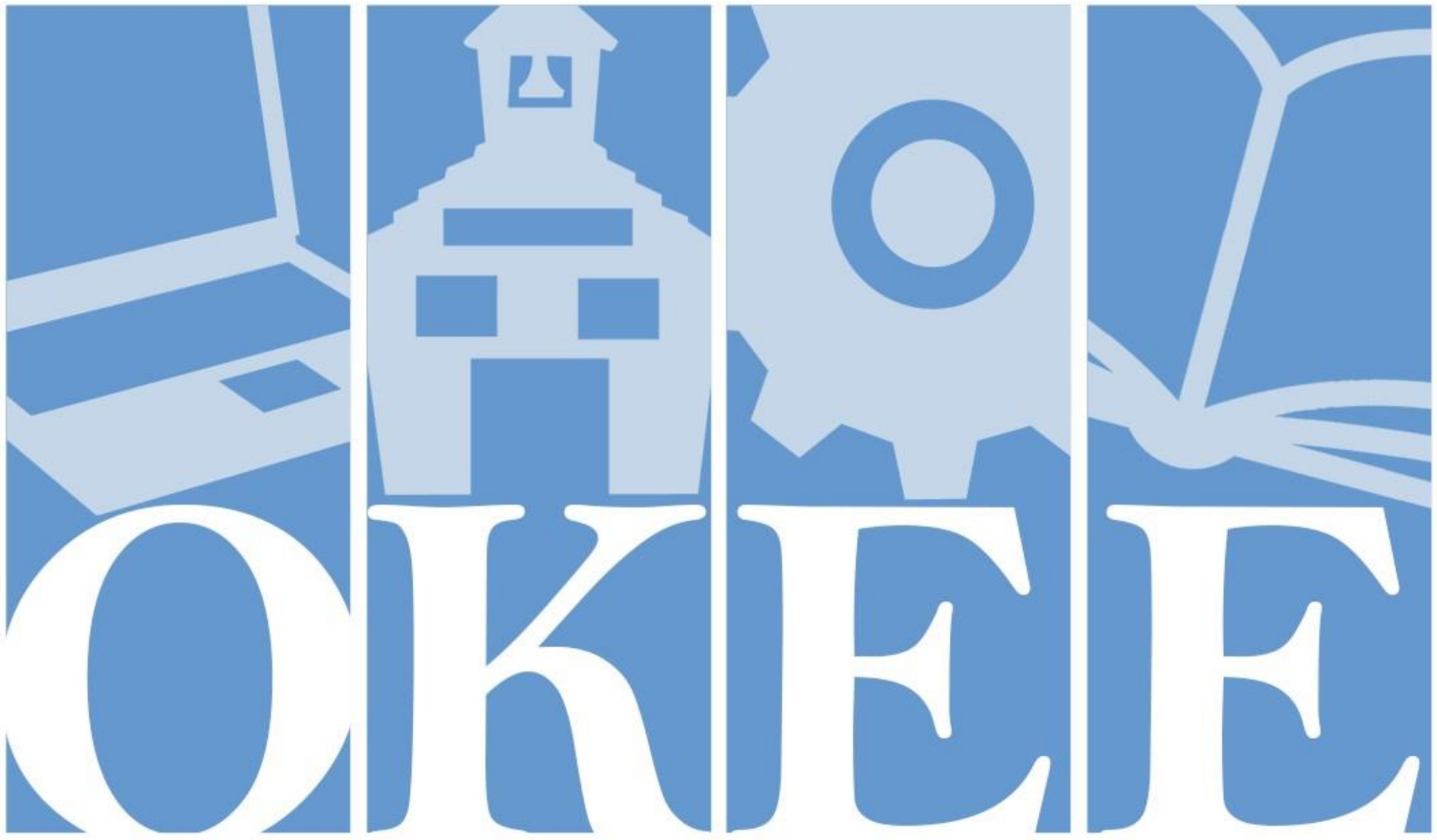


OKED

Online K-12 Engineering Education

LEGO Constructopedia

Welcome To The Constructopedia

Major Topics Covered

Charging & Using the EV3 Brick

Overview of Parts in the Kit

Sturdy Structures

Sturdy Motor Attachments

EV3 Sensors

Using Gears

Orange boxes are for important information

Black boxes are for parts you will need for a design

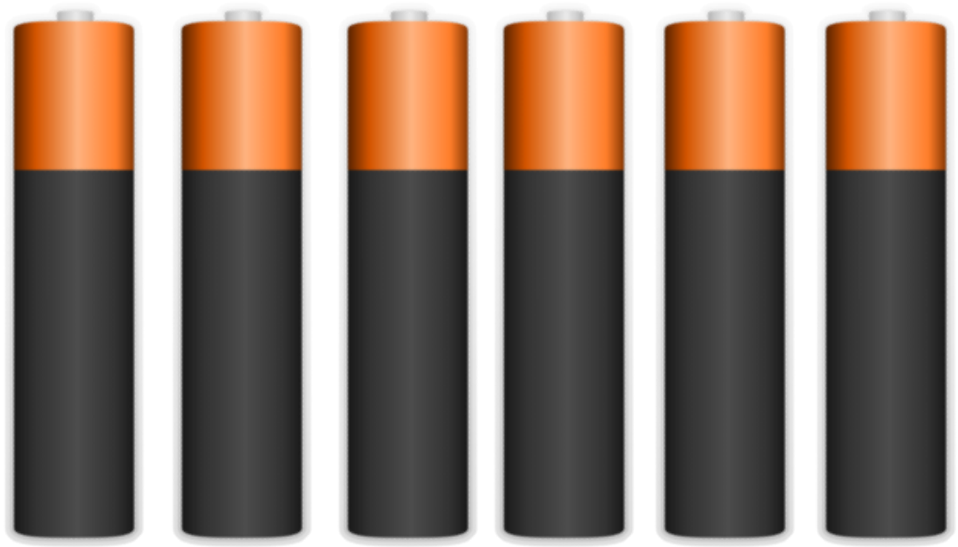
Green boxes are for notes

Blue boxes are for key vocabulary

Charging Your EV3 Battery

EV3 Rechargeable Battery with Charger Cord

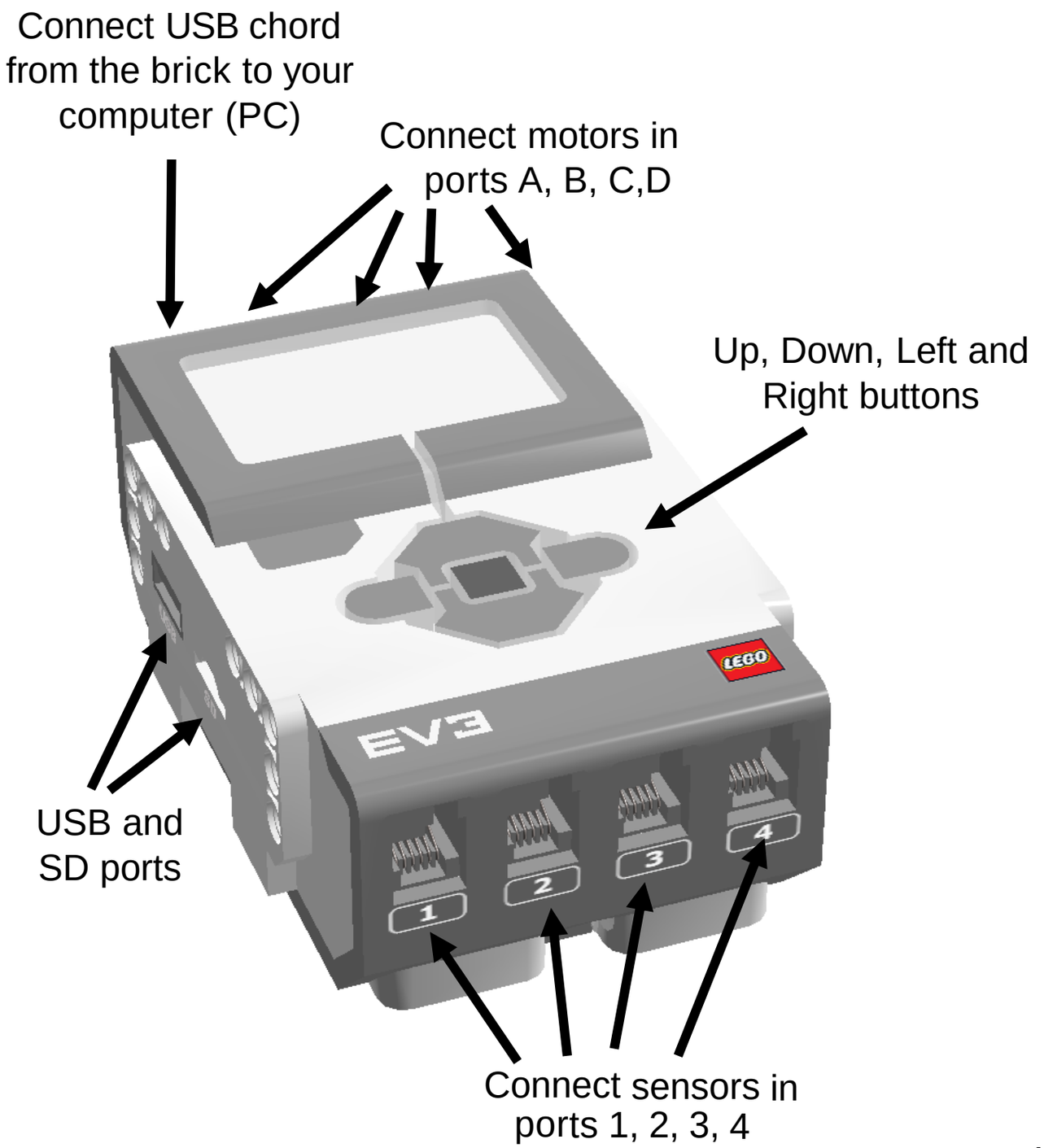
or



6 AA Batteries

- Takes approximately 4 hours to fully recharge
- Green indicator light turns on when the battery is connected to the power adapter
