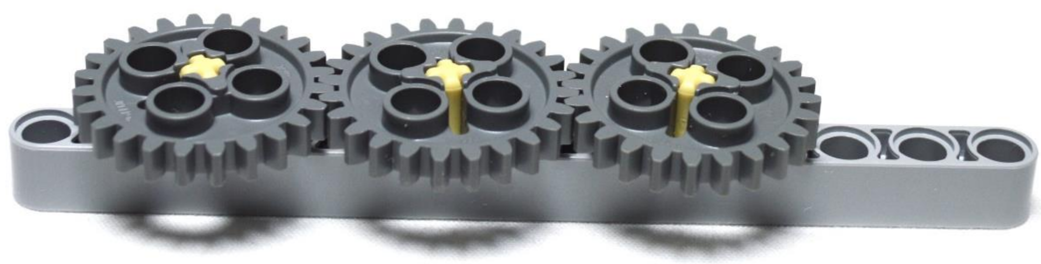
Scenario 5:

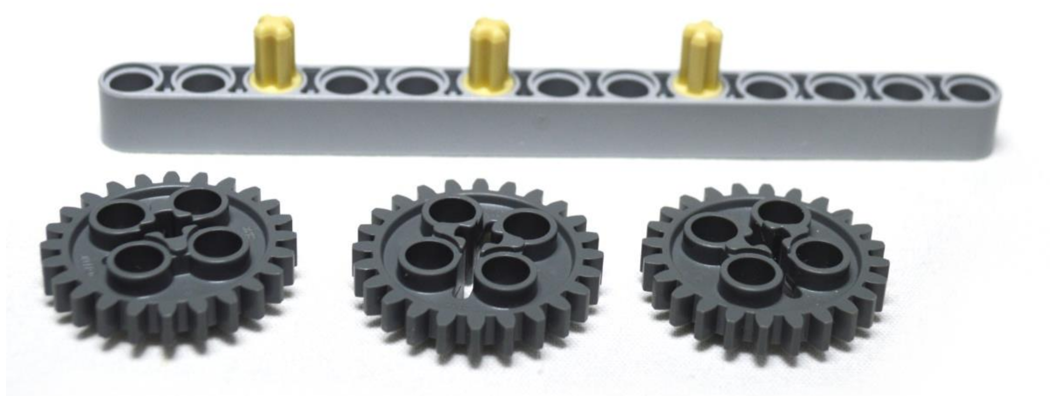
The bot moves <u>Forward</u> by <u>3 wheel rotations</u> and then <u>stops by braking</u>

ACTIVITY

< *Three Gear Drive* >

In this activity, we will explore meshing gears – we will observe how the direction of the driven gear is opposite to the driver gear. Create a gear assembly as shown below

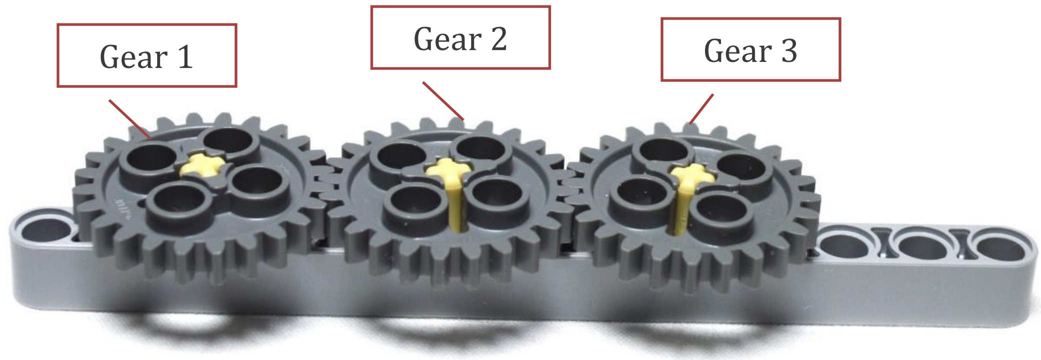




You will need the following parts

☐ 3 X 24-tooth gears ☐ 3 X 2M connector peg with axle ☐ 1 X 13M beam

Answer the questions below



If Gear 1 is rotated in clockwise direction, fill in the following blanks?

1. Gear 2 rotates in ________________________________ direction.
2. Gear 3 rotates in ________________________________ direction.

ACTIVITY

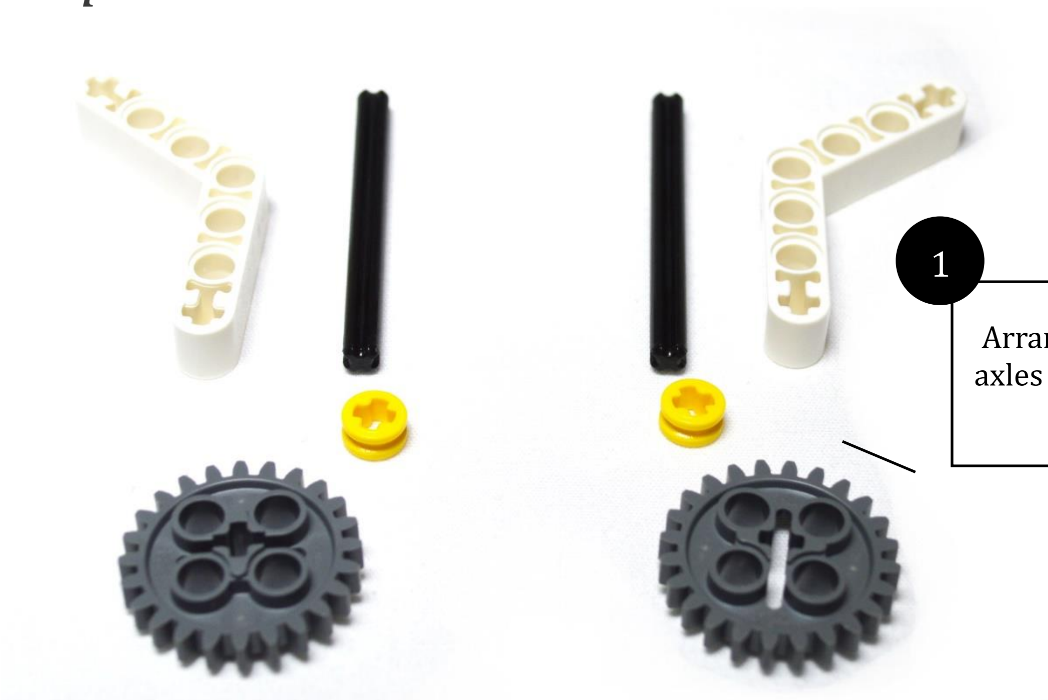
< *Gear Claw* >

In this activity, we will make an assembly that is like a crab claw. The claw opening and closing is synchronized using gears. Additionally, the claws are opened and closed by subjecting an axle to a torque.

You will need the following parts

- ☐ 2 X 24-tooth gears
- ☐ 1 X 8-tooth gear
- ☐ 6 X ½ M bushings
- ☐ 2 X 6M axles
- ☐ 1 X 12M axle
- ☐ 1 X 10M axle
- ☐ 1 X 9M beam
- ☐ 2 X 4x4 angular beam

Step 1



1

Arrange the two 6M axles and other parts as shown

Step 2

1

Assemble the parts as shown

Step 3

1

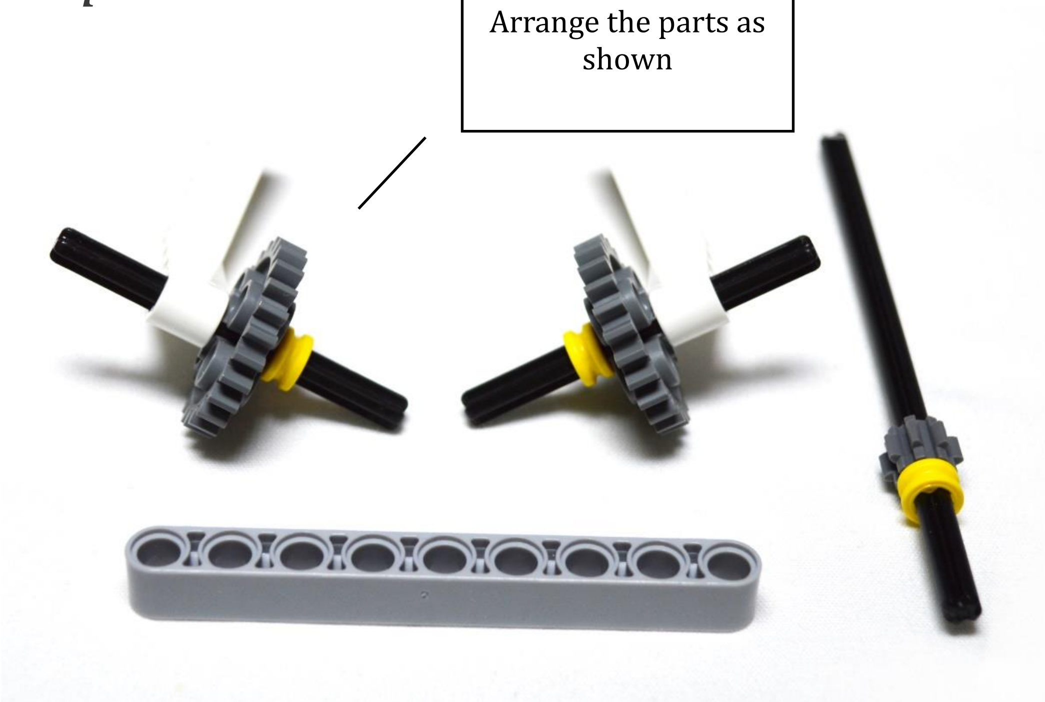
Arrange the 12M axle and other parts as shown

Step 4

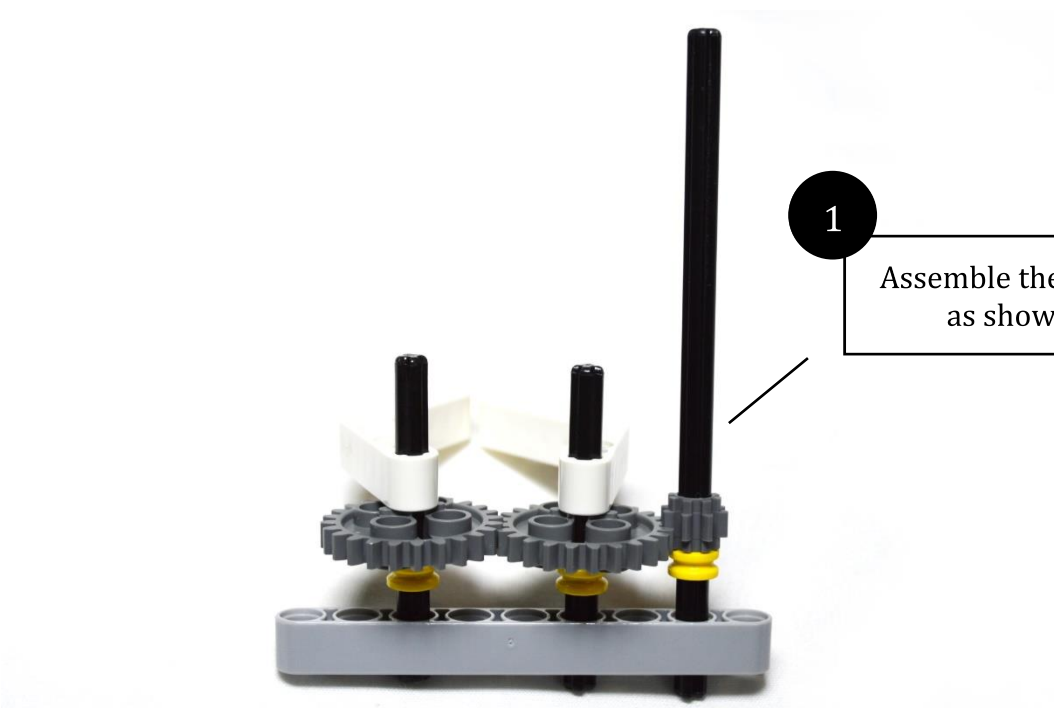
1

Assemble the parts as shown

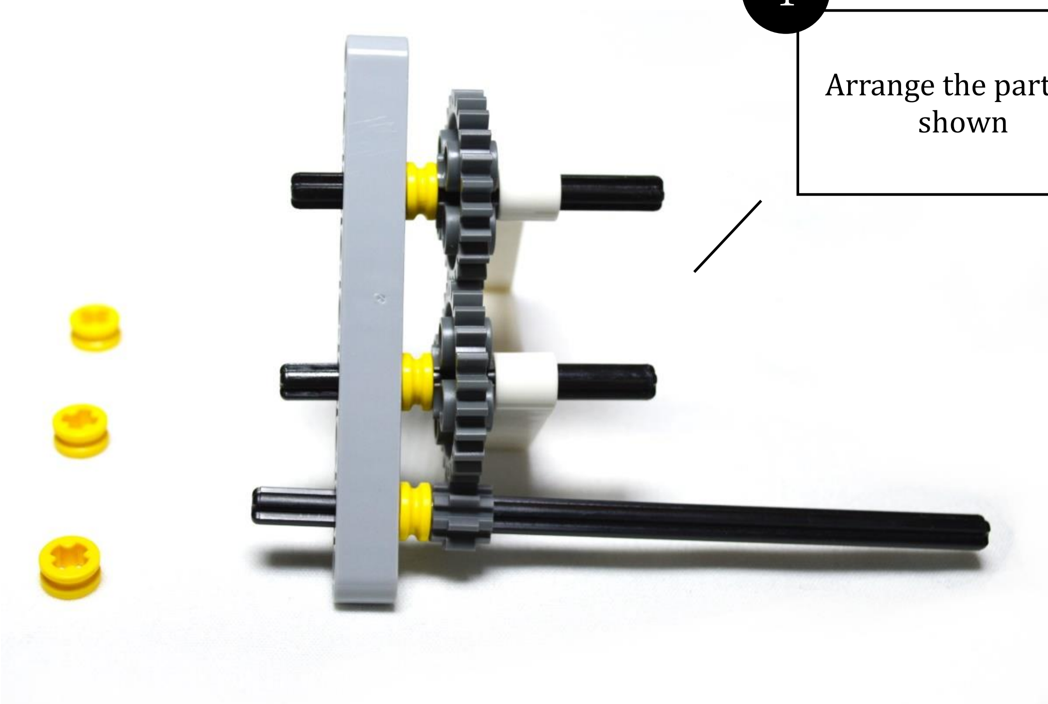
Step 5



Step 6



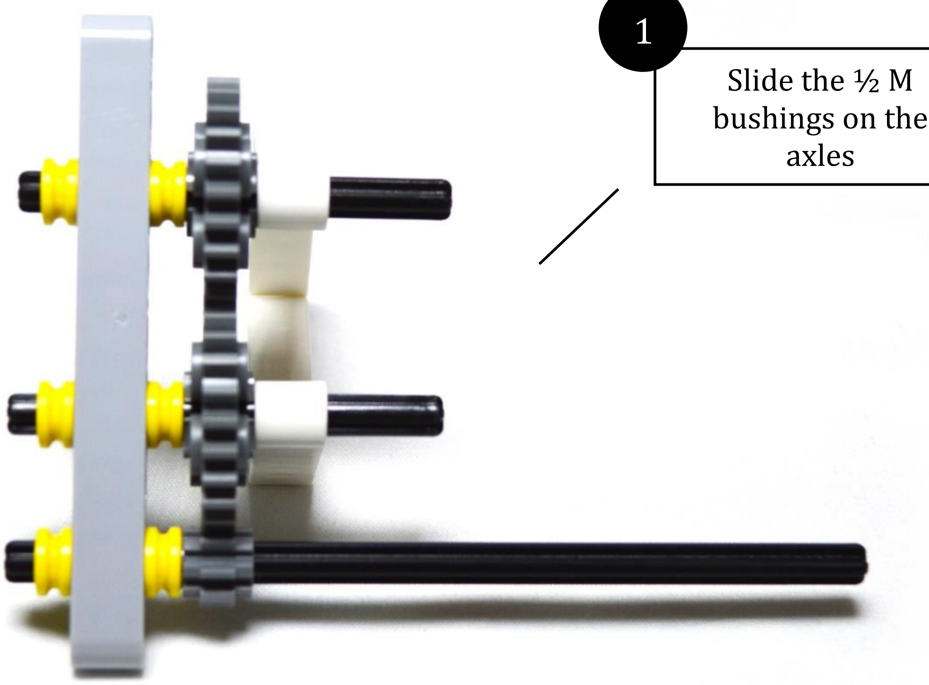
Step 7



1

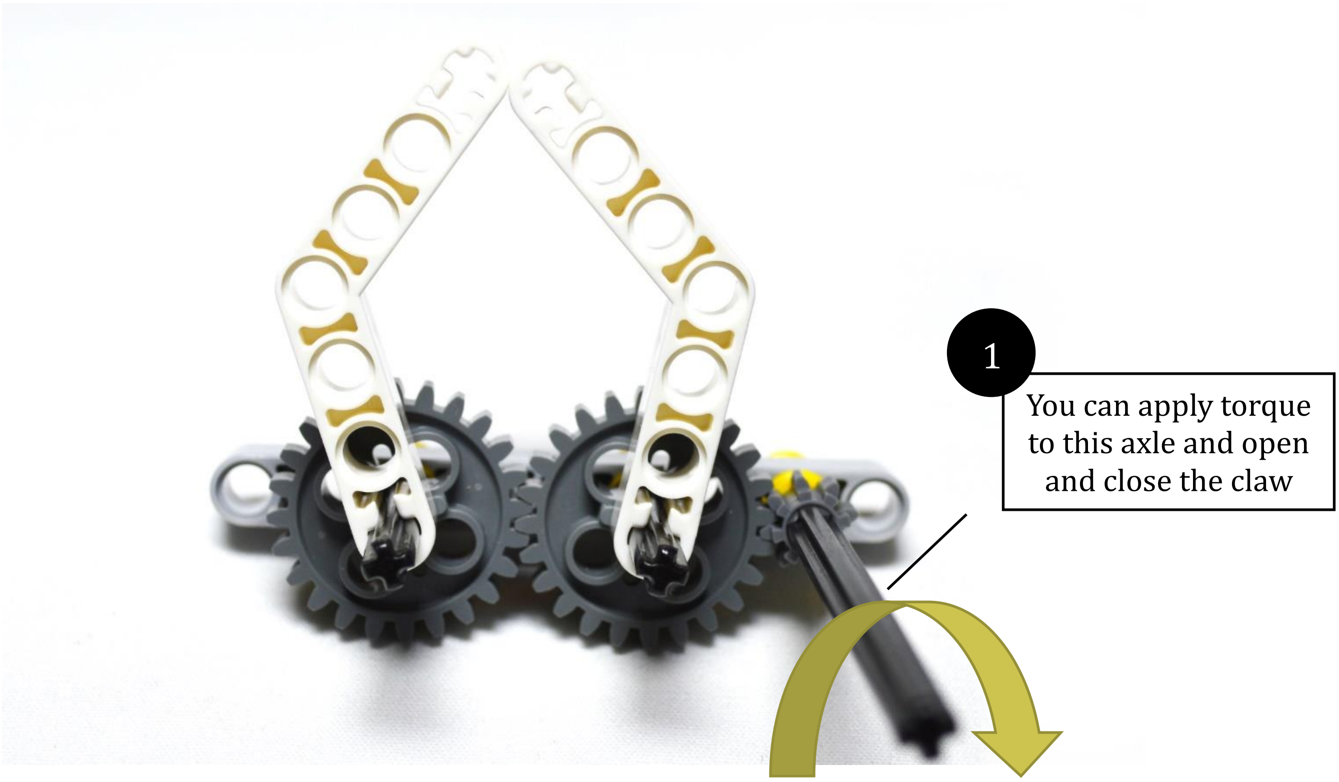
Arrange the parts as shown

Step 8



1

Slide the ½ M bushings on the axles


1
You can apply torque to this axle and open and close the claw

ACTIVITY

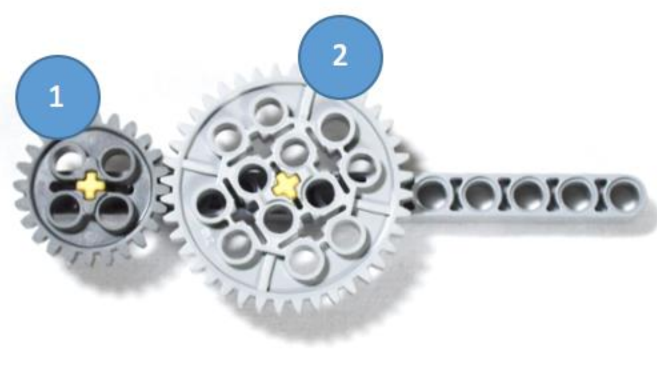
< *Gear Ratio* >

Let's define the term *gear ratio*: gear ratio is **the number of teeth of the driver gear to the number of teeth of the driven (follower) gear**. In addition, the **revolutions per minute (RPM) of the driven gear equals gear ratio time the RPM of the driver gear**. Thus

$$\boldsymbol{GearRatio} = \frac{NumberOfTeethOfDriver}{NumberOfTeethOfDriven}$$

$$\boldsymbol{RPM_{Driven}} = GearRatio * RPM_{Driver}$$

Consider an example case below, gear one has 24 teeth and gear two has 40 teeth. Additionally, gear one which is the driver gear has an RPM of 10 – if we were to calculate the RPM of gear 2 we will follow the following steps:

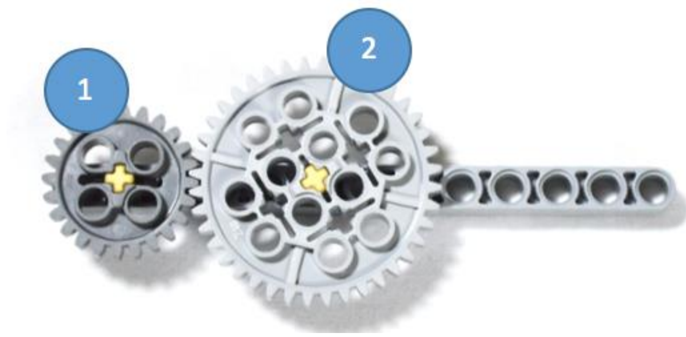


Gear ratio = $\frac{24}{40}$ and $\text{RPM}_{\text{Gear2}} = \frac{24}{40} * 10 = 6$

That is for every 10 revolutions of gear 1, gear 2 will have 6 revolutions.

Answer the questions below

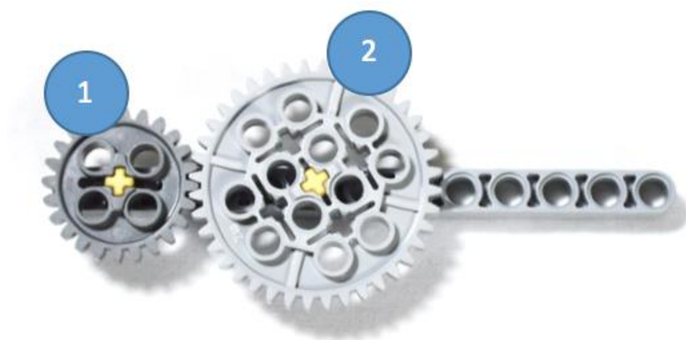
1) Once again gear one has 24 teeth and gear two has 40 teeth. Gear one is the driver gear has an RPM of 20– calculate the RPM of gear 2:



Gear ratio = ——— and RPM_{Gear2} =

Thus, for every 20 revolutions of gear 1, gear 2 will have ______________ revolutions.

2) Once again gear one has 24 teeth and gear two has 40 teeth. However, gear two is the driver gear and it has an RPM of 10 – calculate the RPM of gear :



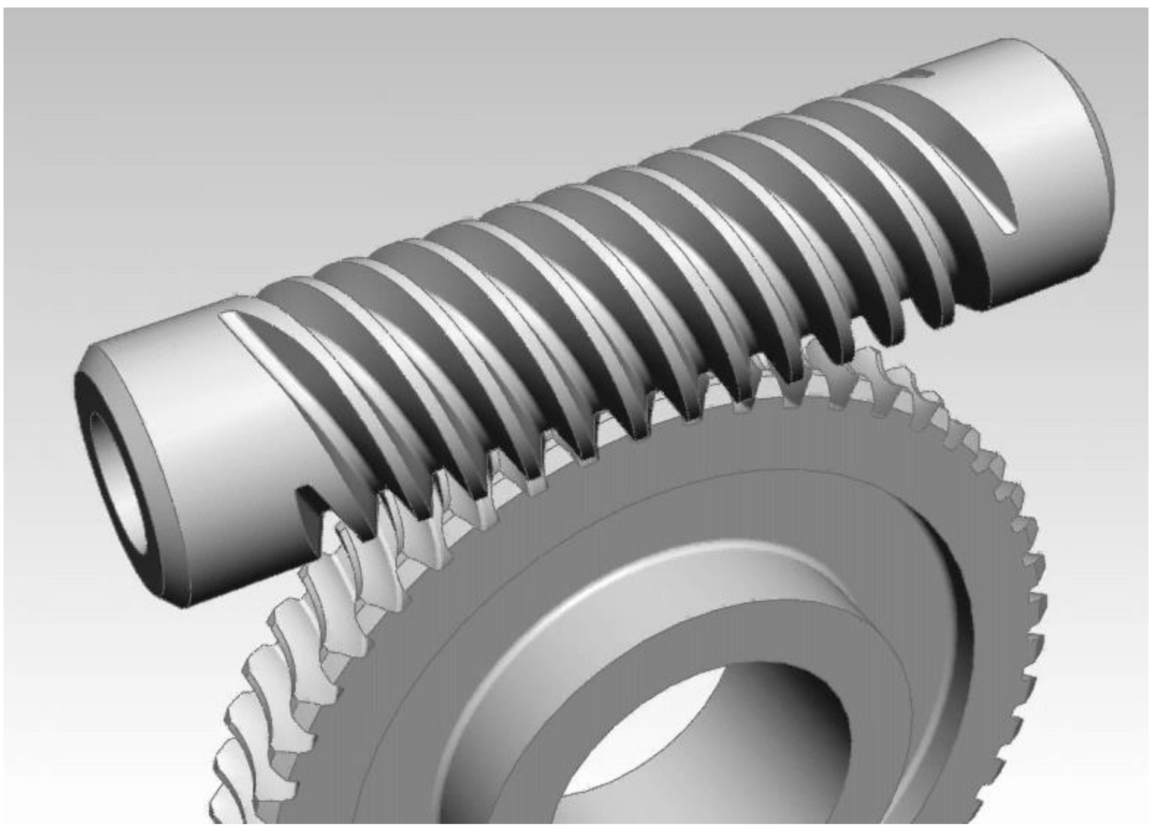
Gear ratio = ——— and RPM_{Gear1}= ——— * 10 **=**

Thus, for every 10 revolutions of gear 2, gear 1 will have ______________ revolutions.

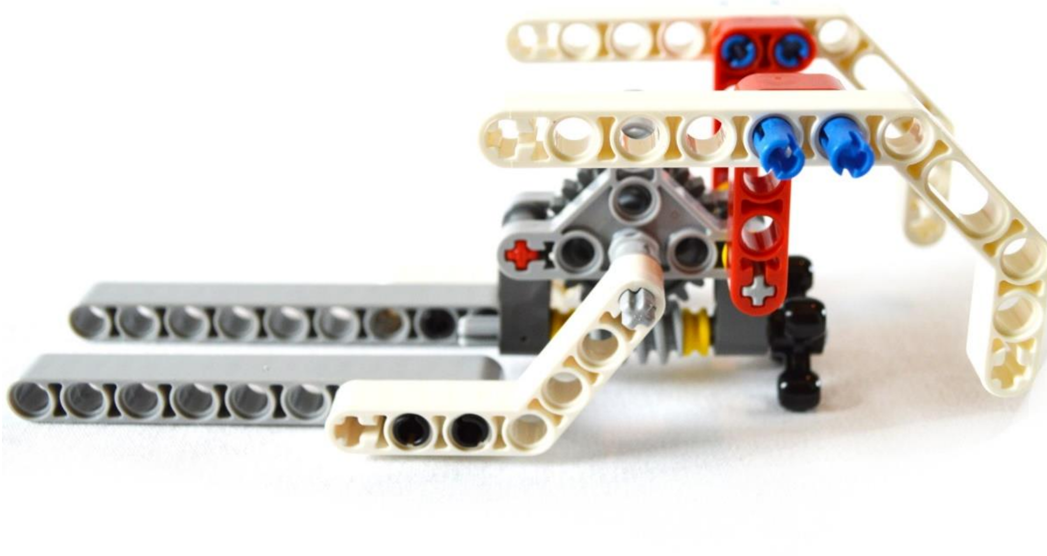
ACTIVITY

< *Fork* ***Attachment*** >

A worm gear is a screw that turns a spur gear with its axle at right angle. A worm gear creates a high gear ratio. Each time the worm gear shaft spins one revolution, the spur gear moves one tooth forward. The worm gear has an unusual advantage of self-locking - <u>you can turn the worm gear shaft to drive the output shaft, but you cannot turn the output shaft to drive the worm gear shaft</u>.



In this activity, we will create a fork attachment that can be powered up or down by applying torque to the axel of the assembly. The final bot will look like the one shown below.



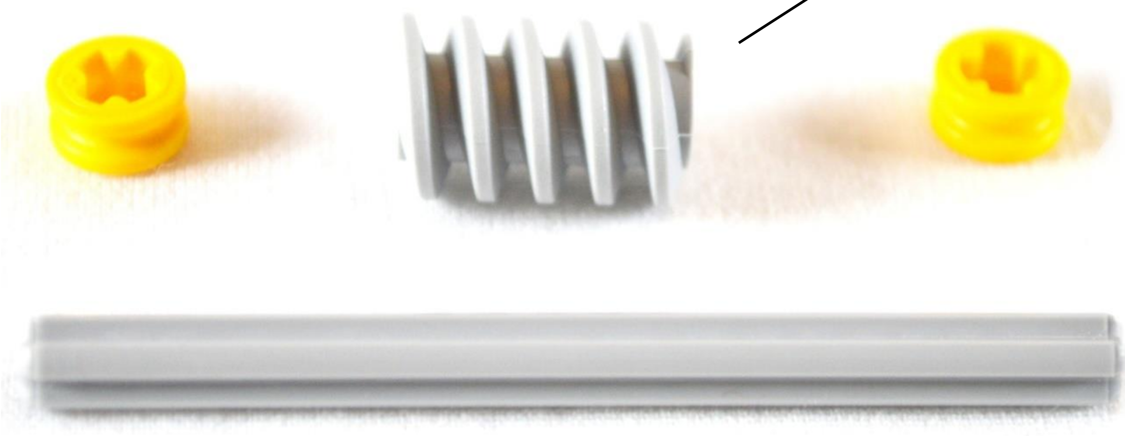
Find the following from your Mindstorms kit (refer to the EV3 parts list for identifying shapes with names) – you may follow the steps provided in following pages.

☐ 2 X 9 M beams	☐ 2 X 3x7M double angular beam
☐ 2 X 4x4M angular beams	☐ 4 X 3M connection peg with friction
☐ 4 X 2M peg with friction	☐ 2 X 2x4 angular beams
☐ 1 X 4-tooth gear	☐ 2 X ½ triangle beam 5x3M
☐ 1 X worm gear	☐ 4 X ½ M bushing
☐ 1 X 2M axle	☐ 2 X 1M bushing
☐ 1 X 24-tooth gear	☐ 2 X 7M axles
☐ 2 X 3M cross blocks	☐ 1 X 5M axle

Step 1

1

Arrange the 7M axel and other parts as shown



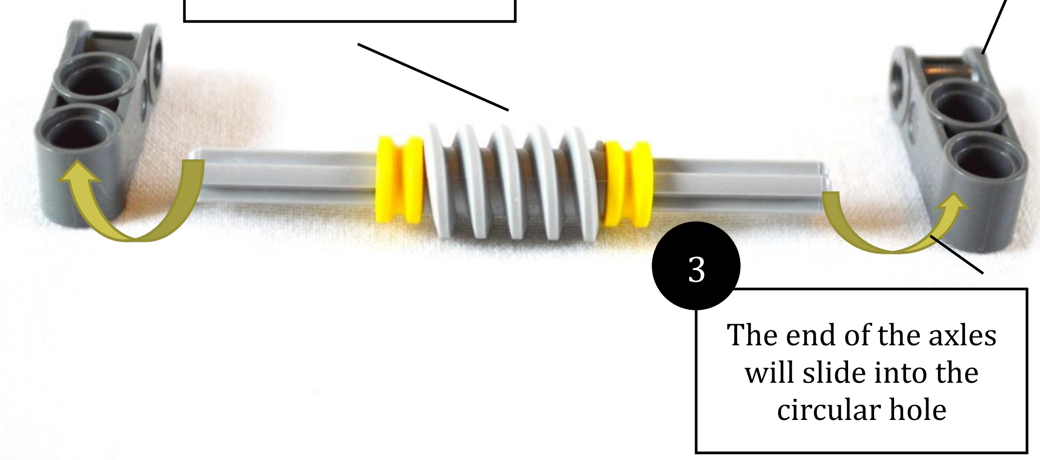
Step 2

1

Assemble the worm gear on the axle and slide ½ M bushings from two sides

2

Place two 3M cross blocks as shown



3

The end of the axles will slide into the circular hole

Step 3

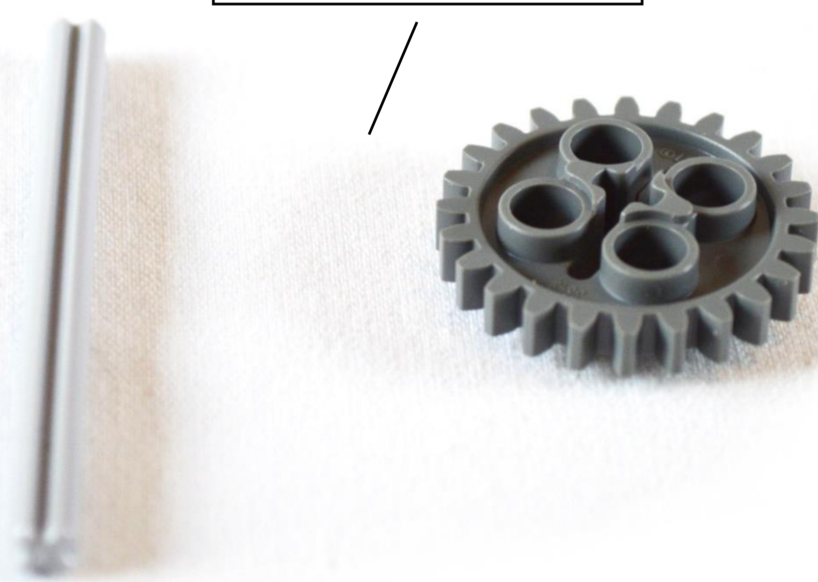
1

The end of the axle is slid into the circular hole

Step 4

1

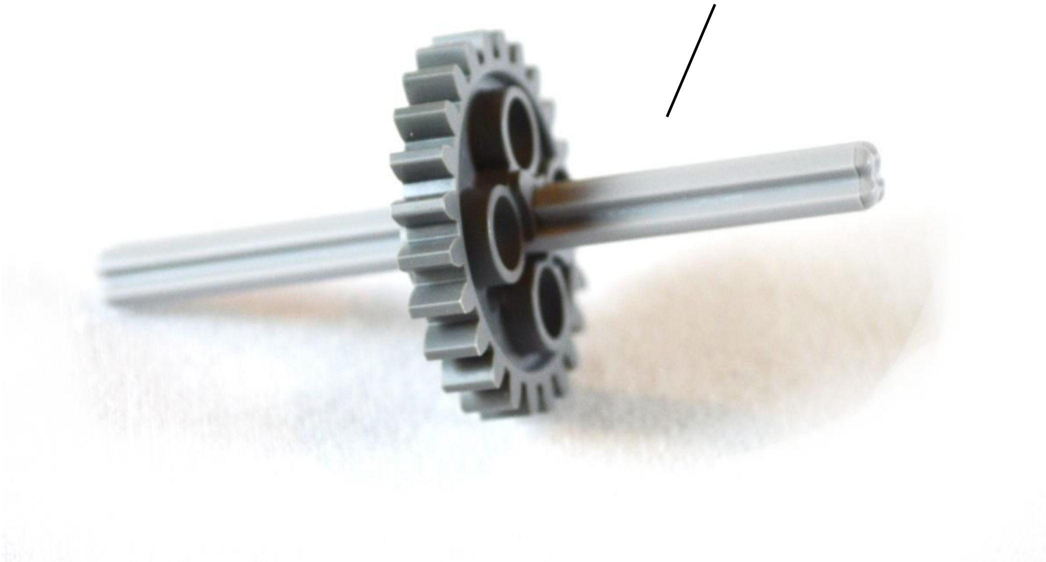
Arrange the 7M axel and the 24-tooth gear as shown