- Red indicator light is on when the battery is recharging and turns off when it is finished charging
- EV3 Brick can be used when battery is charging

EV3 Brick

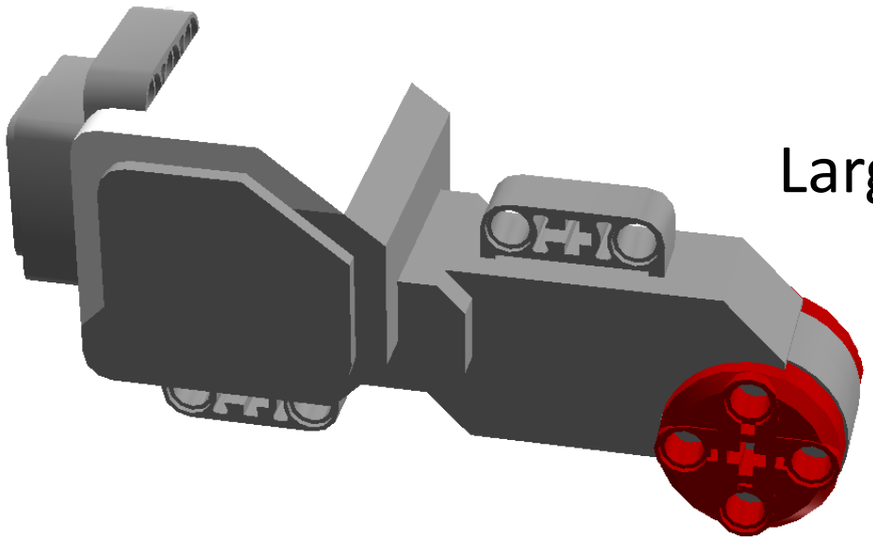


Turn your brick **on** by holding down the center dark grey button
Turn your brick **off** by pressing the grey rectangular button in the top left and selecting the check on the screen with the center button

To access the files you downloaded onto the brick select the second tab then, select your project name “Project” by default, and then scroll using the arrow buttons to find your program file “Program” by default

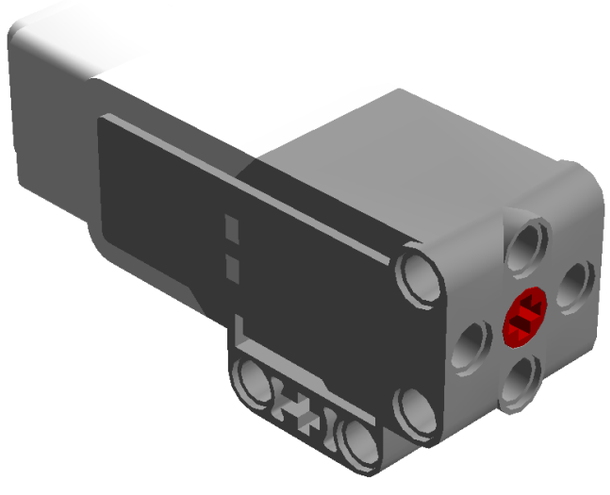
Overview of Parts in the Kit

Motors



Large Motor x2

Medium Motor



USB Cord

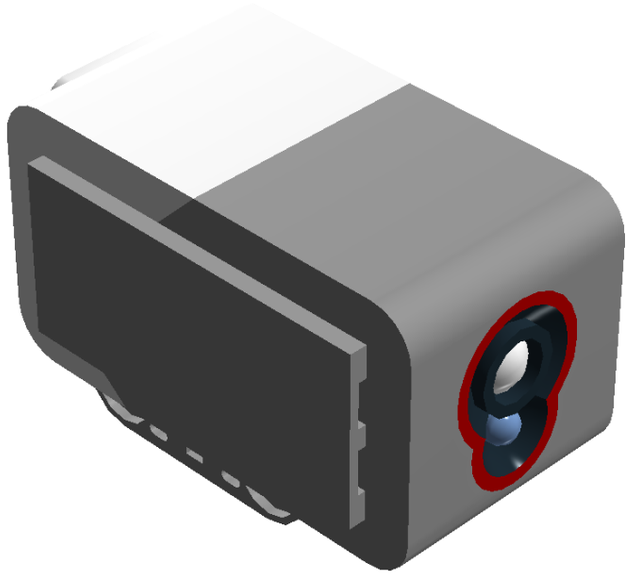
Used to connect the EV3 Brick to your computer

Cables

Cables of varying length used to connect motors and sensors to the brick

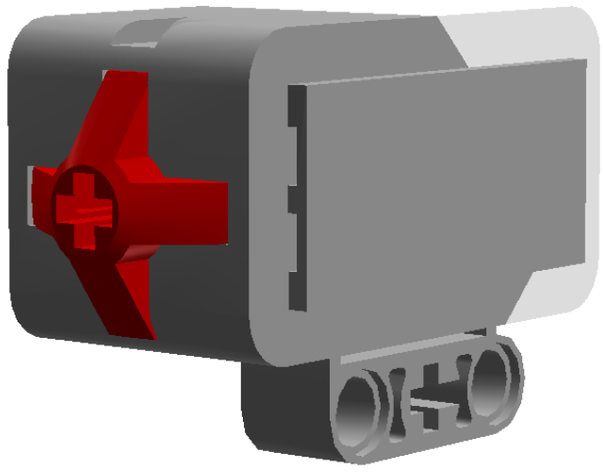
Overview of Parts in the Kit

Sensors

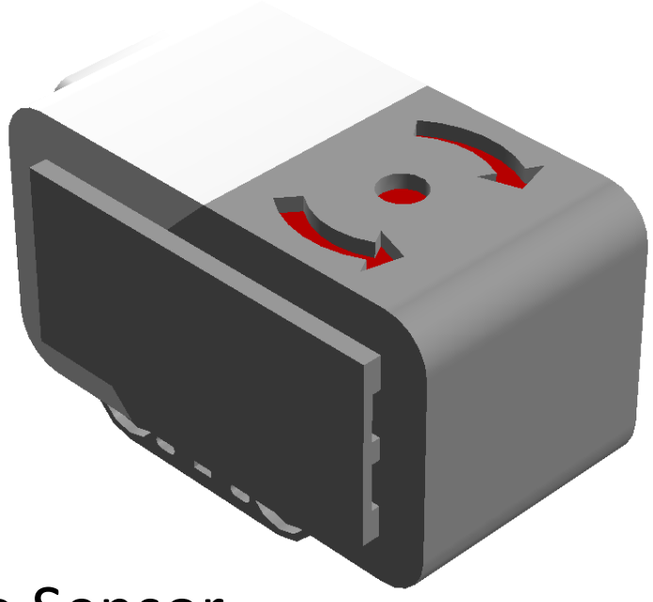


Color Sensor

Ultrasonic Sensor



Touch Sensor x 2

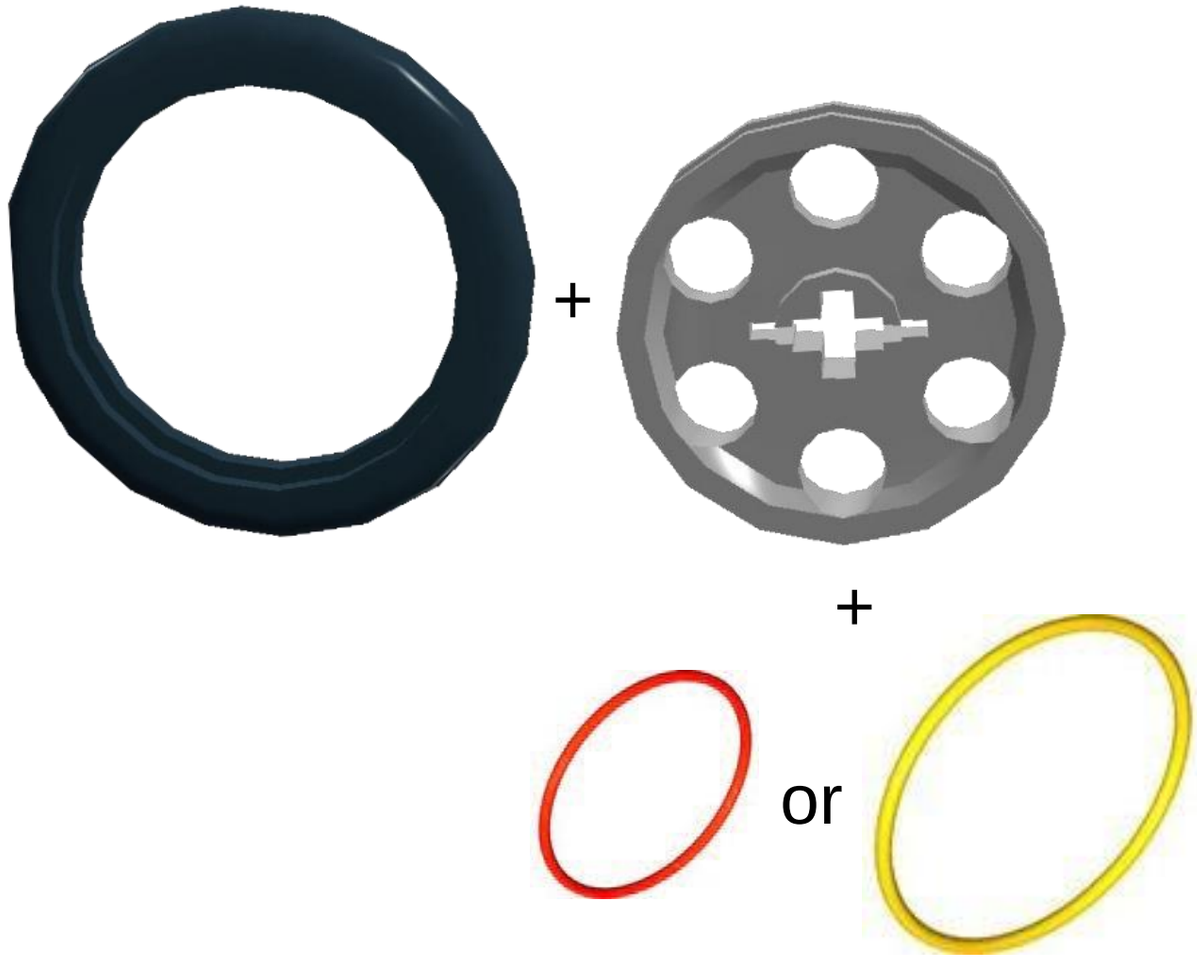


Gyro Sensor

For more detailed information on sensors go to page 36

Overview of Parts in the Kit: Wheels

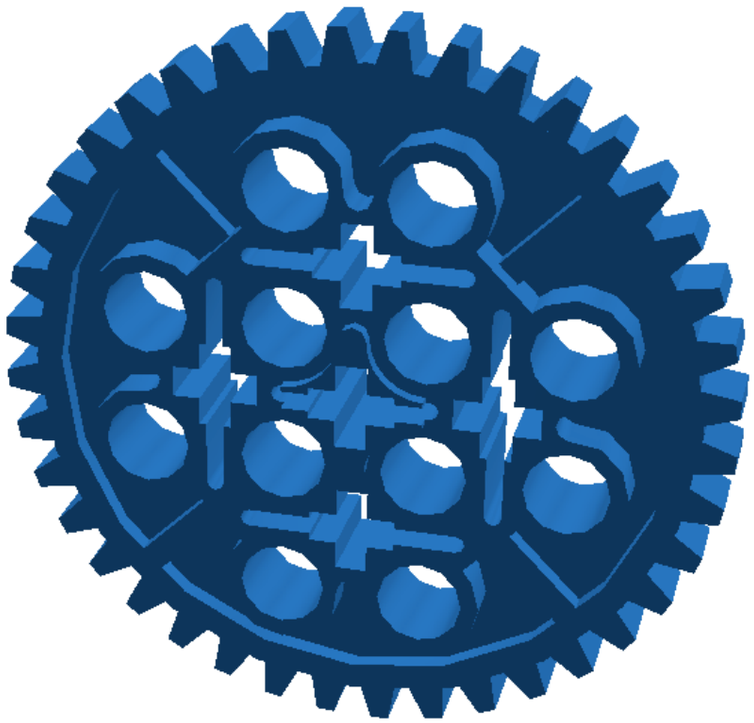
This wheel must be attached to a cross axle



This thin wheel can either be attached to a tire and function as a standard wheel or it can be attached to one of the rubber bands to serve as a pulley wheel

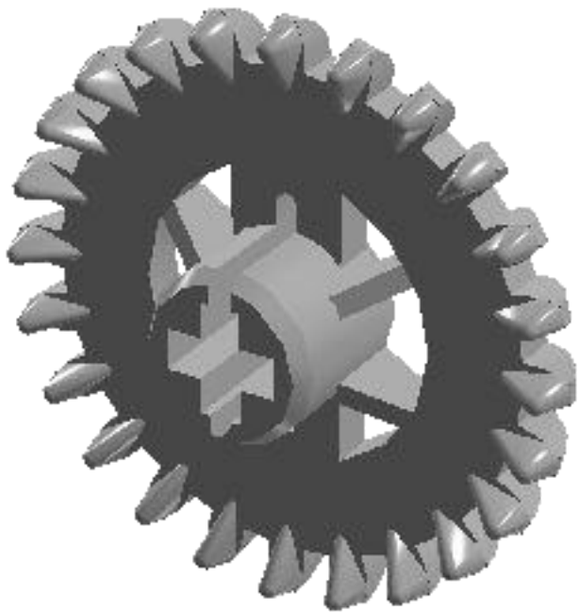
Overview of Parts in the Kit: Different Gear Types