Step 5

1

Slide the 24-tooth gear on the axel



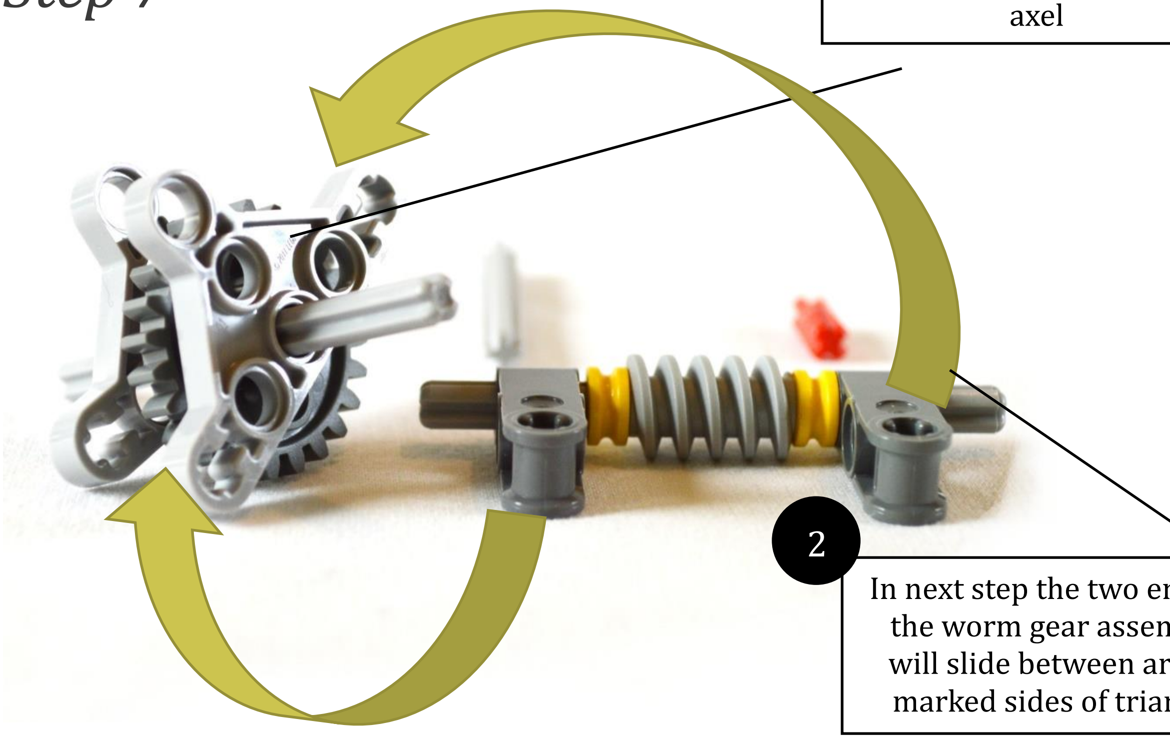
Step 6

1

Arrange the 5M axel and other parts as shown

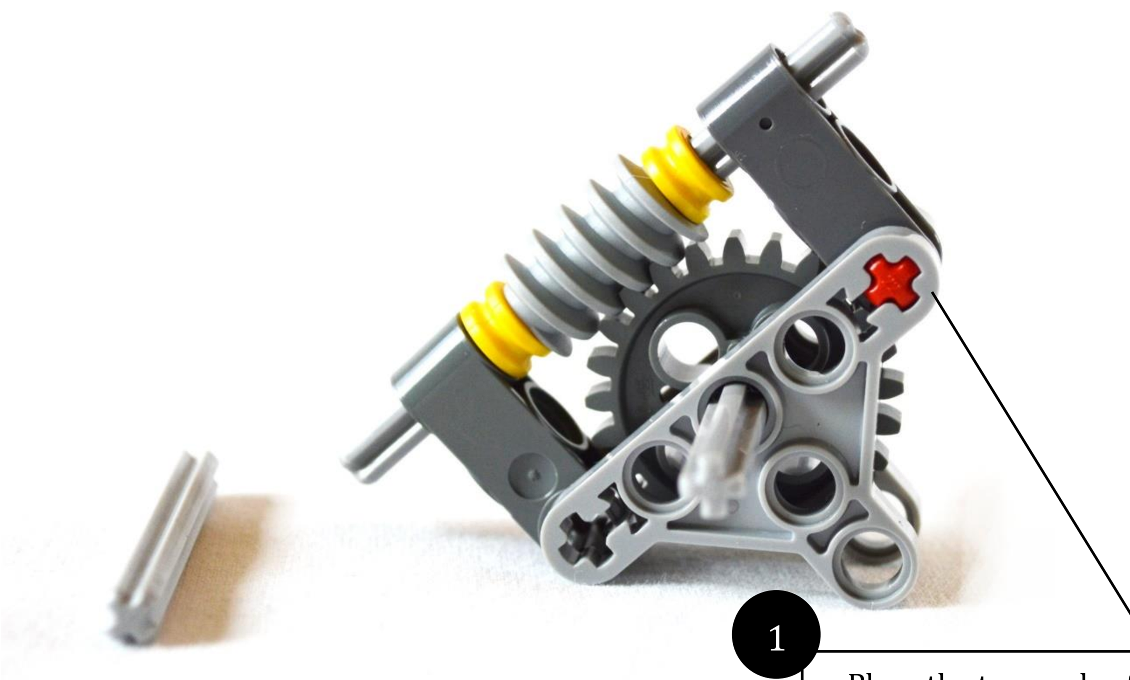
Step 7

1 Slip the triangle beams on the two sides of the gear axel



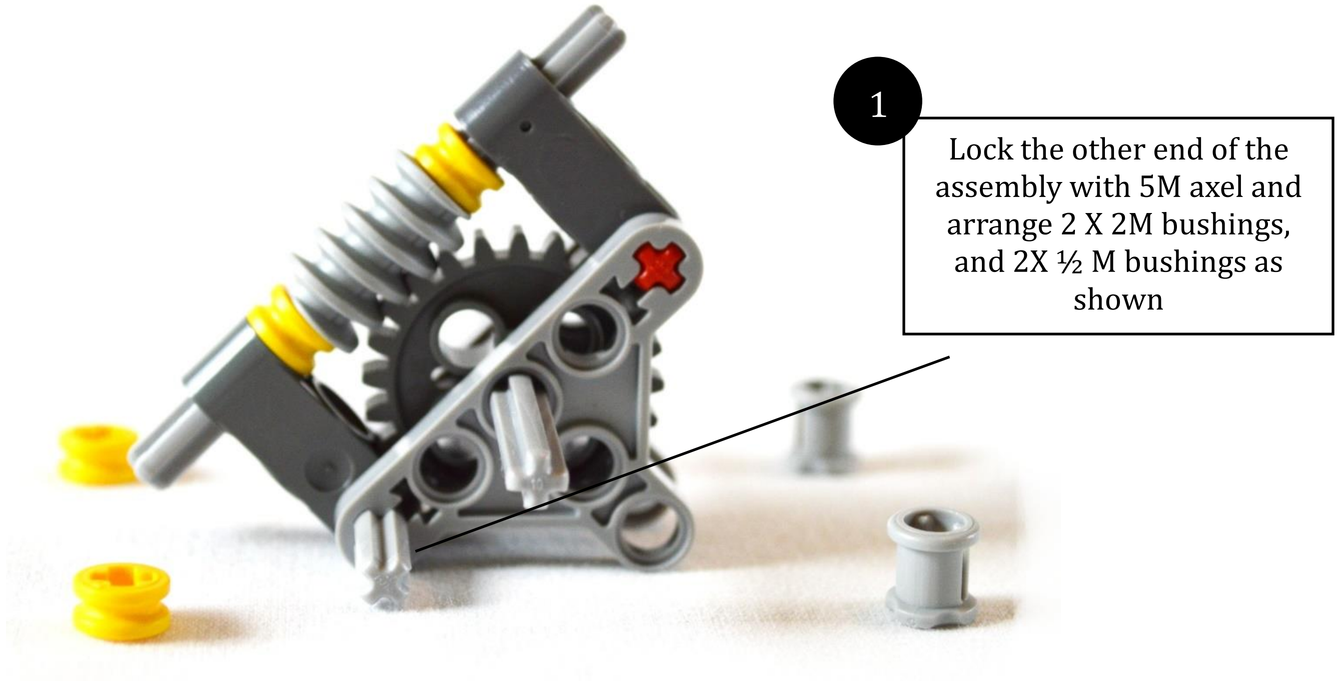
2 In next step the two ends of the worm gear assembly will slide between arrow marked sides of triangle

Step 8

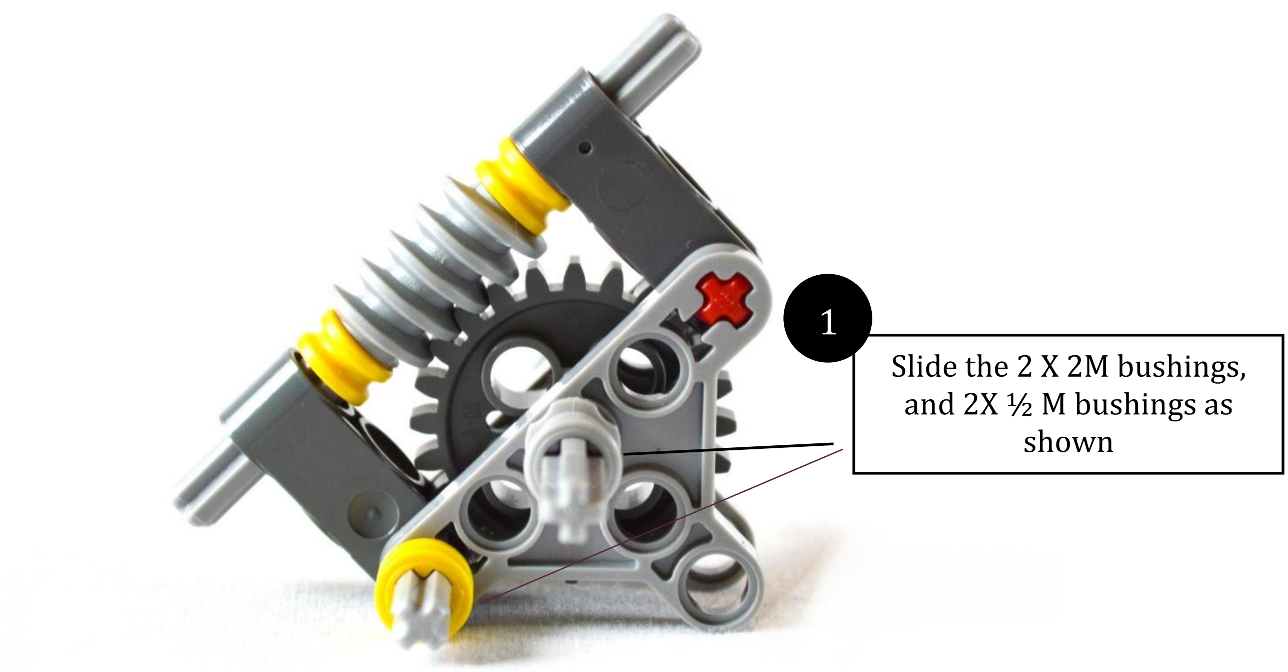


1 Place the two ends of the worm gear assembly and lock as shown using 2M axle

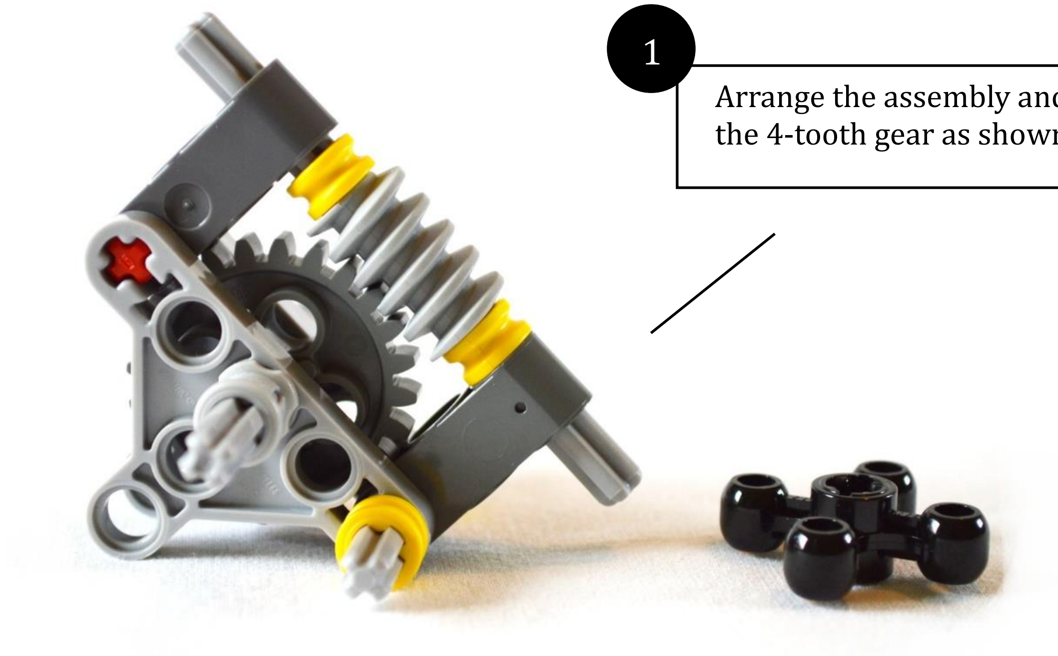
Step 9



Step 10



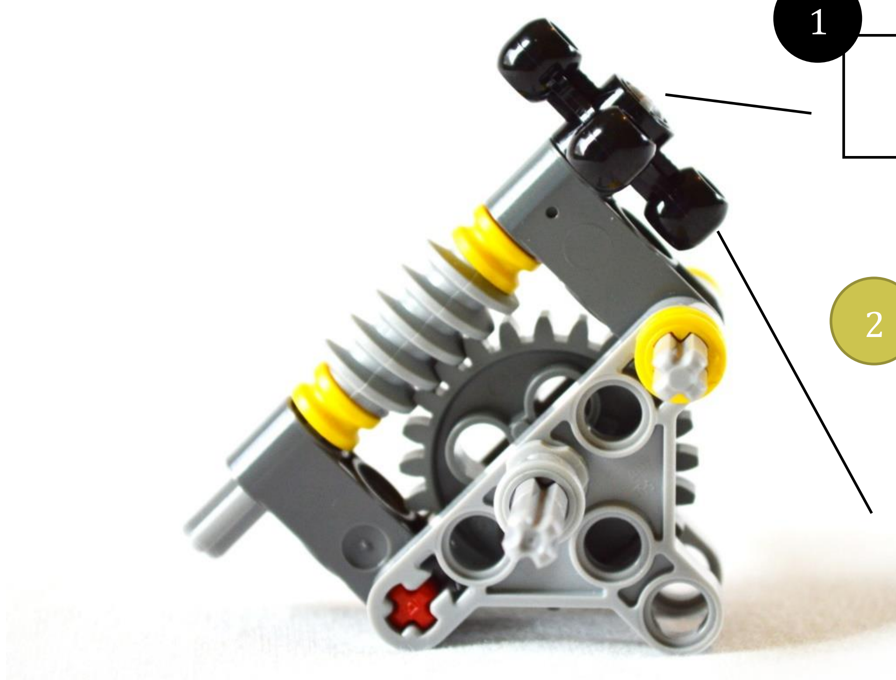
Step 11



1

Arrange the assembly and the 4-tooth gear as shown

Step 12



1

Slip the 4-tooth gear as shown

2

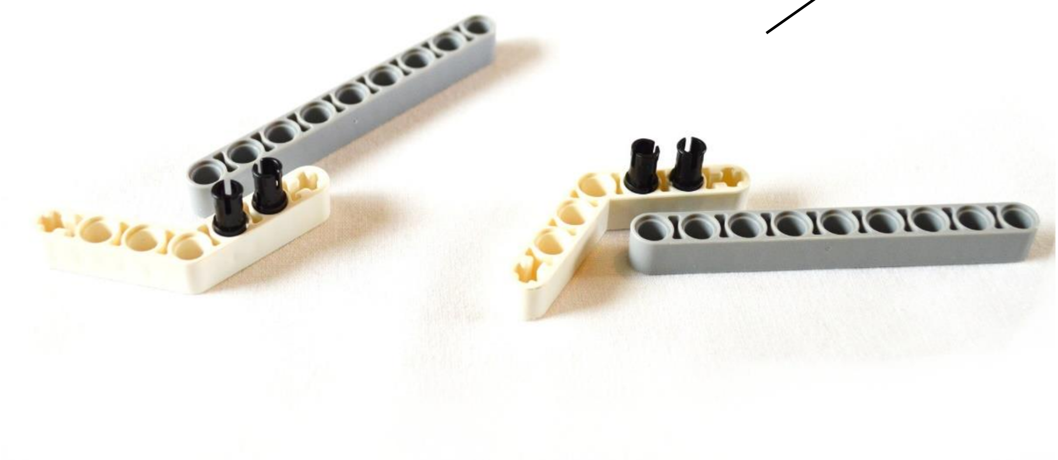
Try to rotate this gear and notice how the 24-tooth gear rotates.

Note that you cannot rotate the 24-tooth gear to rotate the worm gear.

Step 13

1

Arrange parts as shown



Step 14

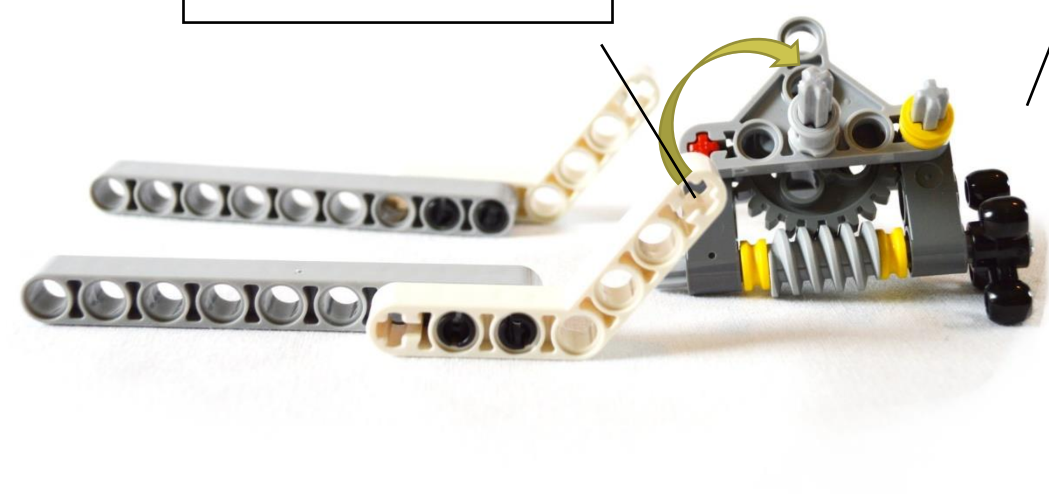
1

Join the beams as shown

Step 15

2 This end of the beams will slide on the axles in the next step

1 Arrange the beams with the assembly as shown



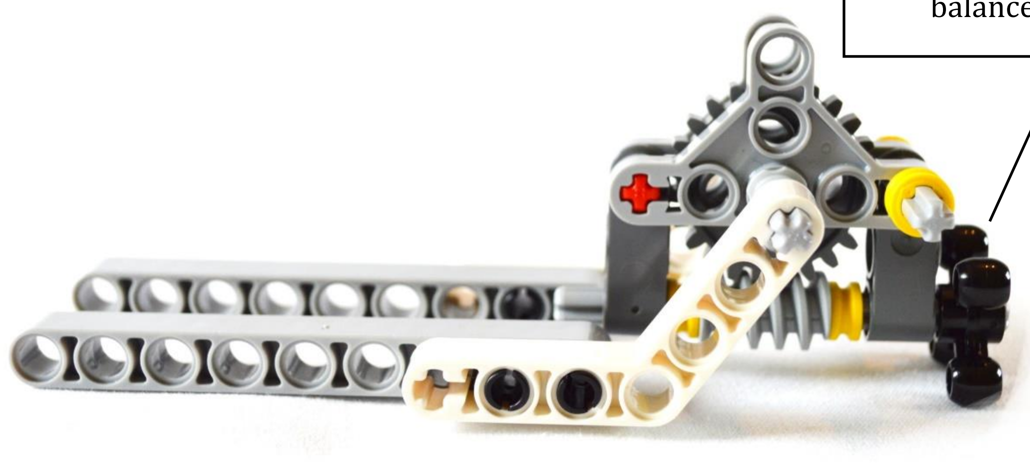
Step 16

1 Slide the beam ends on the axle

Step 17

1

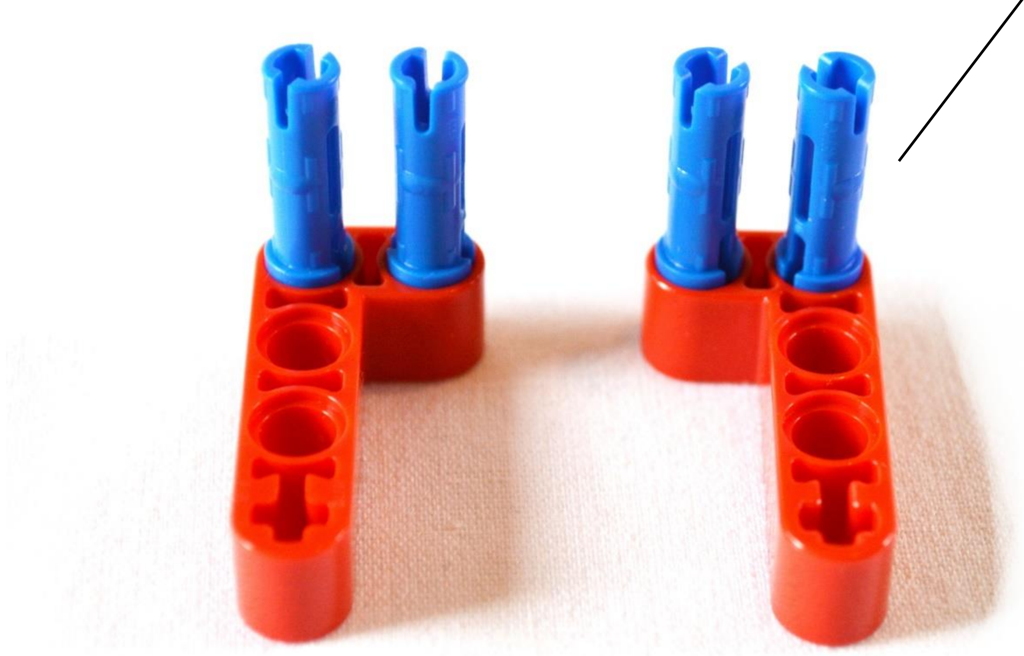
Rotate the 4-tooth gear to make the assembly flat and balanced as shown