8 Tooth Gear

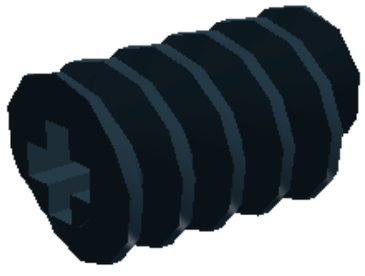


40 Tooth Gear

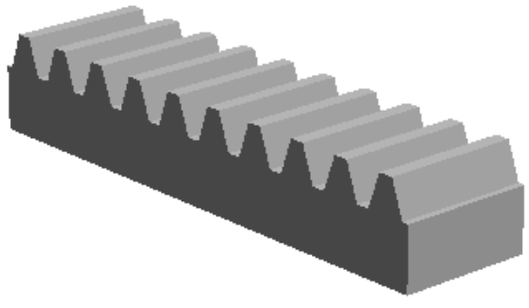
Bevel Gear



Crown Gear

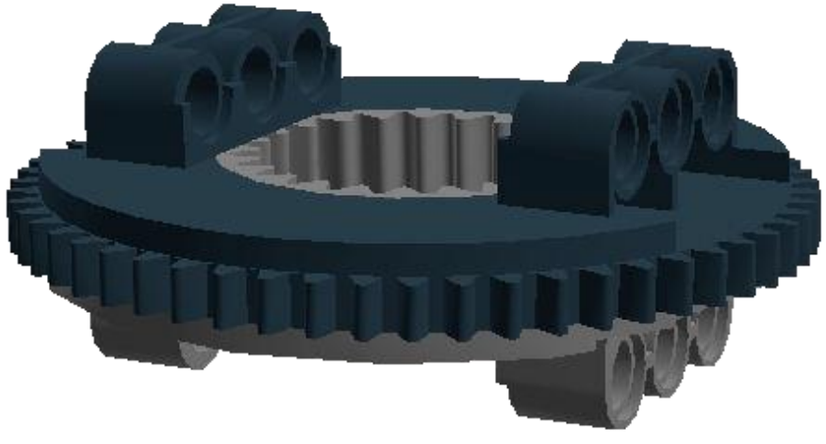


Worm Gear



Gear Rack

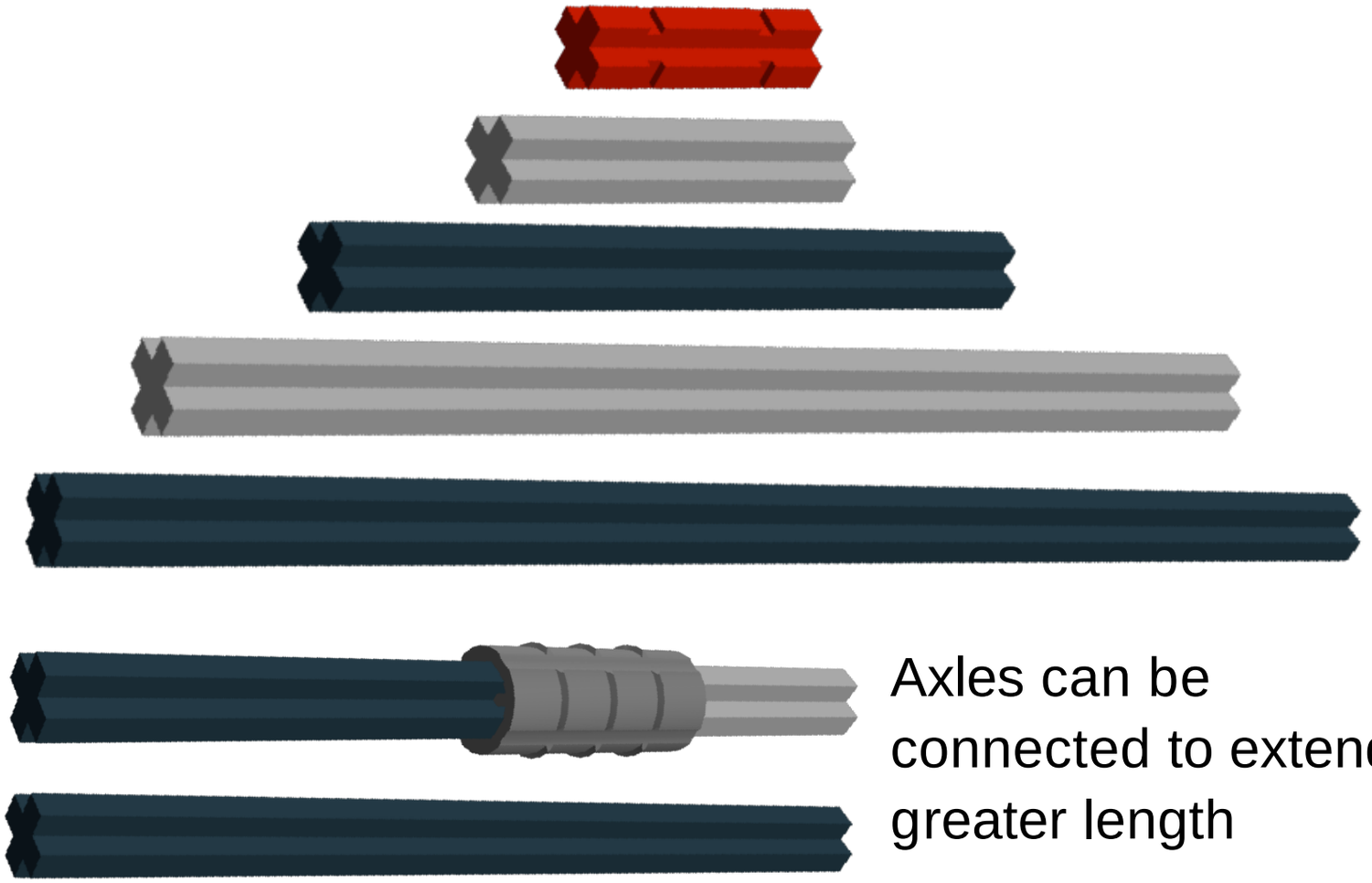
Knob Wheel



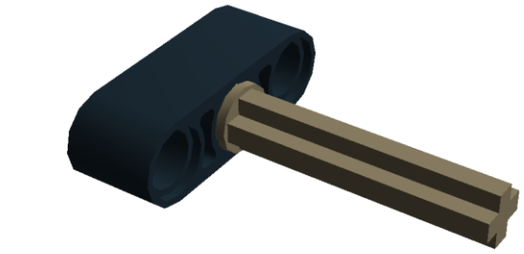
Turntable

For more detailed information using gears go to page 40

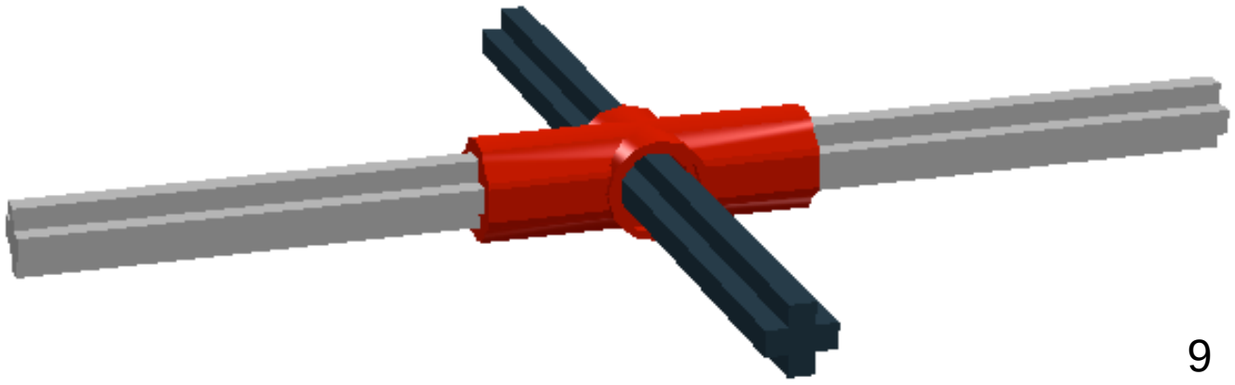
Overview of Parts in the Kit: Axles

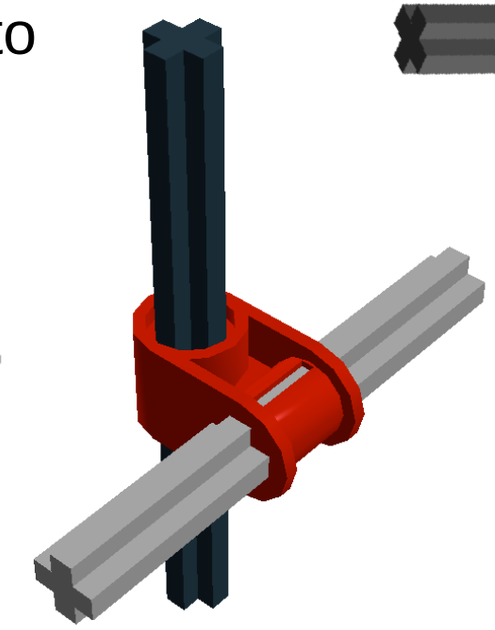


Axles can be connected to extend a greater length



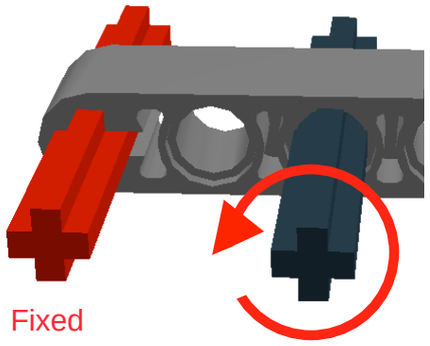
Some axles have knobs to securely attach to beams





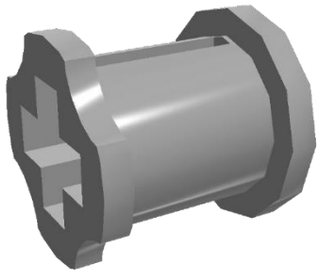
The direction of axles can be changed using various joiners

The circular holes in the beams will allow free rotation of axles and cross holes will not



Some axles have stops on one end

Overview of Parts in the Kit: Bushings

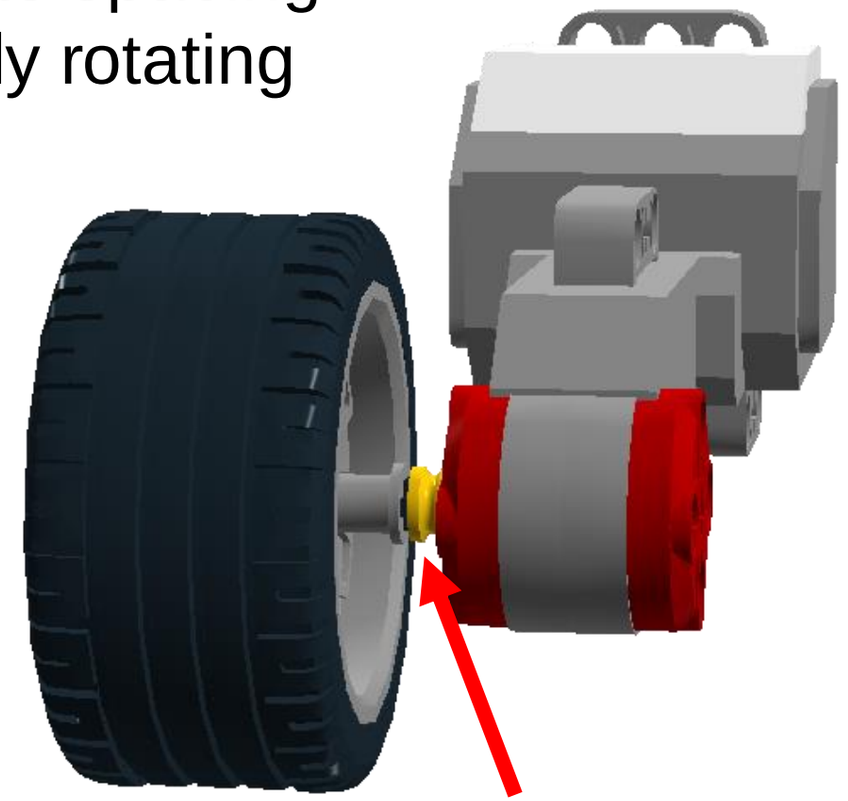


Full Bushing

Half Bushing

Bushings are used to create spacing along axles and hold freely rotating objects in place

Bushings keep the wheel from sliding off the axle

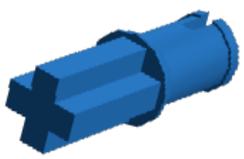


A bushing creates spacing between the motor and the wheel so that the wheel won't rub against the motor as it turns

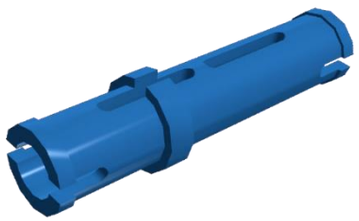
Overview of Parts in the Kit: Pegs

Connector peg with friction
-connects bricks or beams with minimal rotation

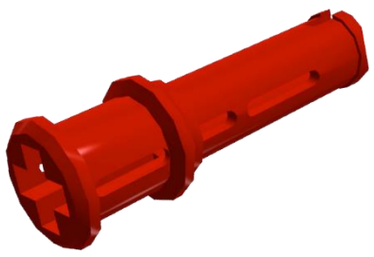
Frictionless connector peg
-connects bricks or beams allowing them to rotate freely



Connector peg with cross axle
-connects a cross hole and a circular hole



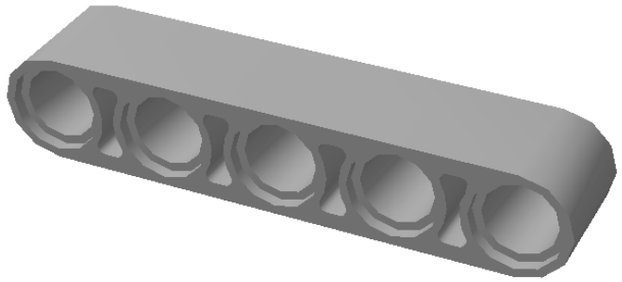
Long connector peg
-extends to connect 3 beams

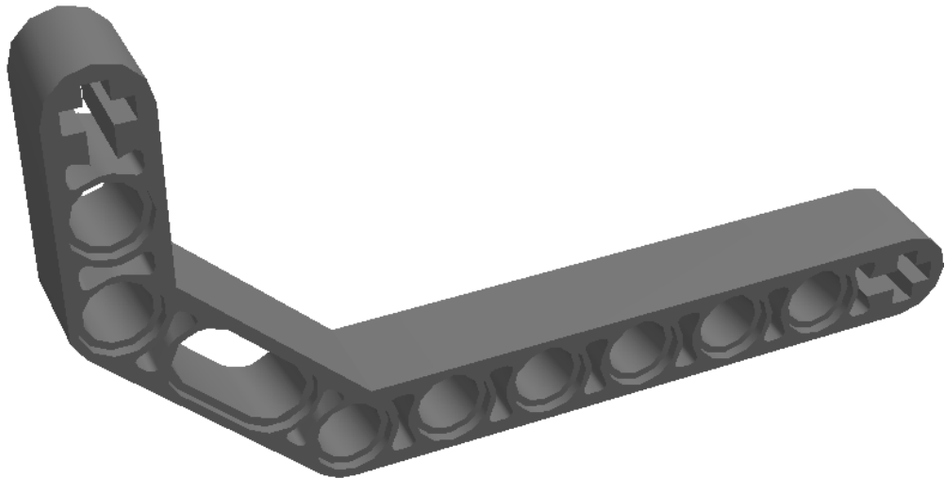


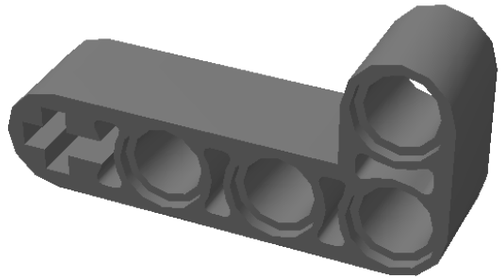
Connector with cross hole
-an axle can be attached at a 90° angle to a beam