Step 18

1

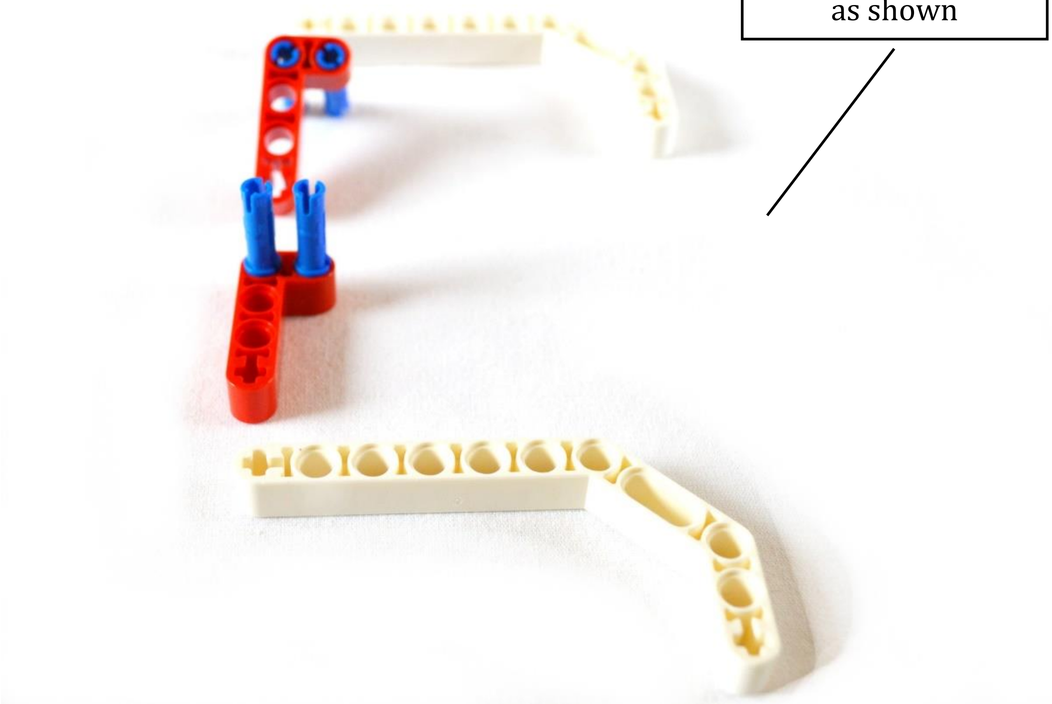
Arrange the parts as shown



Step 19

1

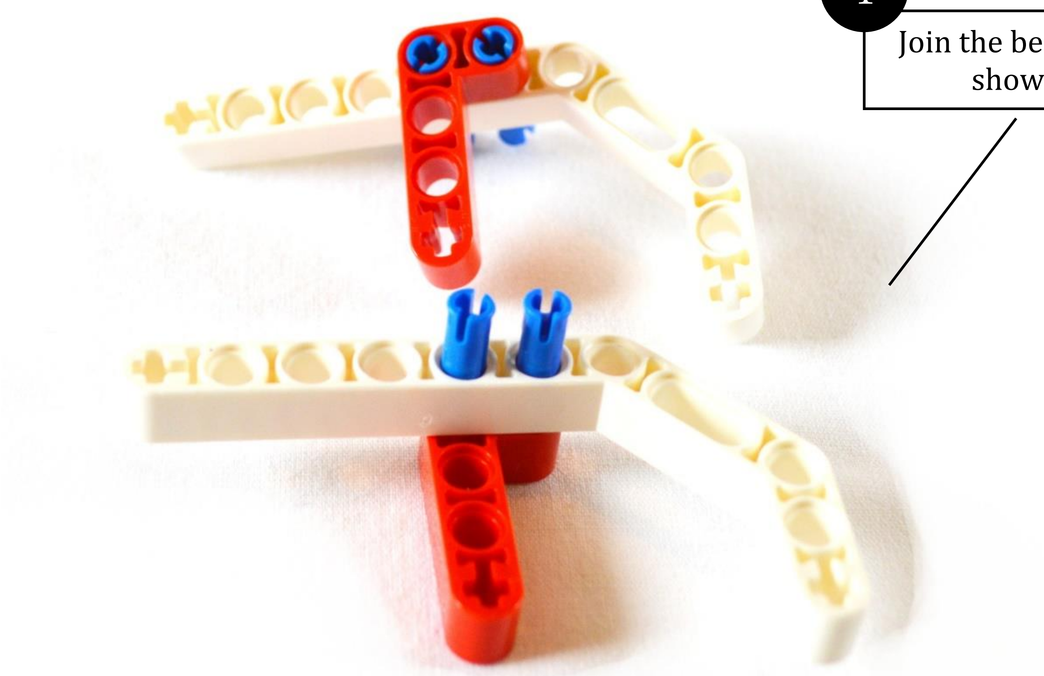
Arrange the parts as shown



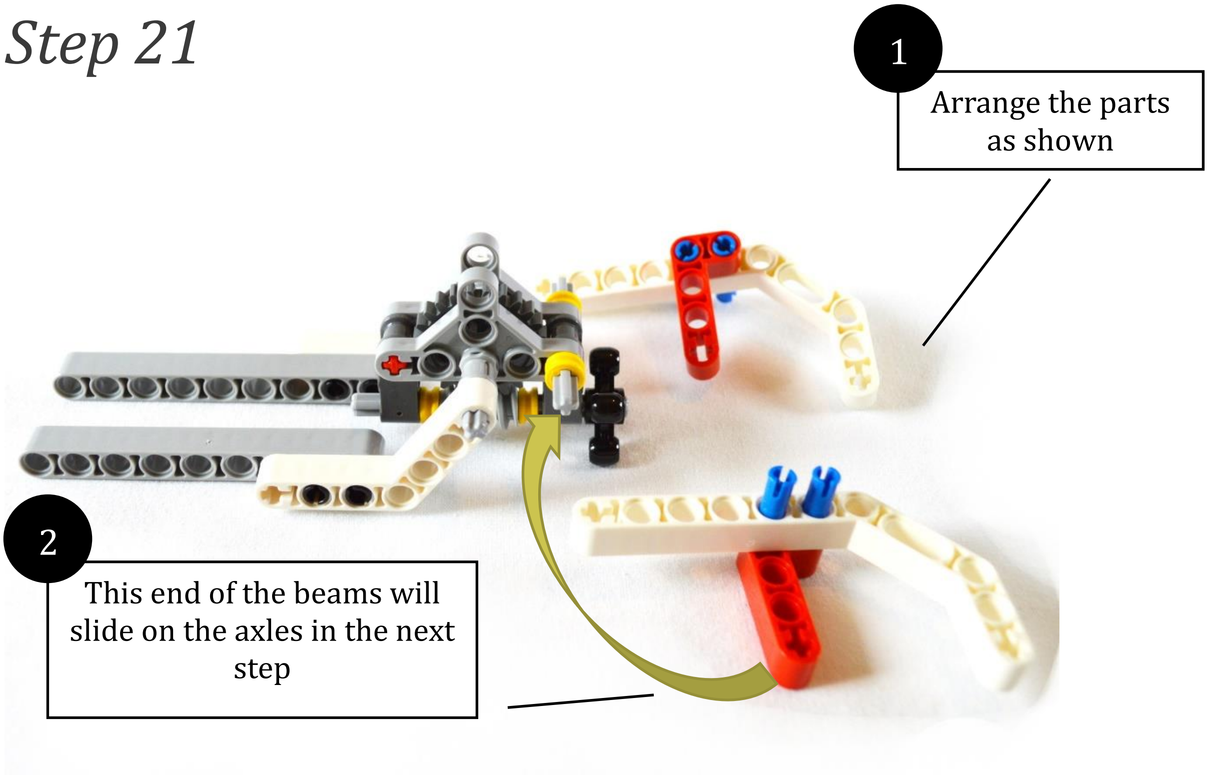
Step 20

1

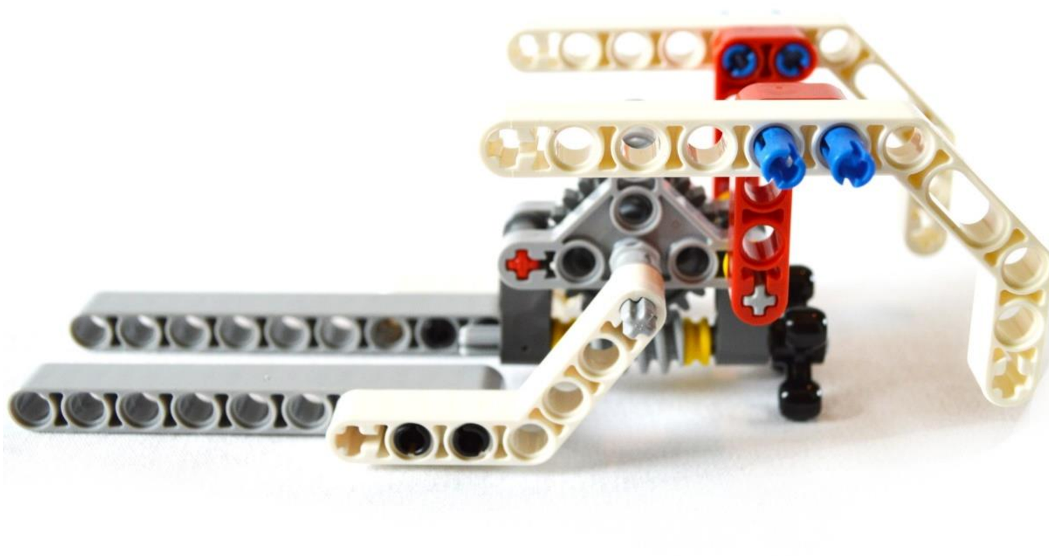
Join the beams as shown



Step 21



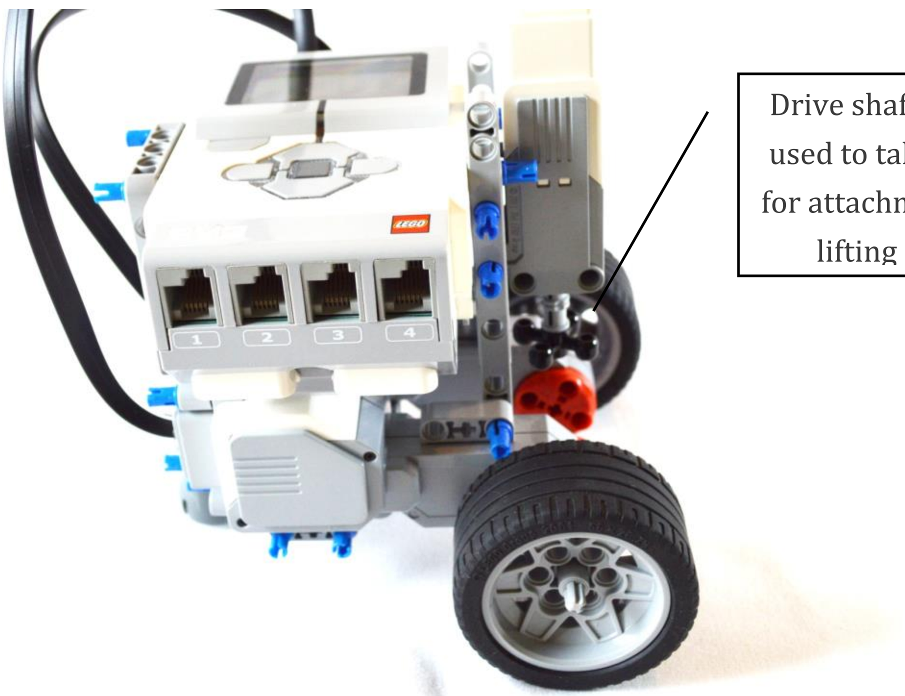
Step 22



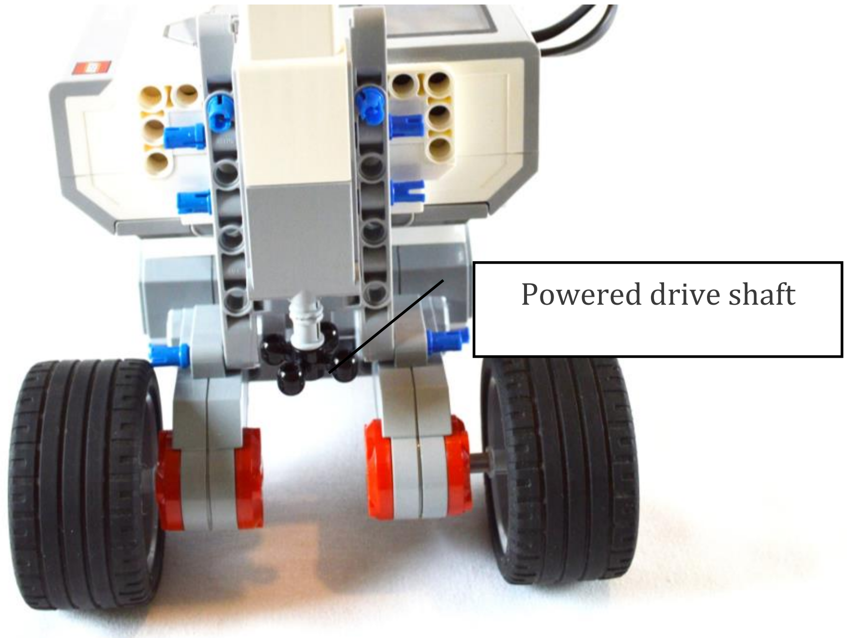
ACTIVITY

< *ds**Bot*** >

In this activity, we will modify the simBot by adding a drive shaft (we will call it ds**Bot**) so that powered attachments such as lifting forks can be supported by this bot – be creative and add to the design if you want.



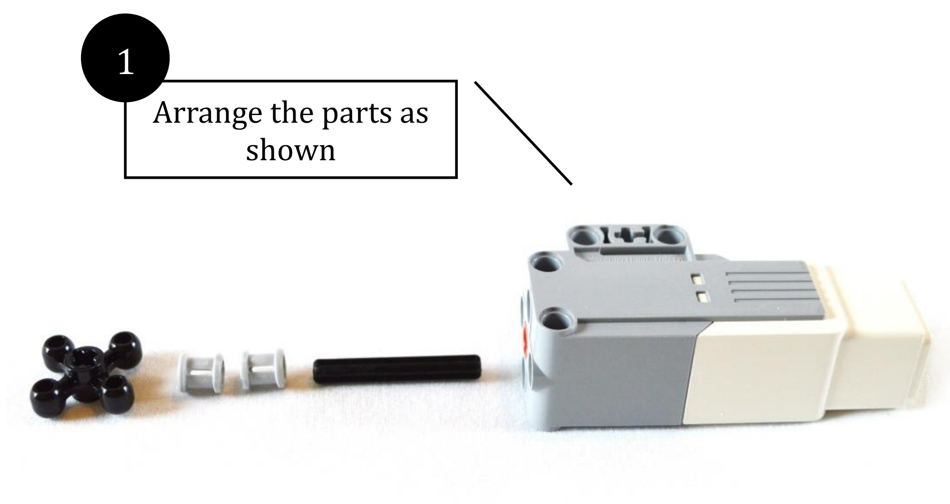
Drive shaft that can be used to take-off power for attachments such as lifting forks etc.



Find the following from your Mindstorms kit – you may follow the steps below.

☐ 1 X 4 tooth gear ☐ 2 X 1M bushing ☐ 1 X medium motor	☐ 1 X 4M axle ☐ 4 X 3M connection peg with friction

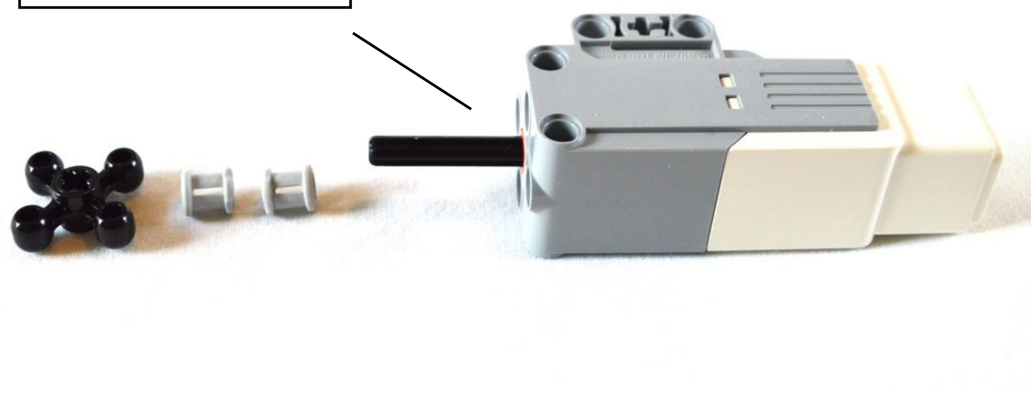
Step 1



Step 2

1

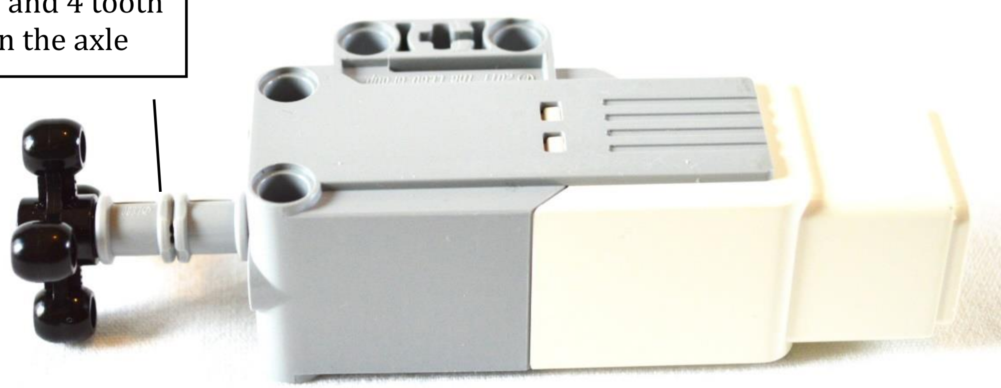
Insert the axle in the motor



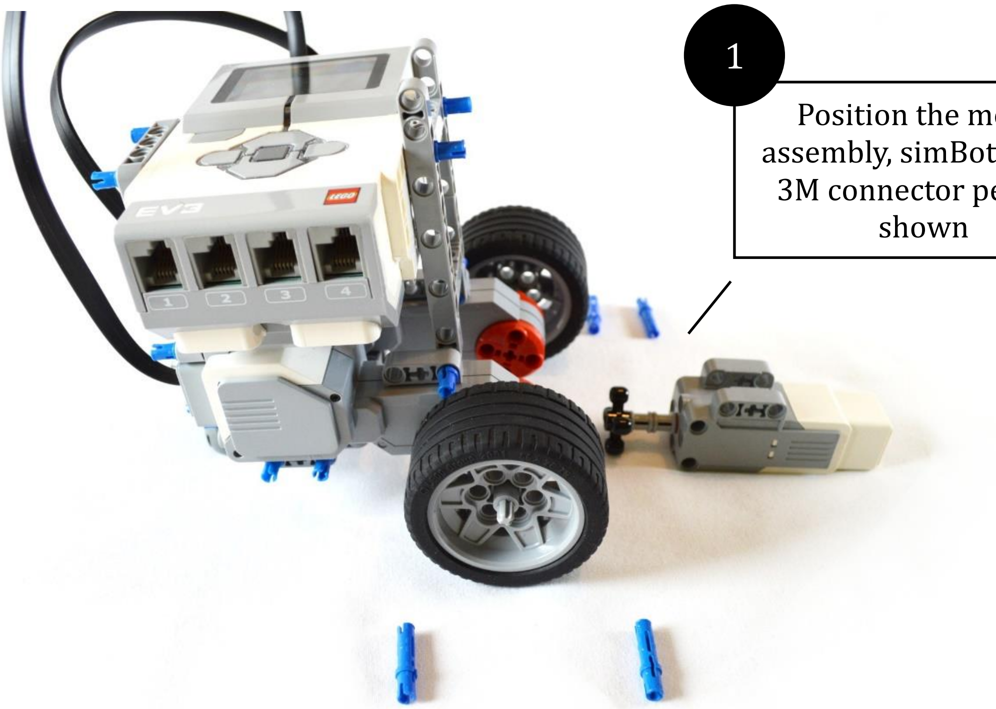
Step 3

1

Push the two 1M bushings and 4 tooth gear on the axle



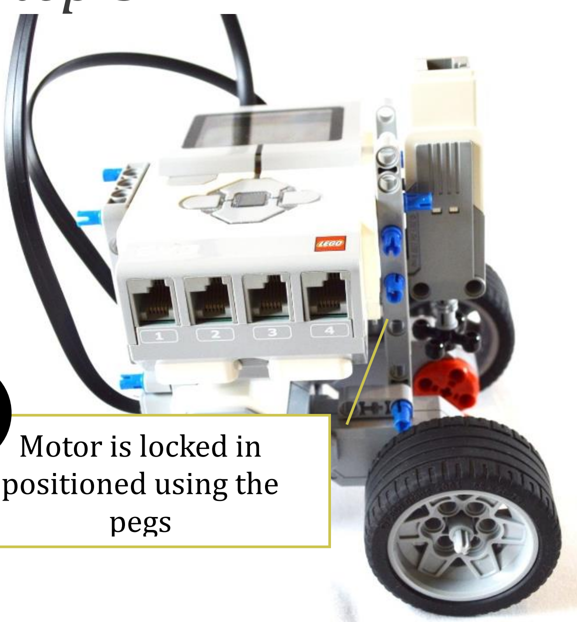
Step 4



1

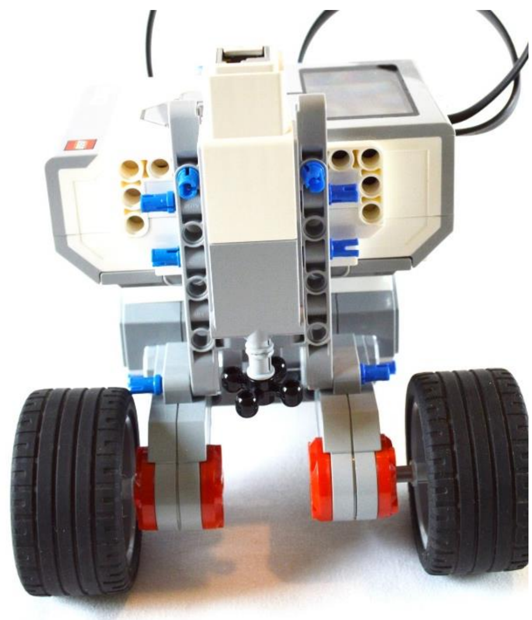
Position the motor assembly, simBot, and 4 3M connector pegs as shown

Step 5



1

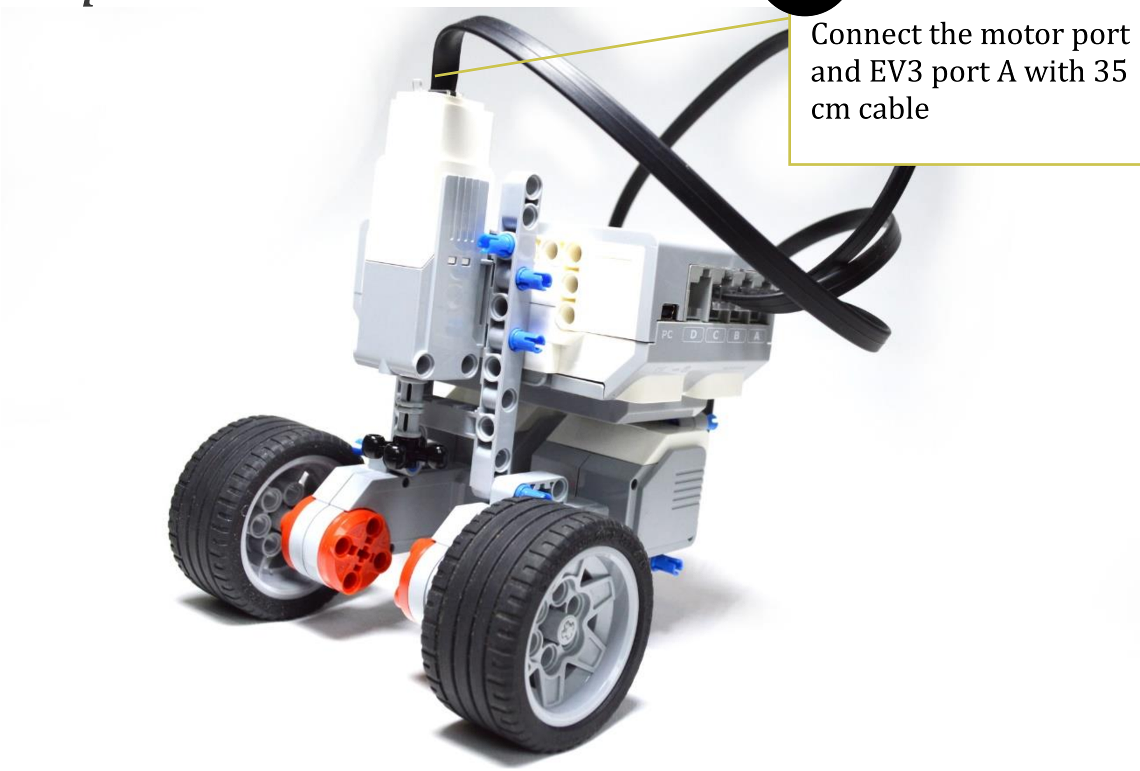
Motor is locked in positioned using the pegs



View from side

View from front

Step 6



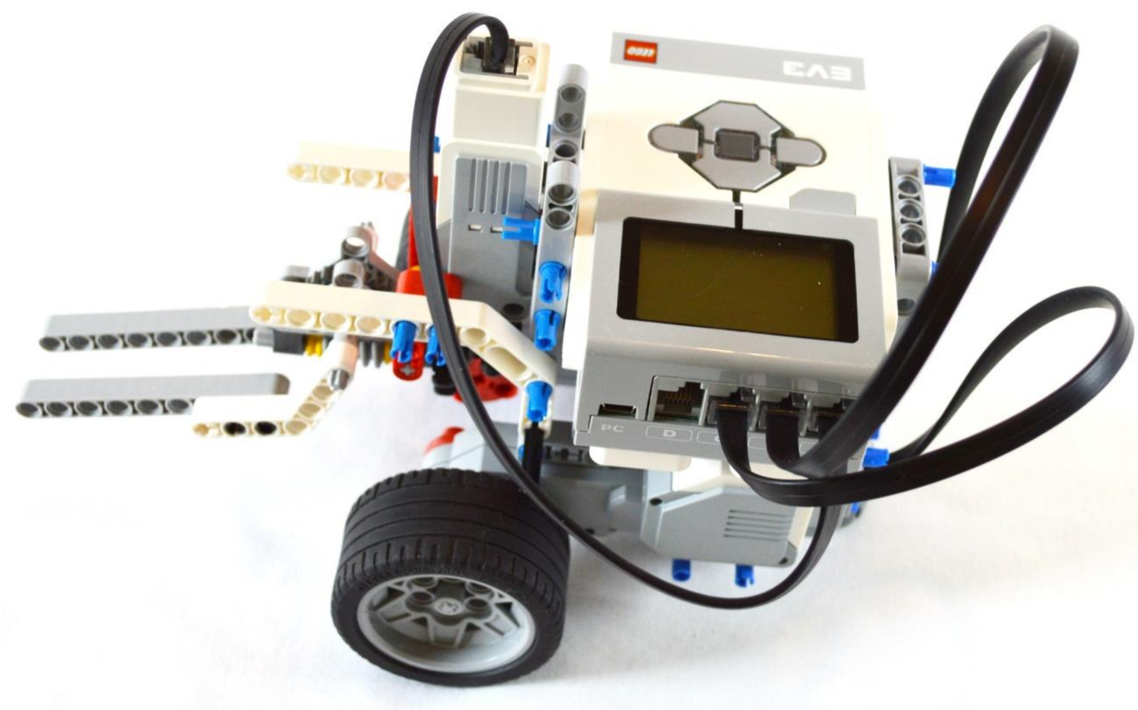
1

Connect the motor port and EV3 port A with 35 cm cable

ACTIVITY

< *fork***Bot** >

In this activity, we will take the ds**Bot** and attach the fork attachment. We call it fork**Bot**



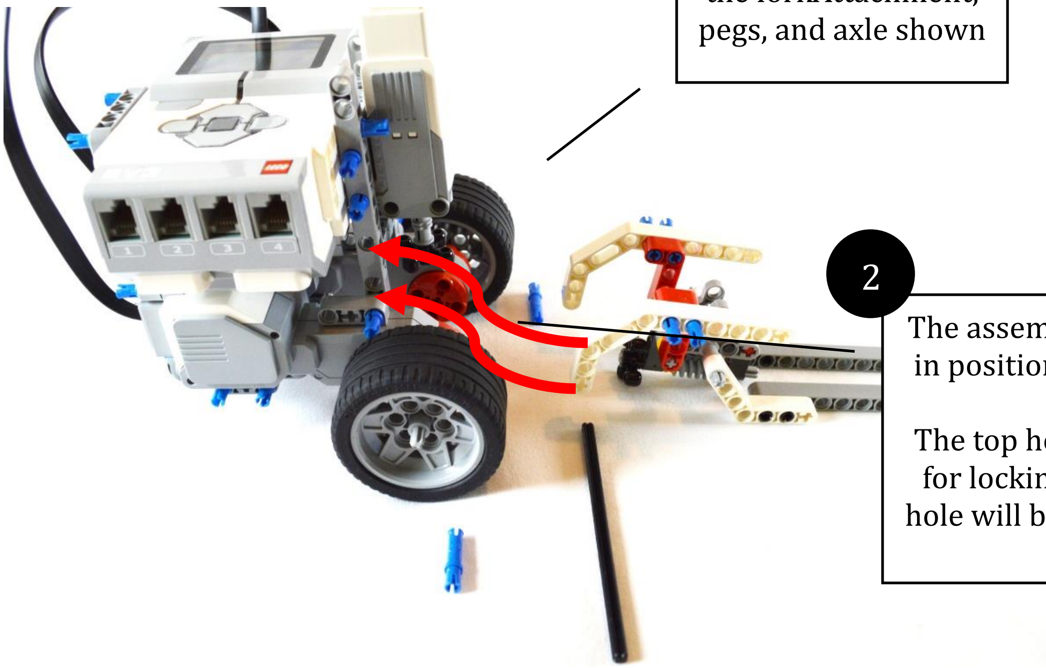
You will need the following assemblies and parts

- ☐ dsBot
- ☐ forkAttachment
- ☐ 2 X 3M peg with friction
- ☐ 1 X 10M axle

Step 1

1

Arrange the dsBot, the forkAttachment, pegs, and axle shown



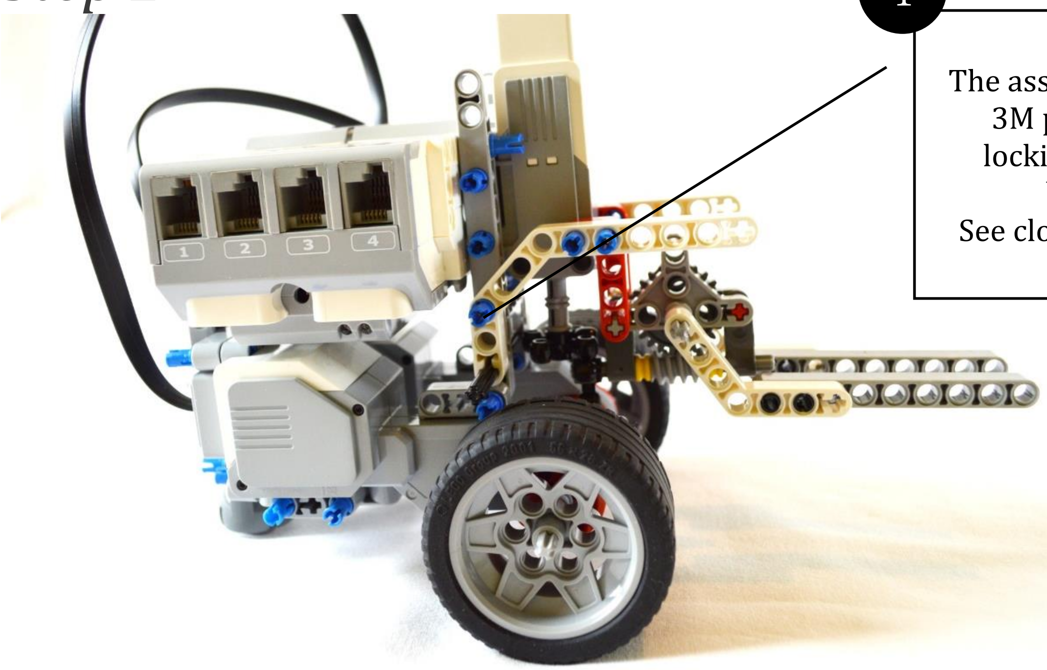
2

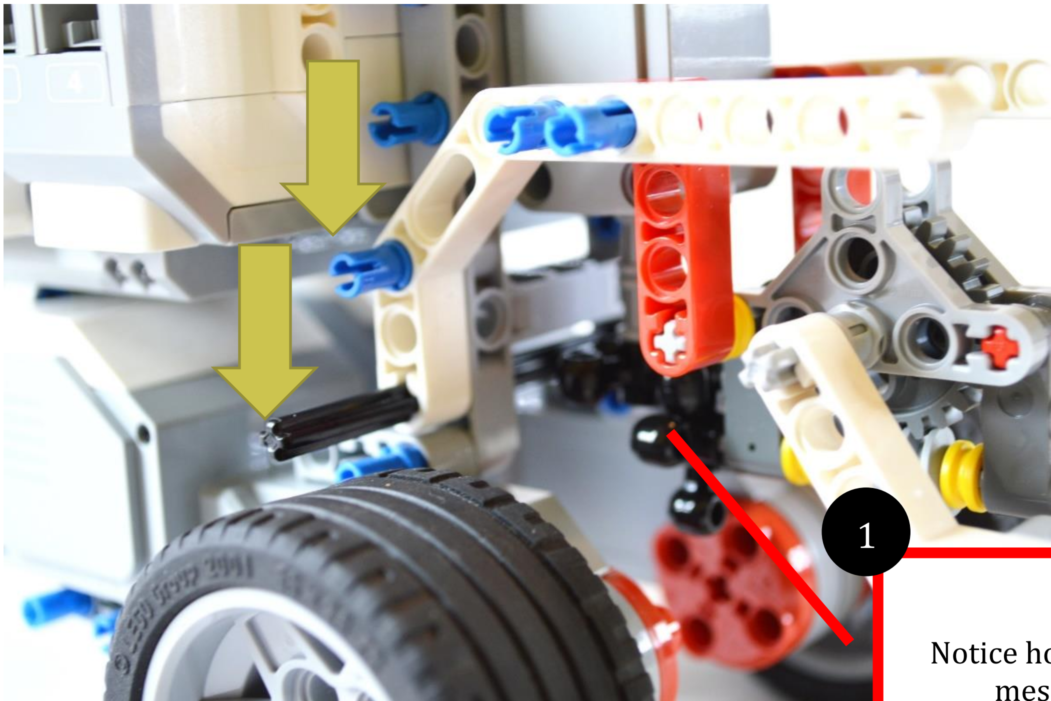
The assembly holes will align in position as marked by the arrows.
The top hole will use 3M pin for locking, and the bottom hole will be attached with the axle.