Using pegs or axles with these connectors can allow you to connect beams at different angles

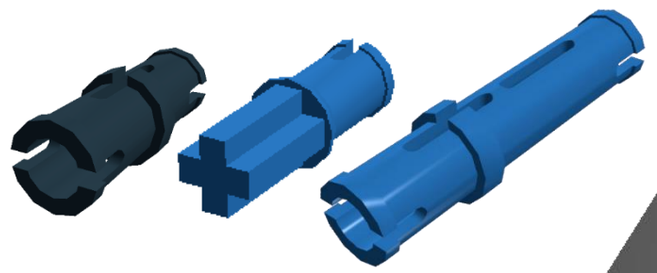
Overview of Parts in the Kit: Technic Beams

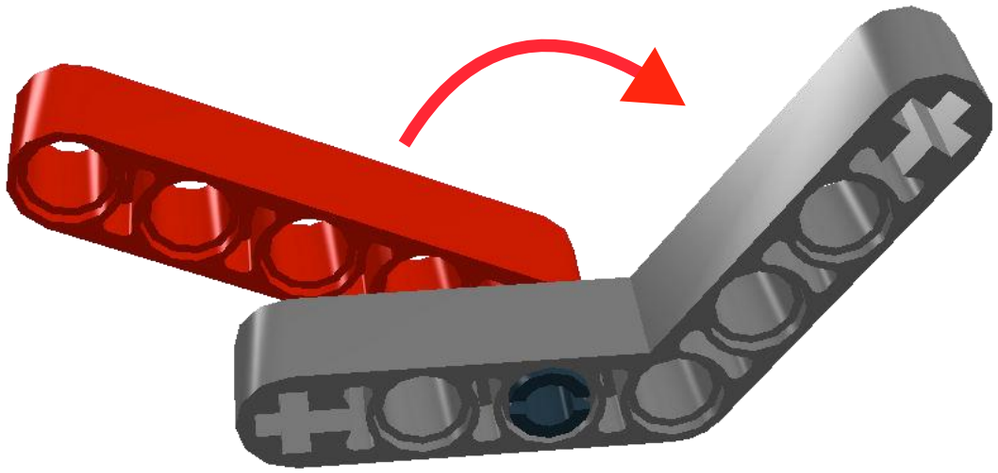


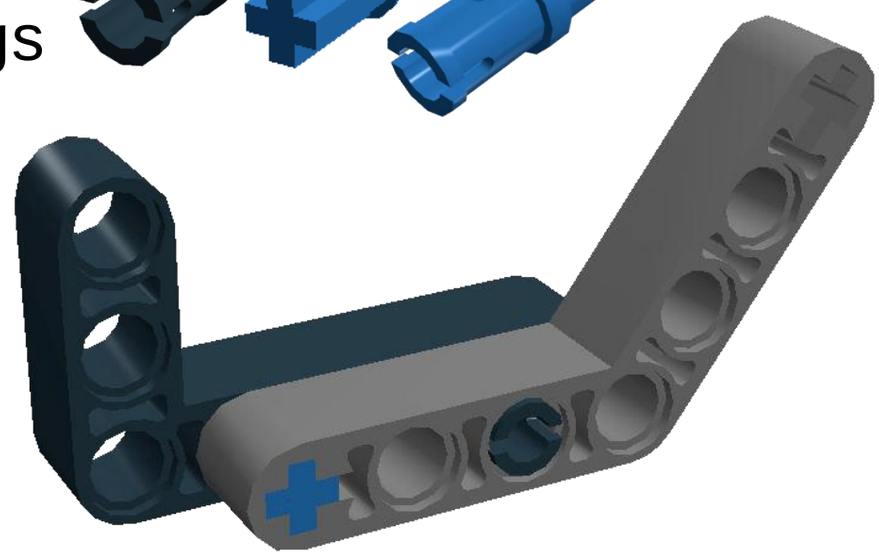




Beams can be connected using a variety of different connector pegs



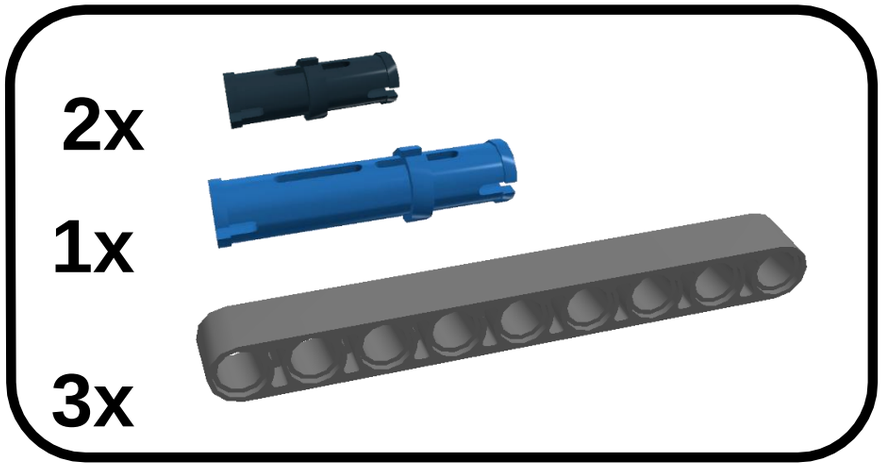


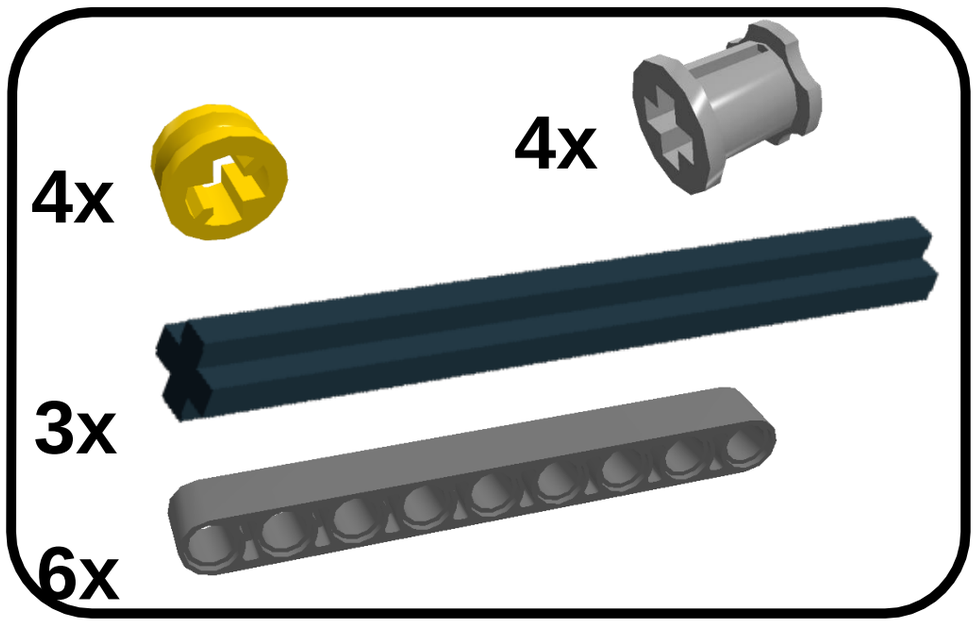


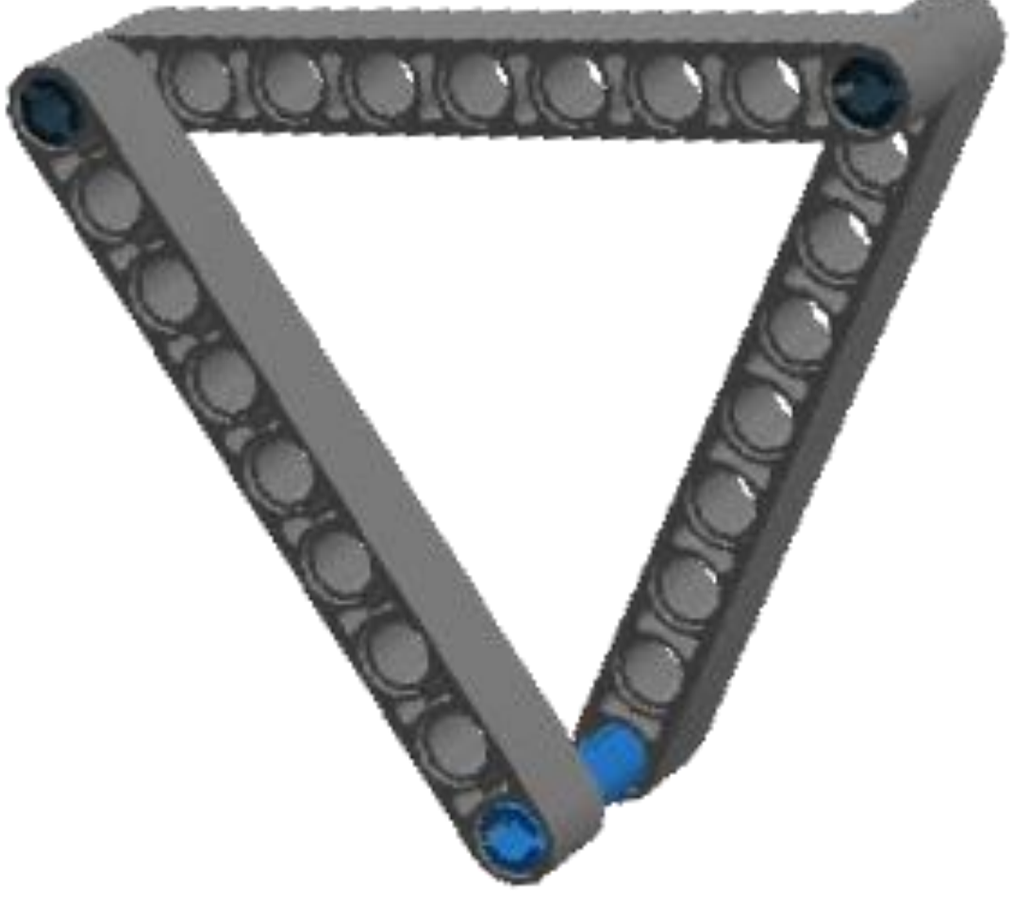
- Connecting with **one** peg will allow the beams to rotate.
- Connecting with **two or more** pegs will keep the structure rigid