Step 2

1

The assembly is made using 3M pin in top hole for locking, and axel in the bottom holes.
See close-up in next image

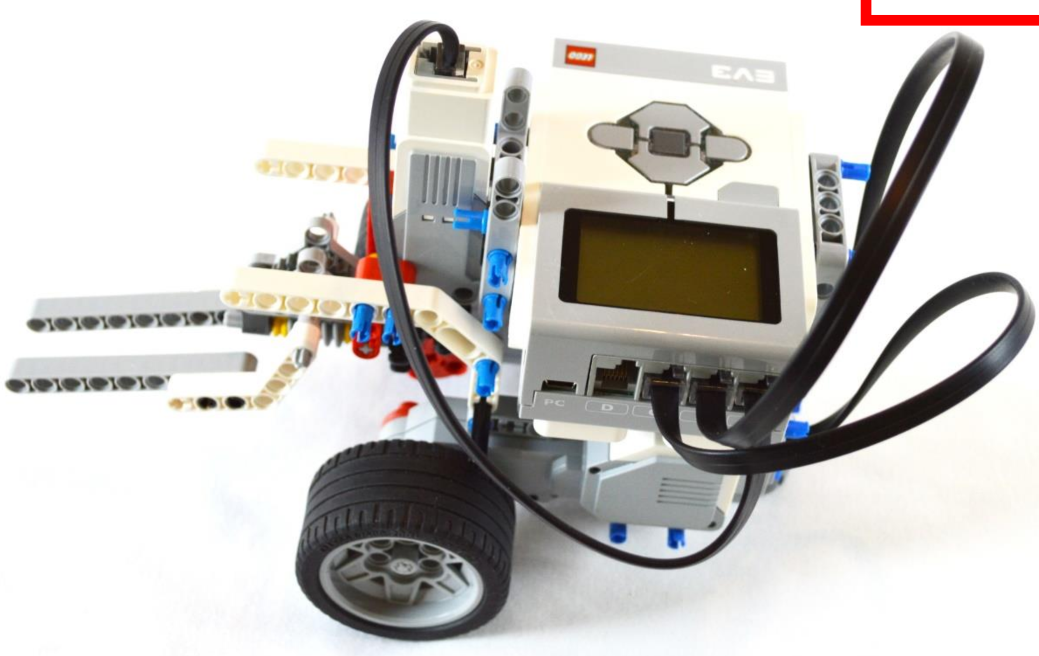




1

Notice how 4-tooth gears mesh for power transmission

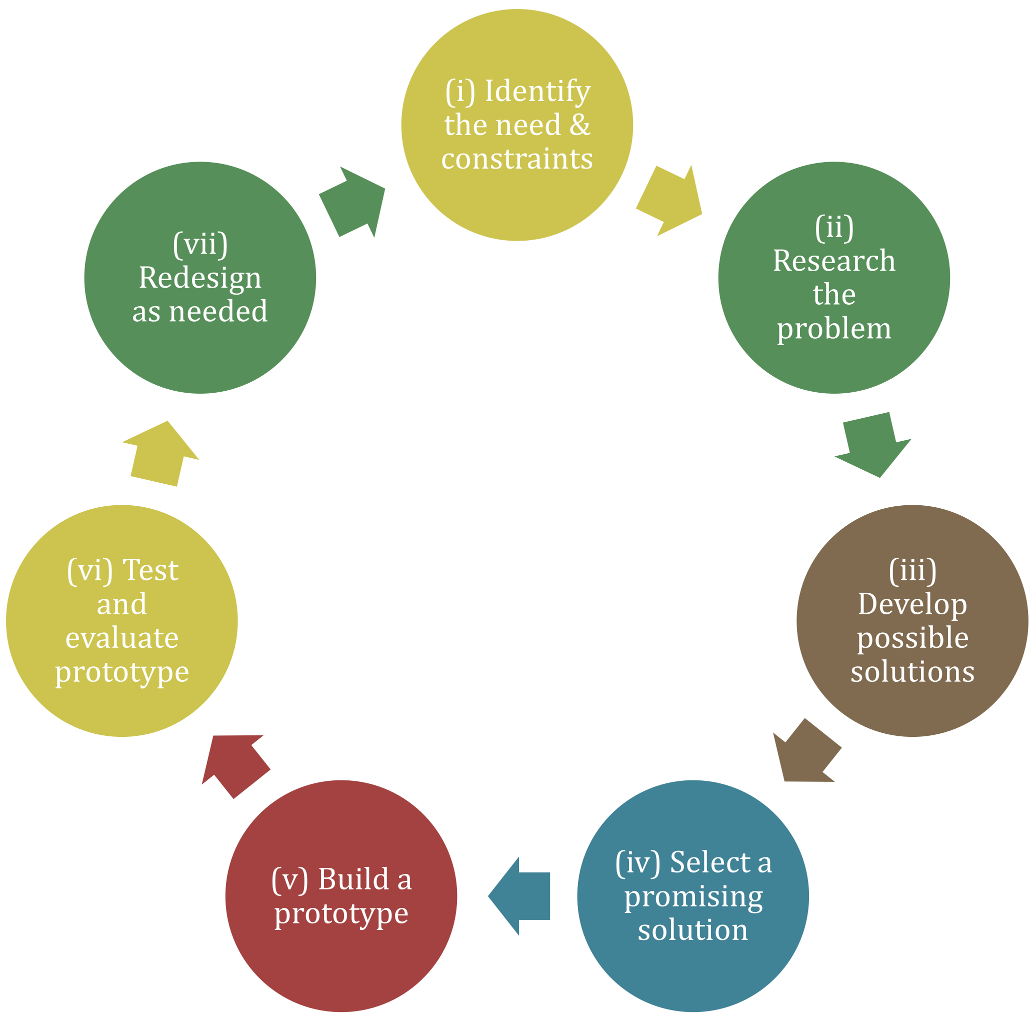
When the axles that need turning meet at an angle - usually a right angle they are called **bevel gear**



ACTIVITY

< *Engineering Design Process* >

Problem solving is a fun and creative process where we can apply technology to create solutions that meet the defined set of needs. A process called an **Engineering Design Process** can immensely help in meeting our desired goals. The Engineering Design Process guides us through a step-by-step method for finding solutions, these steps include



Think about the Maze challenge that you worked on and write down if there were tasks that you performed during that activity that fall under the different steps of the Engineering Design Process.

1. **Identify the need & constraints** – *what are our needs, and what is the problem that we are trying to solve?*

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2. **Researching the problem** – *find what is known about the problems, how others have tried to solve this problem, are their similar problems that may have a solution that we can use as an inspiration?*

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3. **Develop possible solutions** – *think about how you may solve the problem, discuss with your team members and mentors, draw your ideas on the paper, draw on a computer, write your ideas. Create many different possible solutions*

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4. **Select a promising solution** – *from the solutions that you designed in the previous step, select one that will most likely solve the problem best*

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5. **Build a prototype** – *start bringing your idea into a reality, for example if the solution is building a robot then build a robot*

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____
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6. **Test and evaluate prototype** – *test to see if the prototype can solve the problem that you had defined. Write down the things that it does well and things that it does not do well*

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7. **Redesign as needed –** *Using your observations about what worked well and what did not work well, make changes to your solution. Repeat the steps to improve your solution over time*

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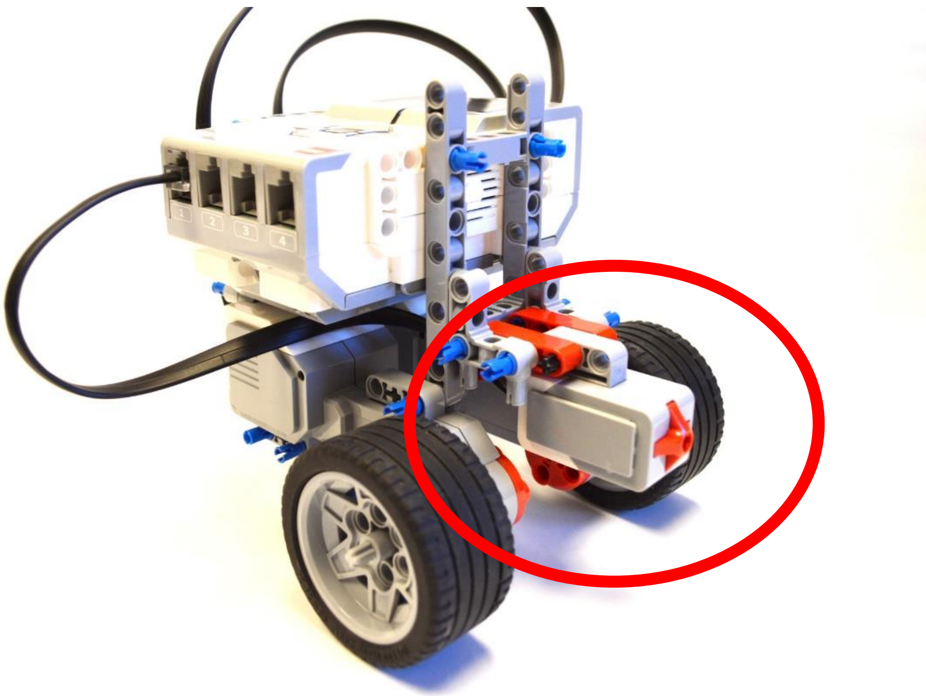
ACTIVITY

< *Touch* ***Sensor*** >

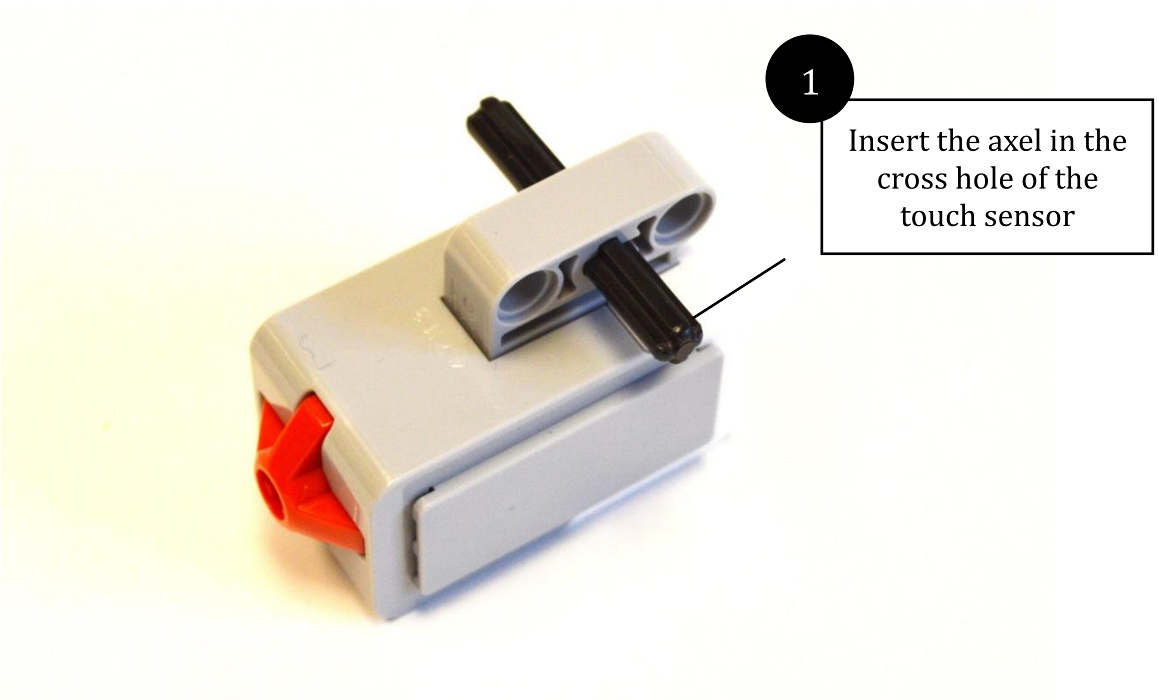
A touch Sensor is a simple tool that can be used as a button, an obstacle sensor, or to count the number of presses of the button. You can use the button to start or stop something. In this activity, we will use it to find when the bot hits an obstacle.



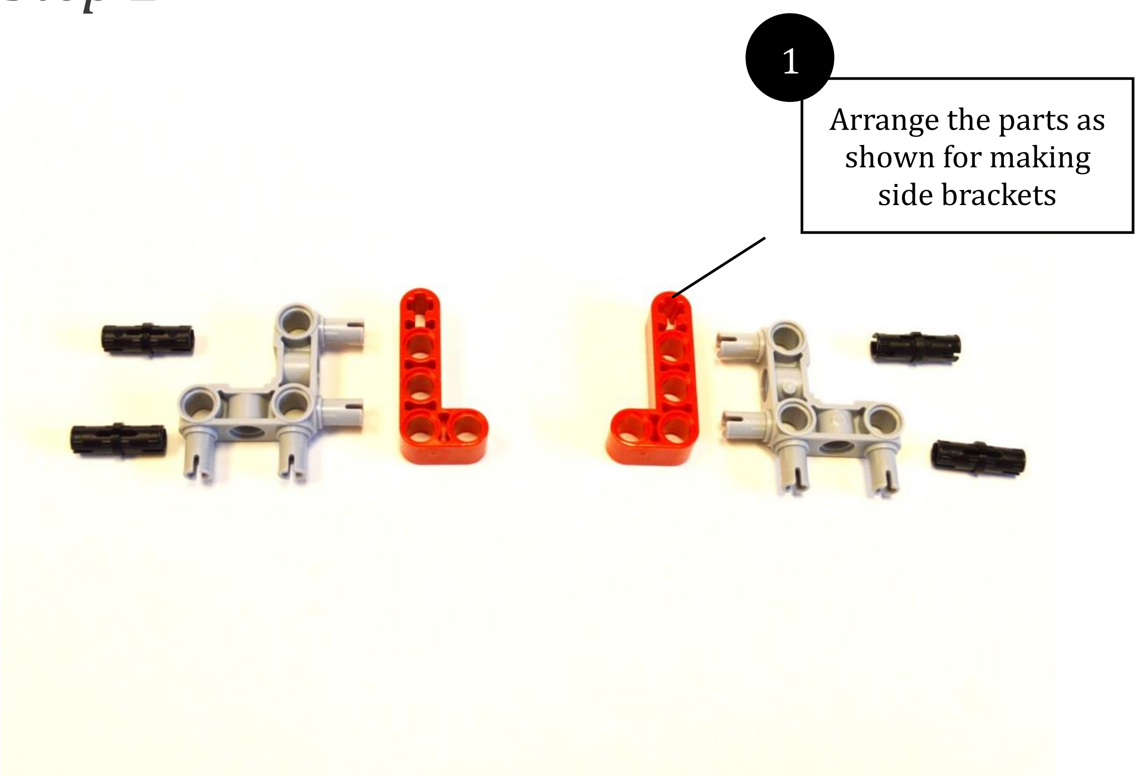
Find the following from your Mindstorms kit (refer to the EV3 parts list for identifying shapes with names) –follow the steps provided in following pages.

- ☐ 1 X touch sensor
- ☐ 2 X 2x4M angular beams
- ☐ 4 X 3M peg with friction
- ☐ 1 X 4M axel
- ☐ 2 X 3X3 angular connector peg
- ☐ 1 X 2M axle
- ☐ 1 cable

Step 1


1
Insert the axel in the cross hole of the touch sensor

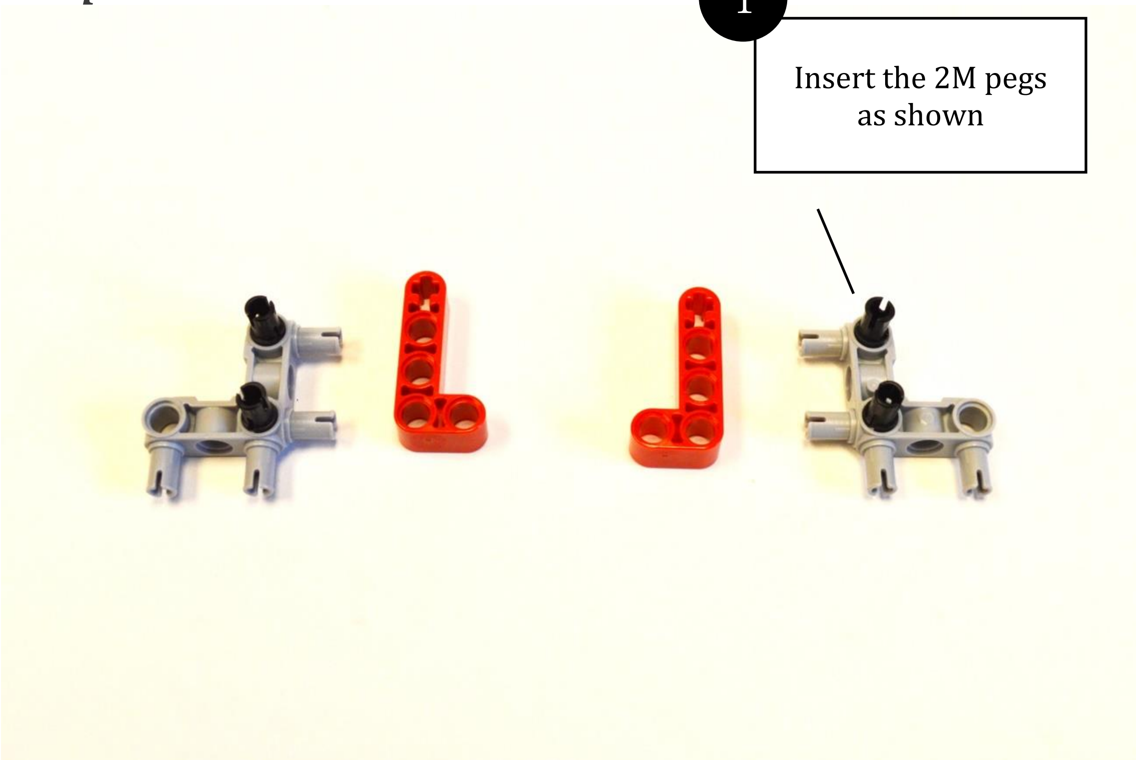
Step 2


1
Arrange the parts as shown for making side brackets

Step 3

1

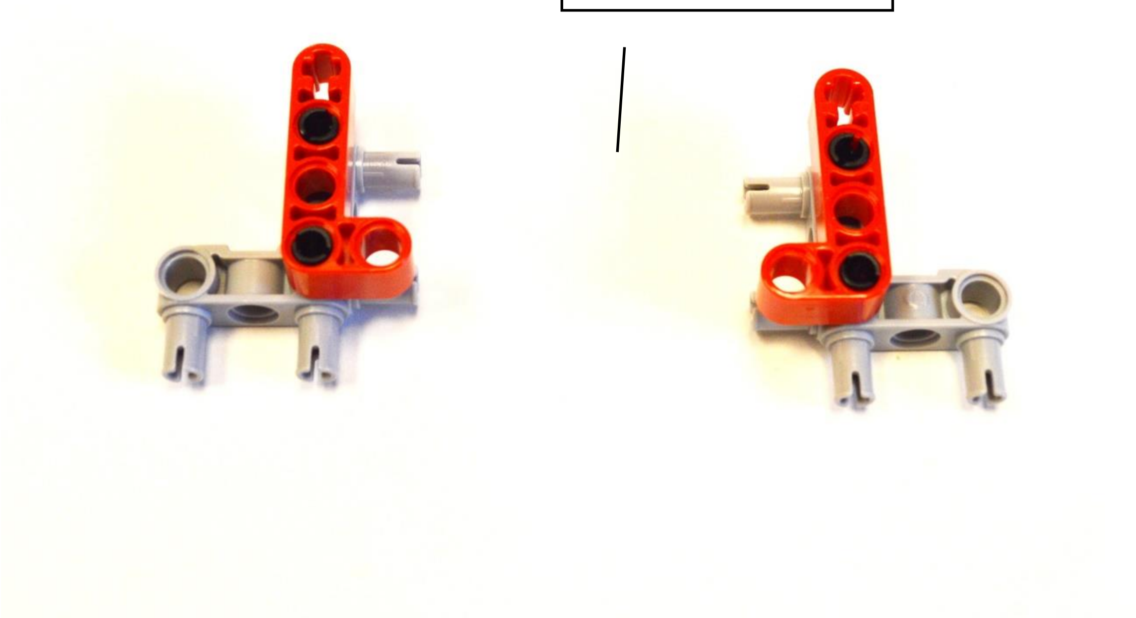
Insert the 2M pegs as shown



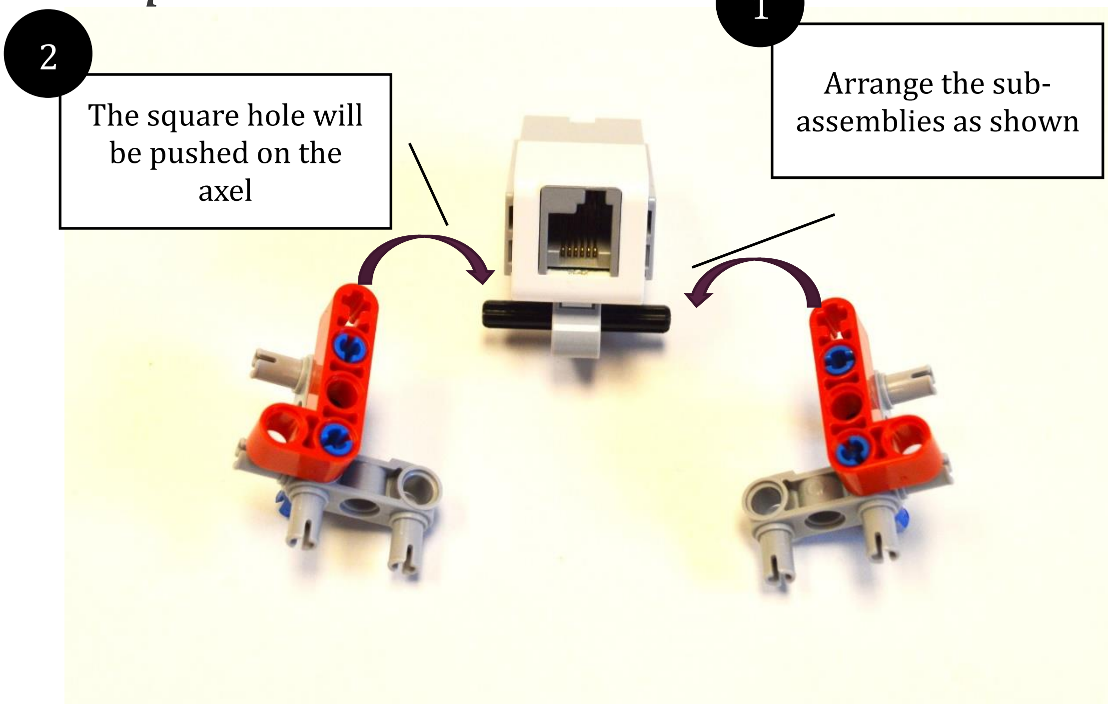
Step 4

1

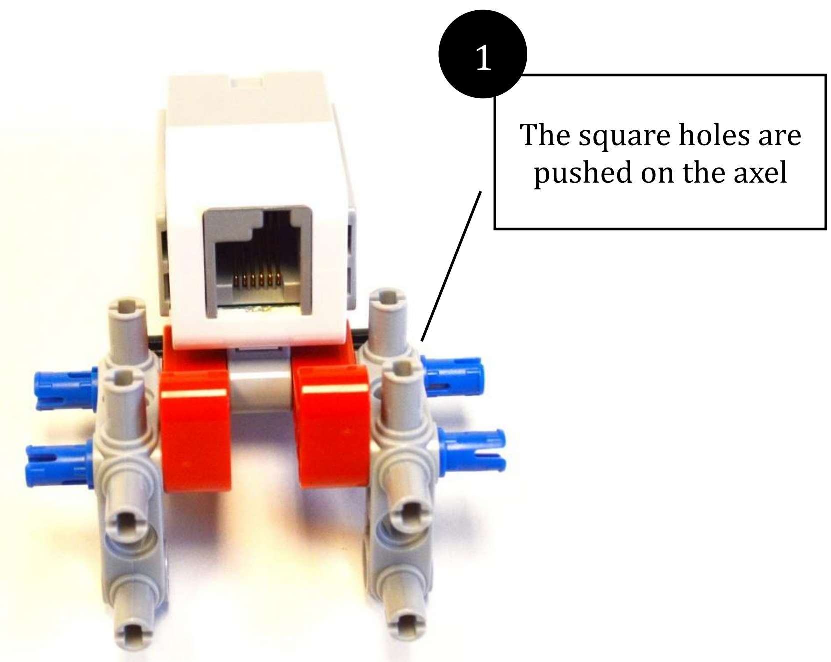
Attach the angular beams as shown



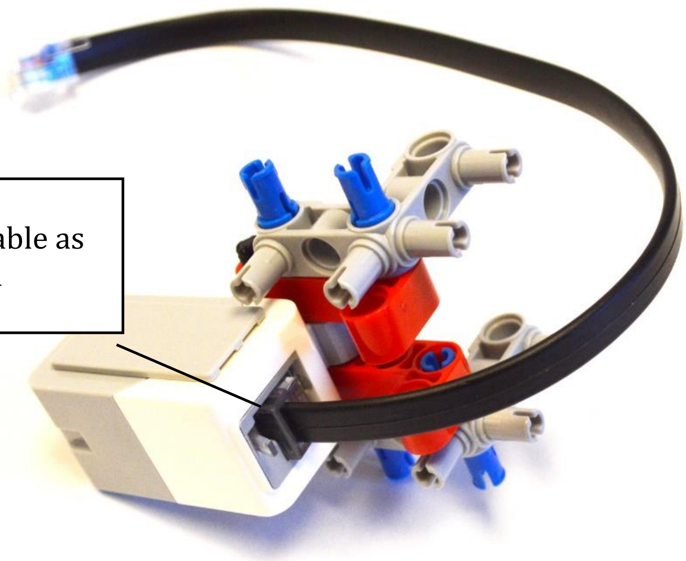
Step 5


2
The square hole will be pushed on the axel
1
Arrange the sub-assemblies as shown

Step 6


1
The square holes are pushed on the axel

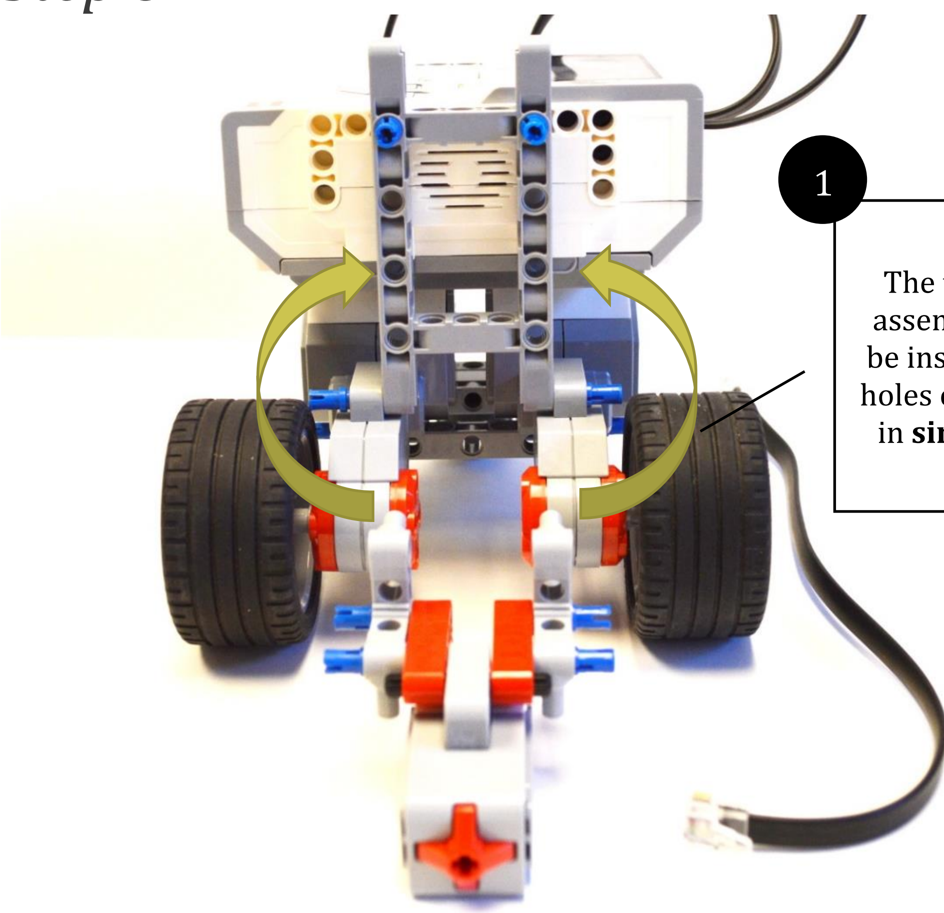
Step 7



1

Attach the cable as shown

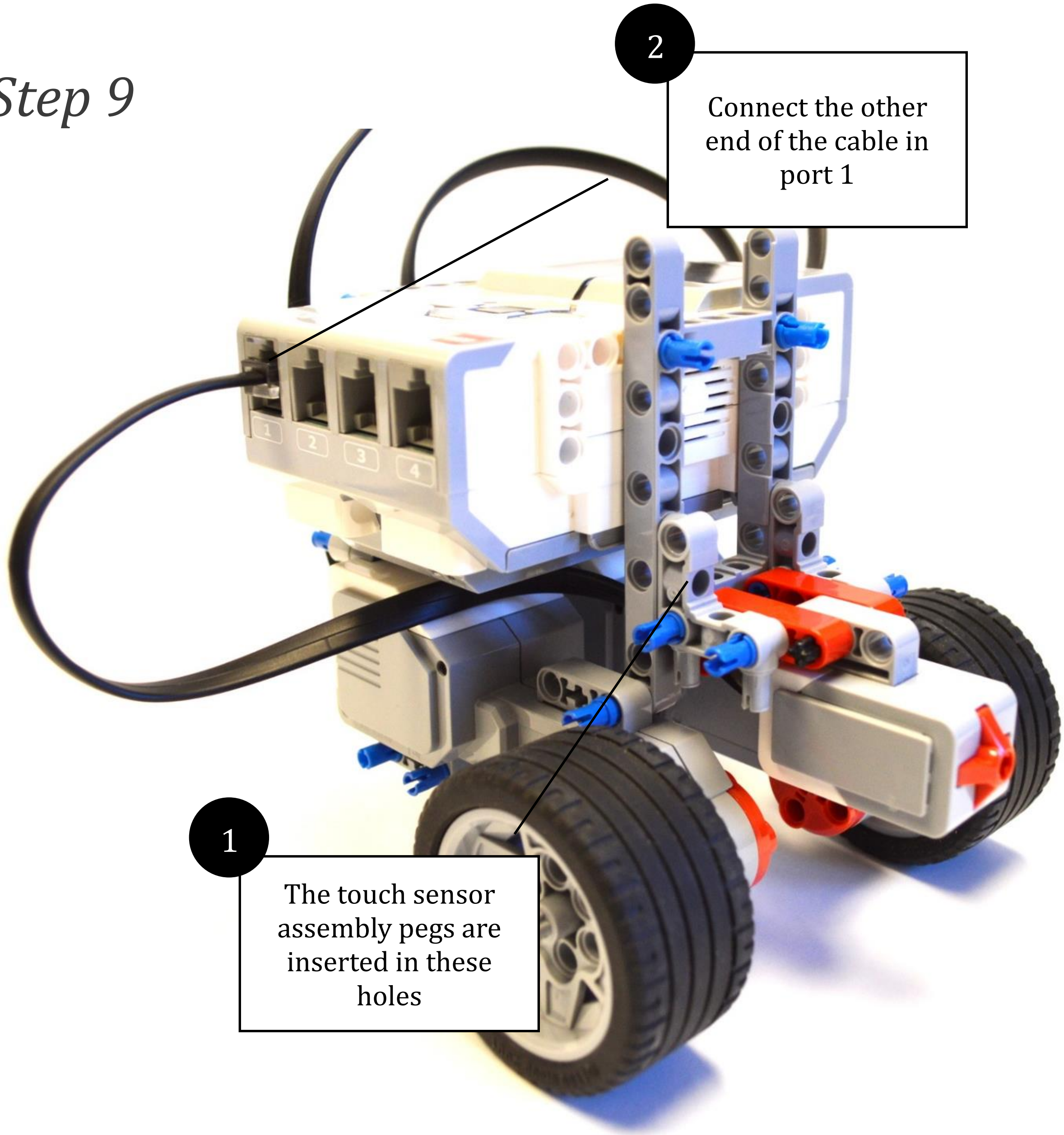
Step 8



1

The touch sensor assembly pegs will be inserted in these holes of the bot built in **simBot** activity

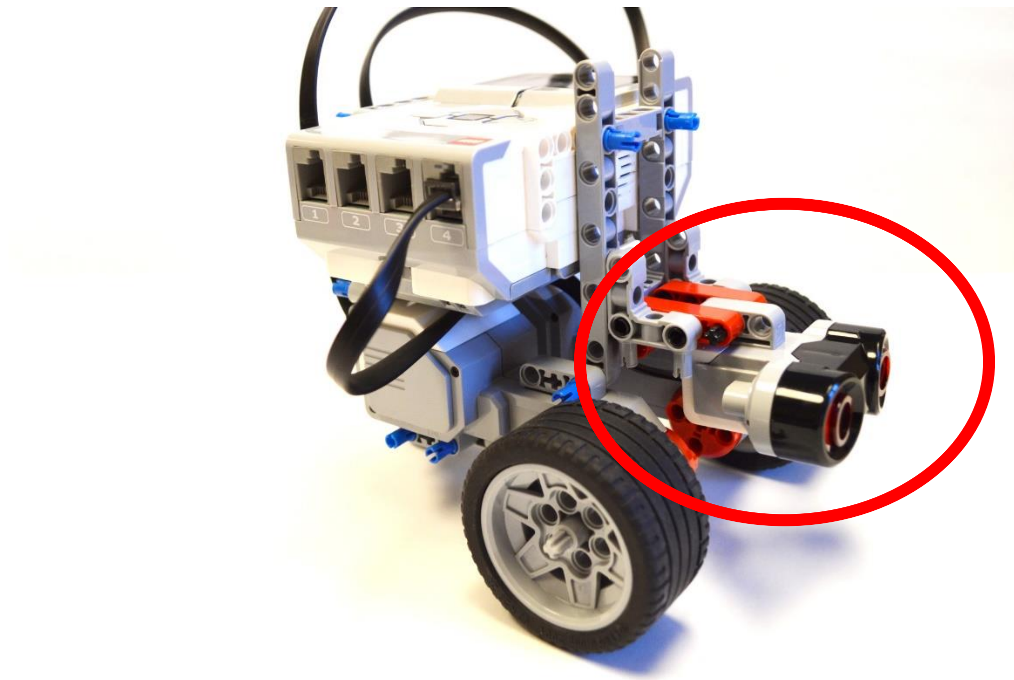
Step 9


2
Connect the other end of the cable in port 1
1
The touch sensor assembly pegs are inserted in these holes
1
2
3
4

ACTIVITY

< *Ultrasonic* ***Sensor*** >

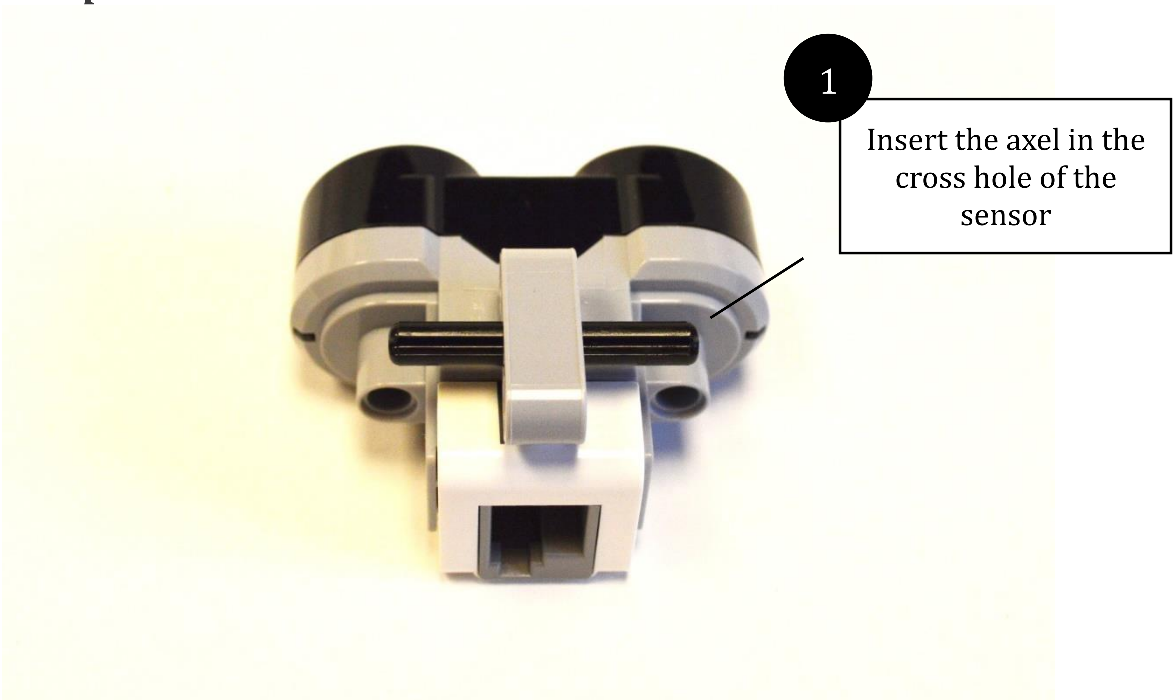
The challenge is shown using the image below. The bot must navigate through the maze from the starting position to the ending position. In the first case the robot will turn before hitting a wall.



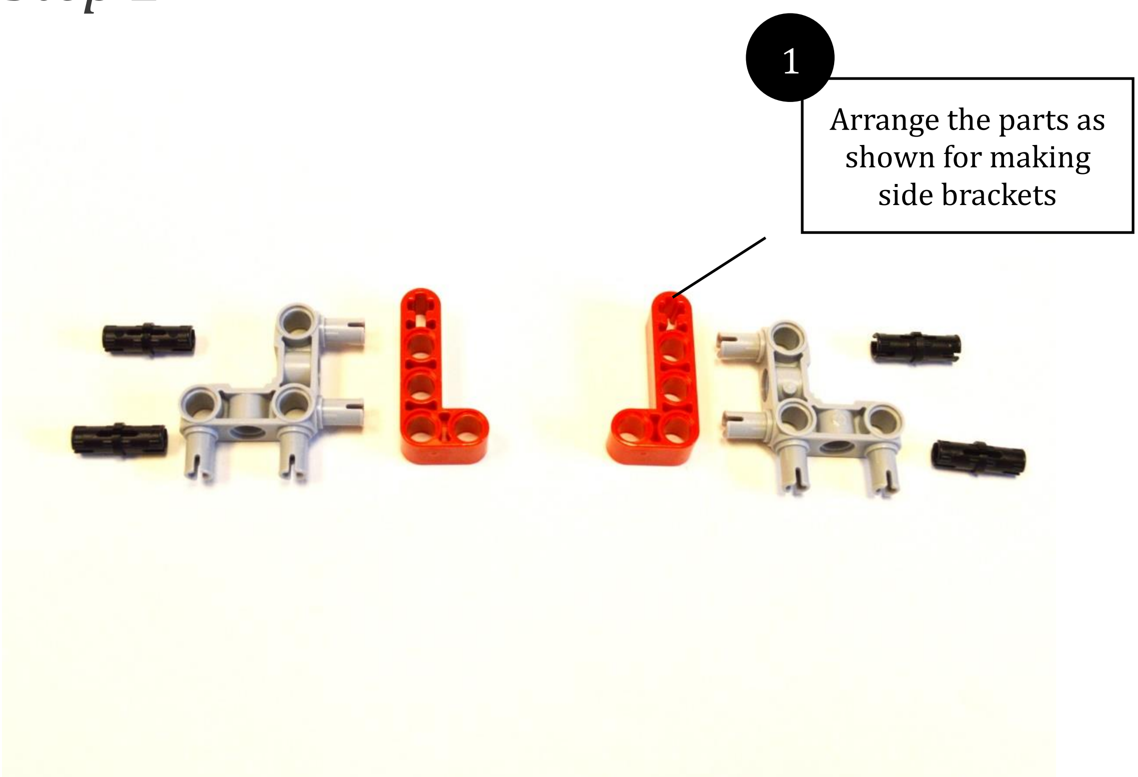
Find the following from your Mindstorms kit (refer to the EV3 parts list for identifying shapes with names) –follow the steps provided in following pages.