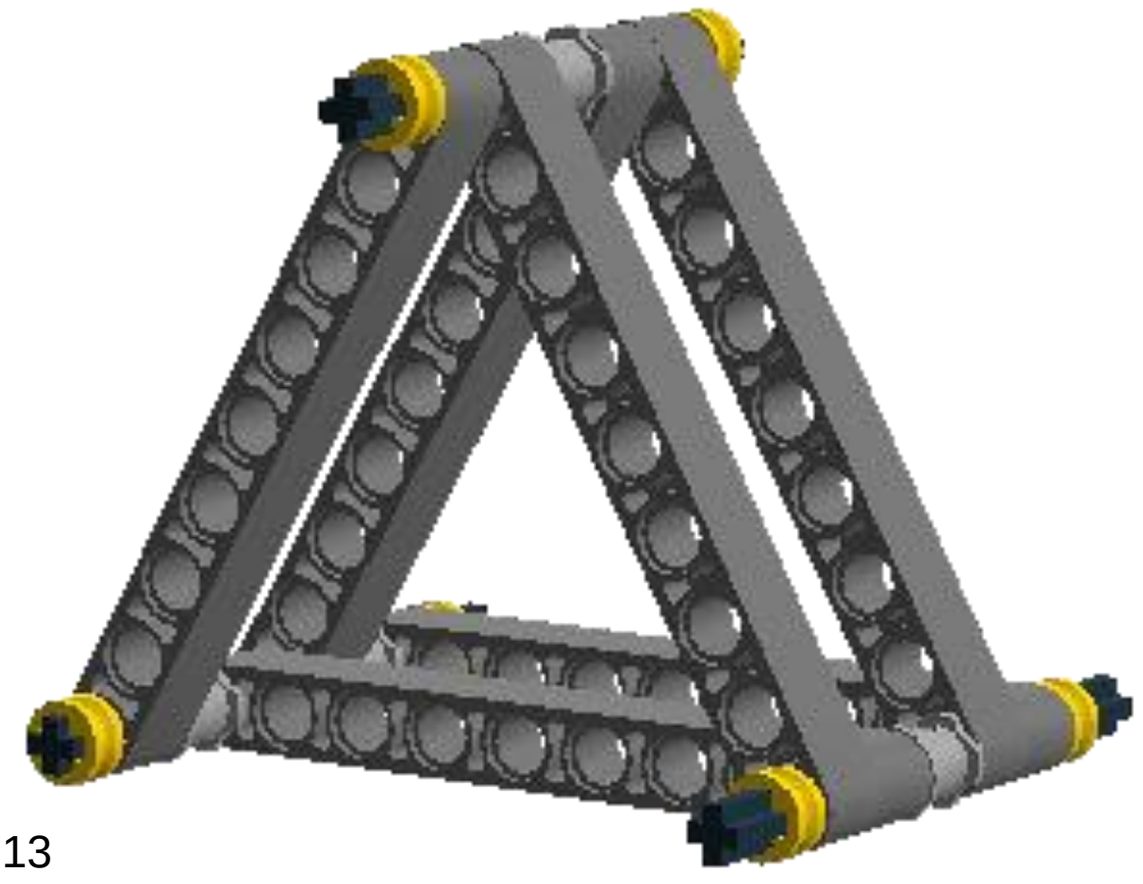
Sturdy Structures

Triangles



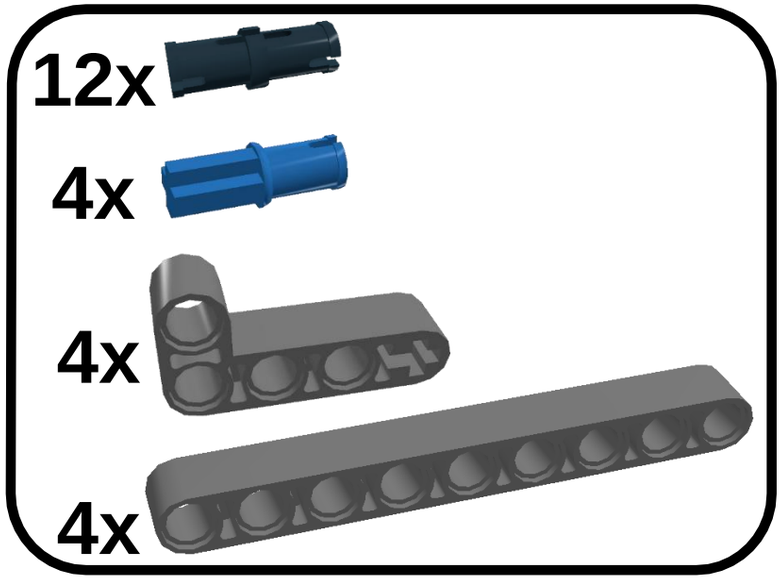


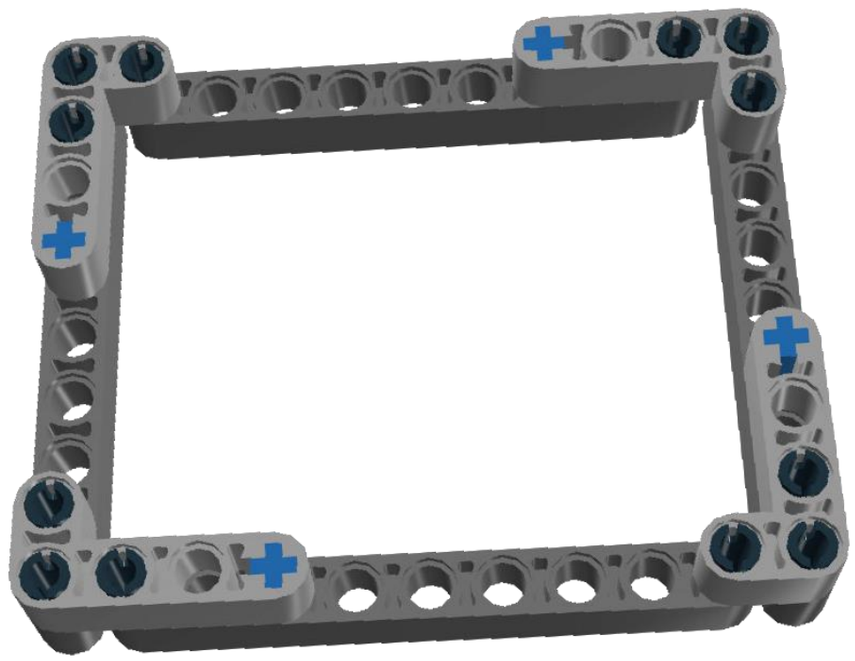