- ☐ 1 X ultrasonic sensor
- ☐ 2 X 2x4M angular beams
- ☐ 4 X 3M peg with friction
- ☐ 1 X 4M axel
- ☐ 2 X 3X3 angular connector peg
- ☐ 1 X 2M axle
- ☐ 1 cable

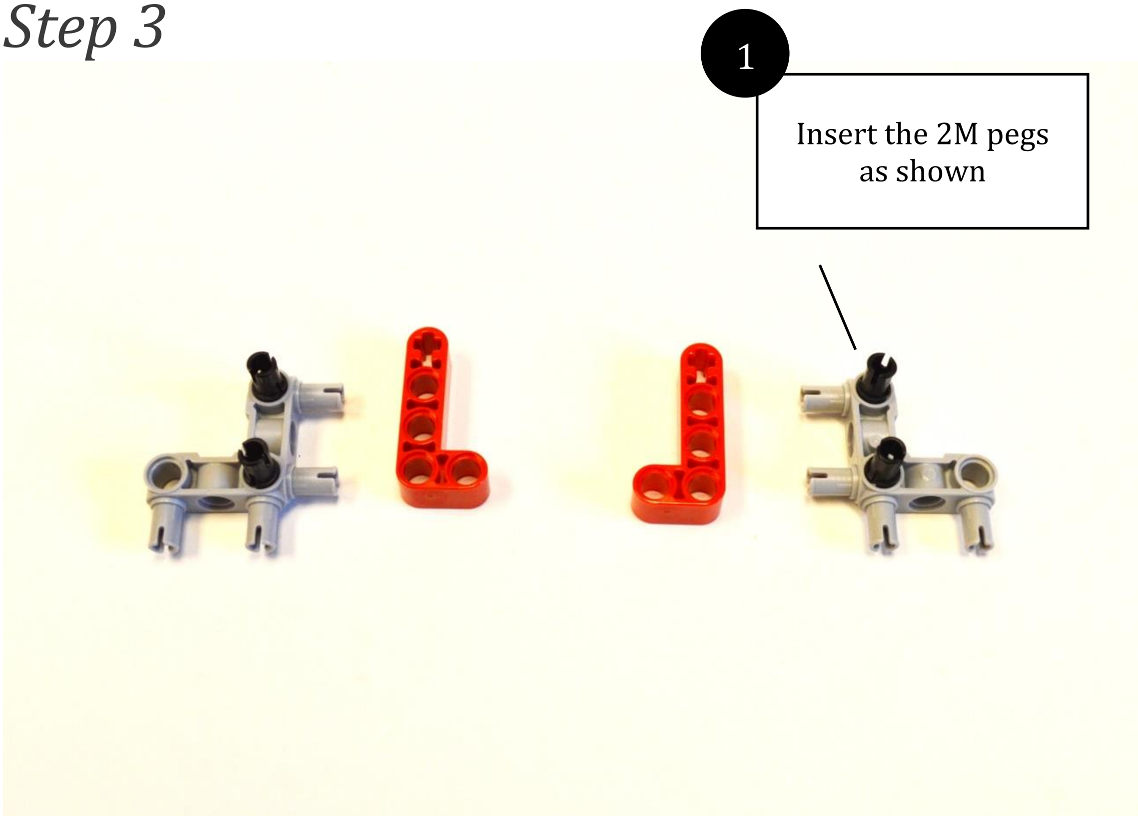
Step 1


1
Insert the axel in the cross hole of the sensor

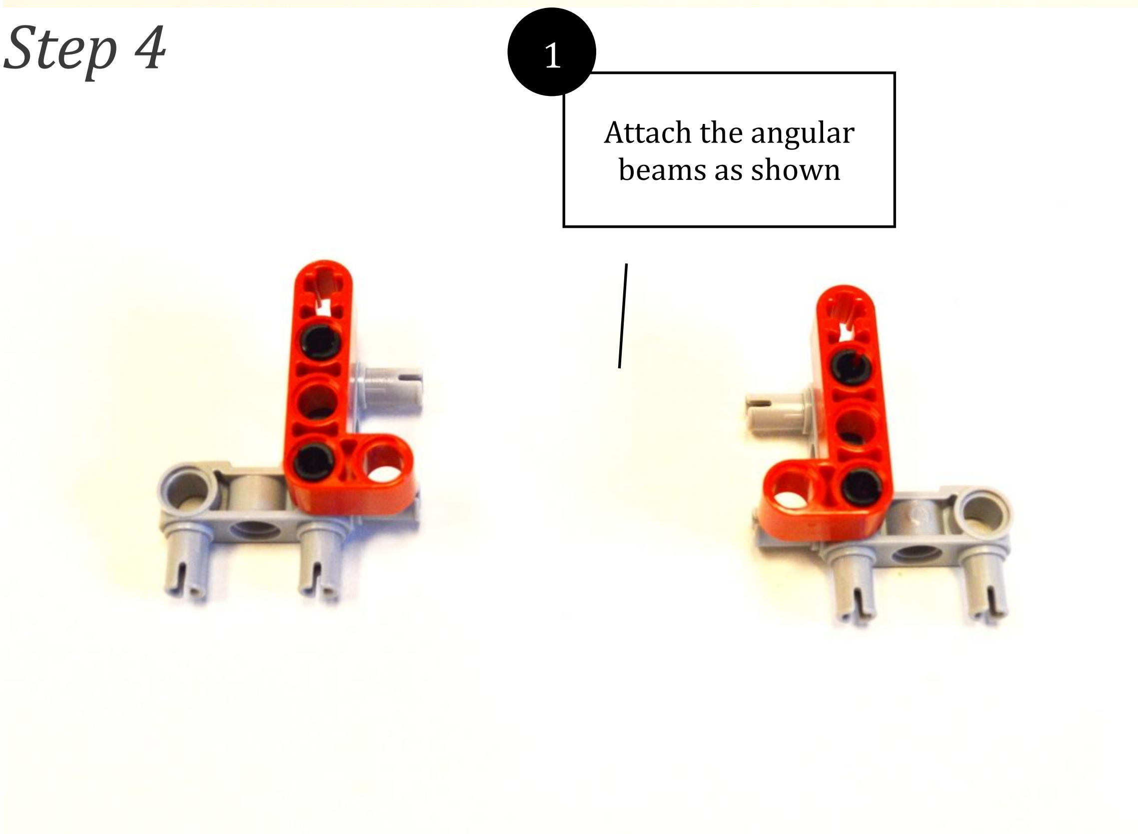
Step 2


1
Arrange the parts as shown for making side brackets

Step 3


1
Insert the 2M pegs
as shown

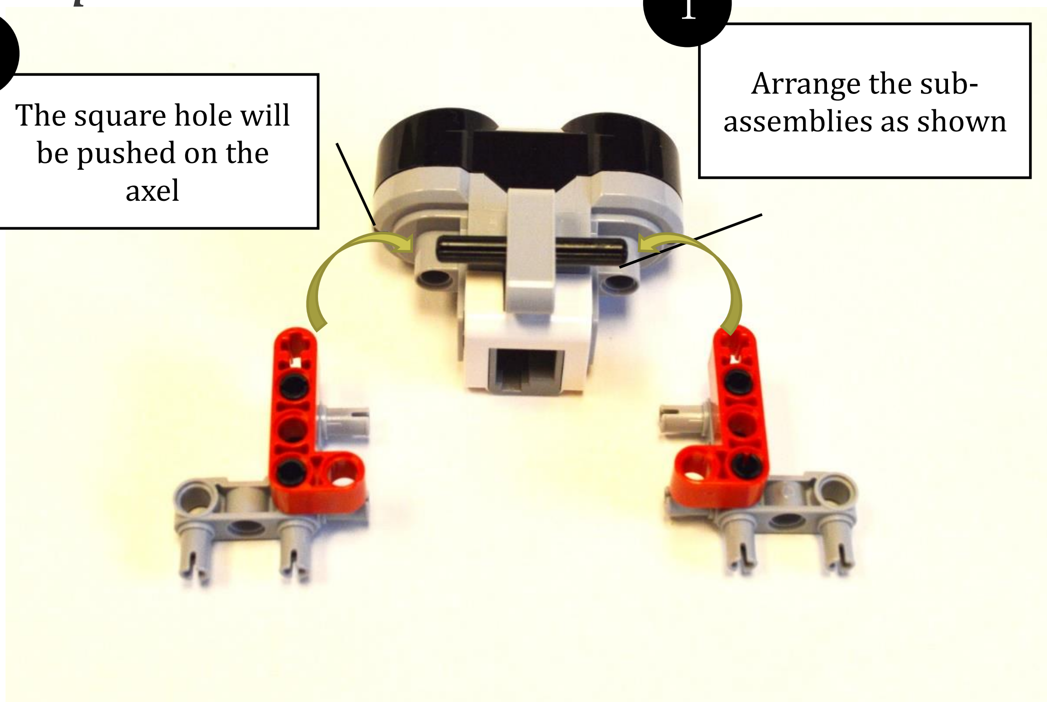
Step 4


1
Attach the angular
beams as shown

Step 5

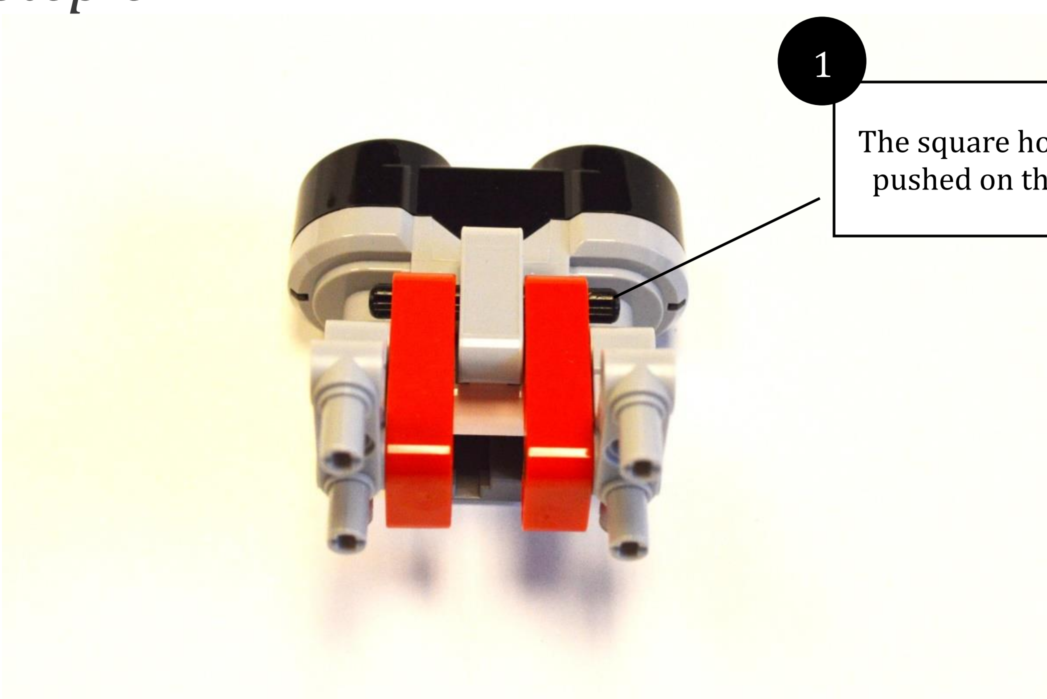
1 Arrange the sub-assemblies as shown

2 The square hole will be pushed on the axel

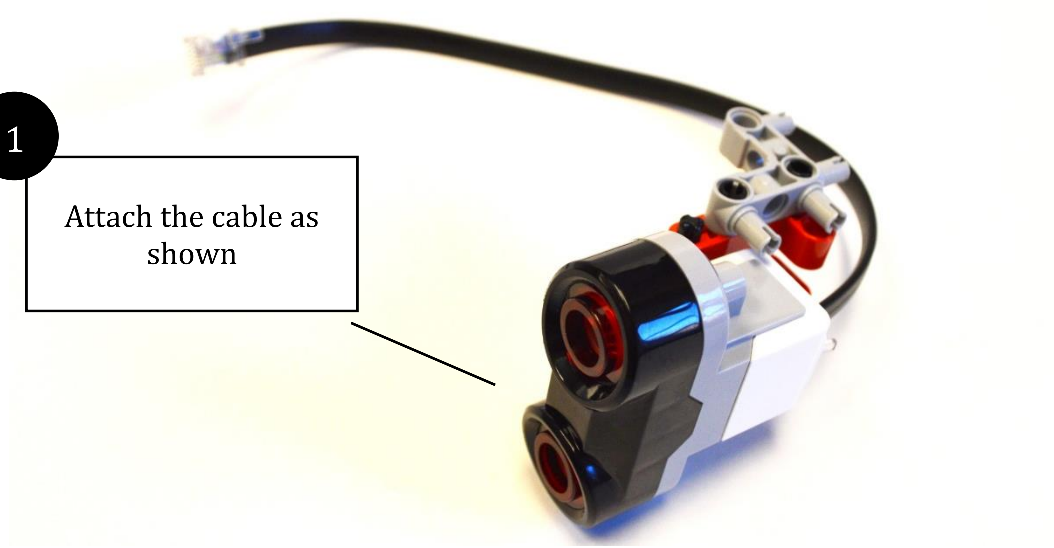


Step 6

1 The square holes are pushed on the axel



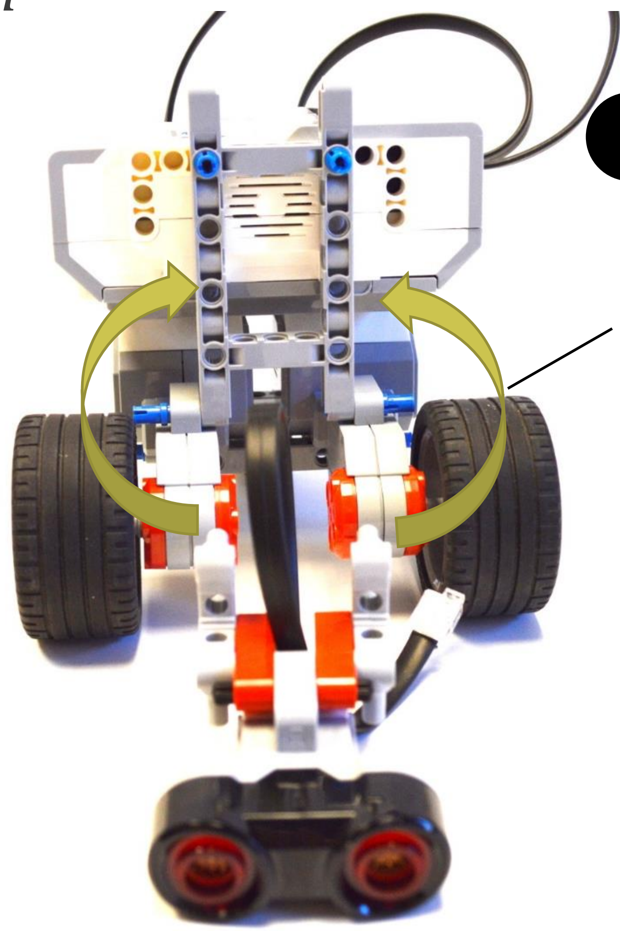
Step 7



1

Attach the cable as shown

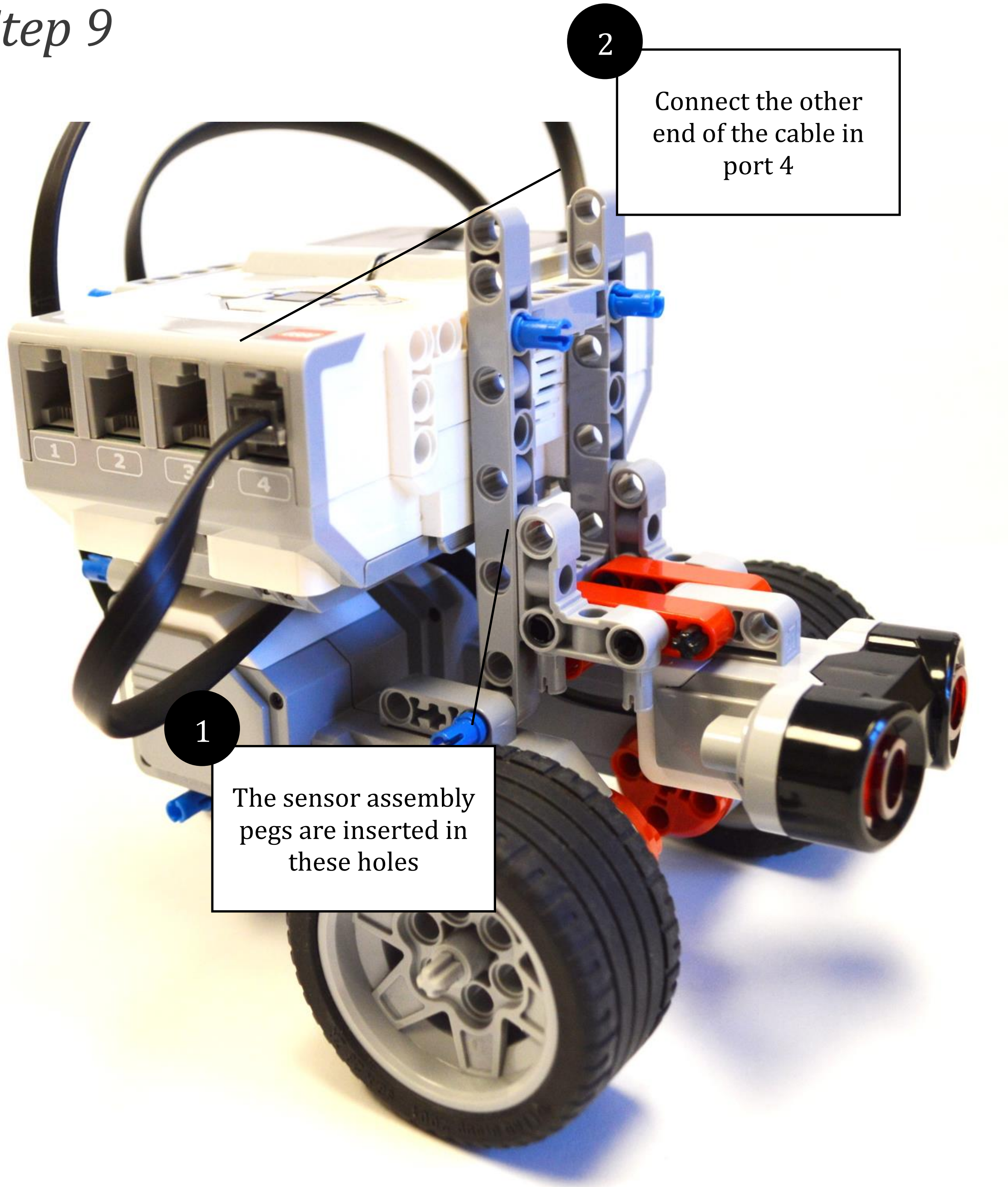
Step 8



1

The touch sensor assembly pegs will be inserted in these holes of the bot built in **simBot** activity

Step 9


2
Connect the other end of the cable in port 4
1
The sensor assembly pegs are inserted in these holes