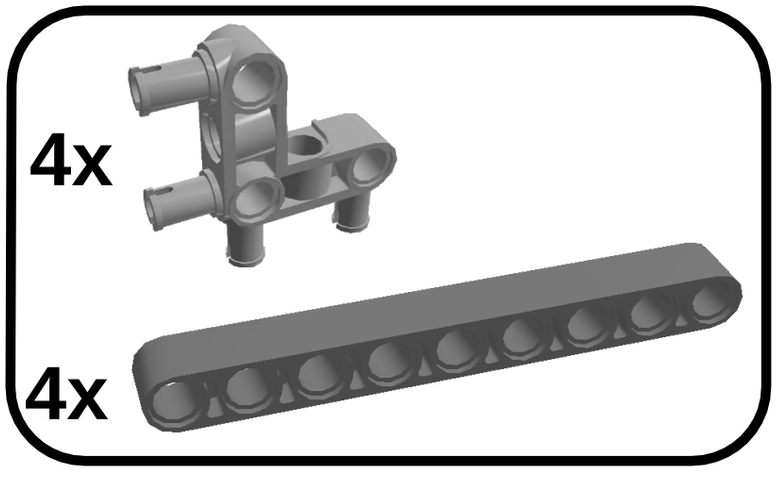


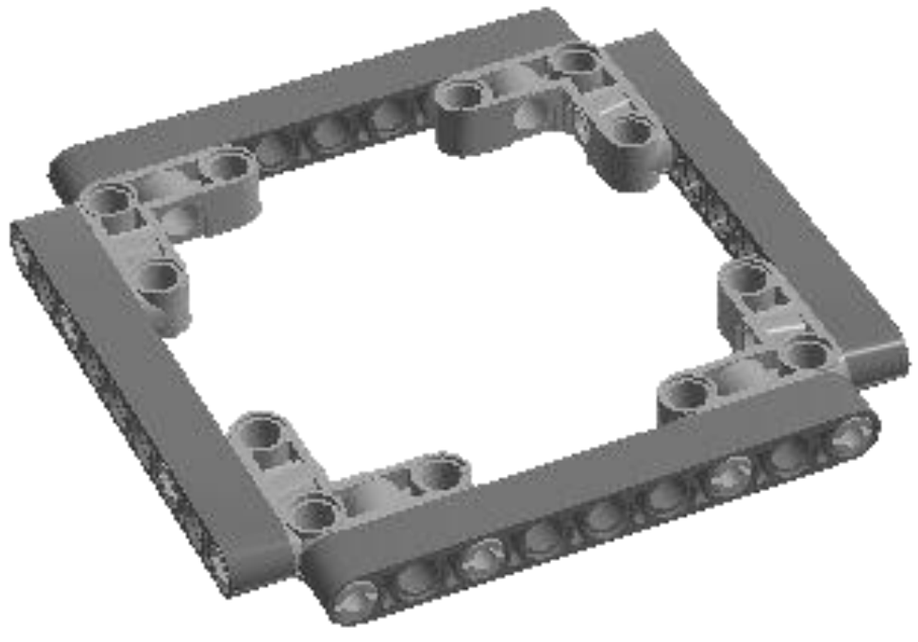
Sturdy Structures

Squares

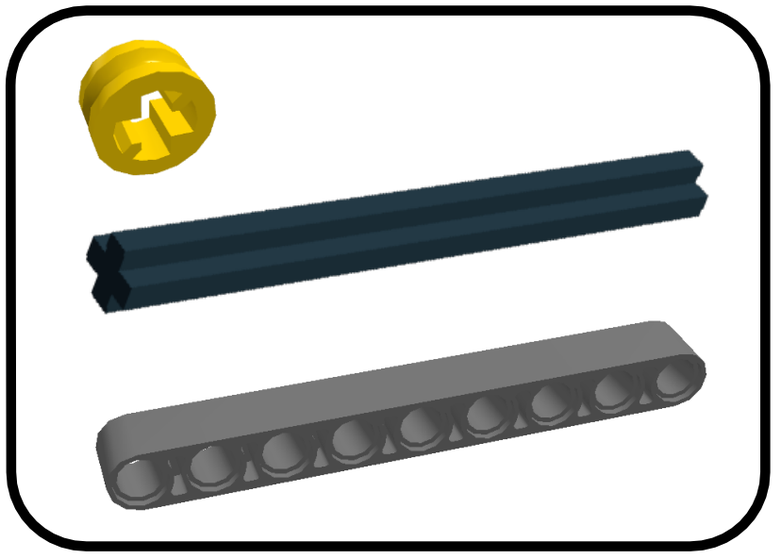


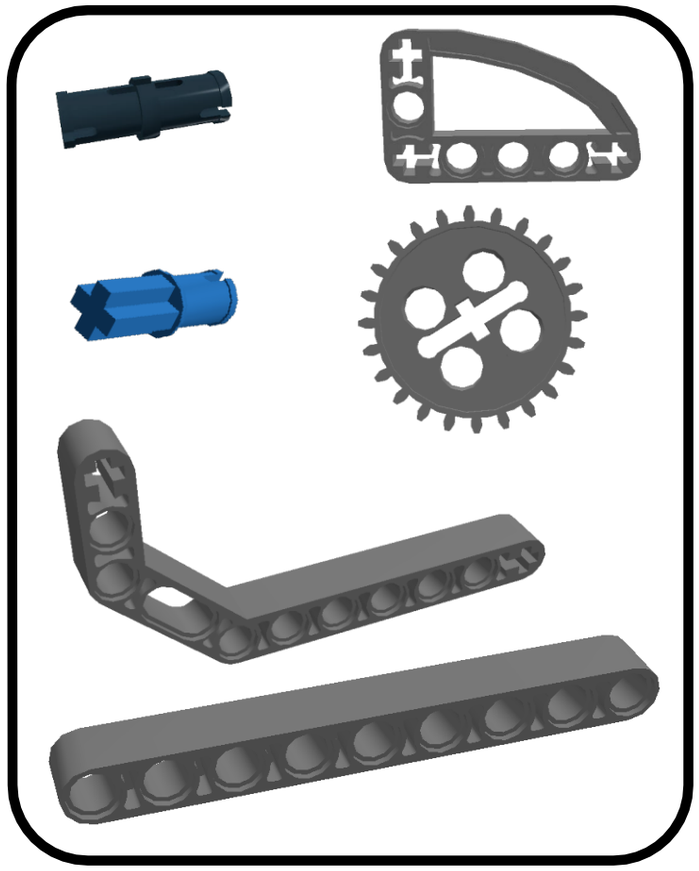


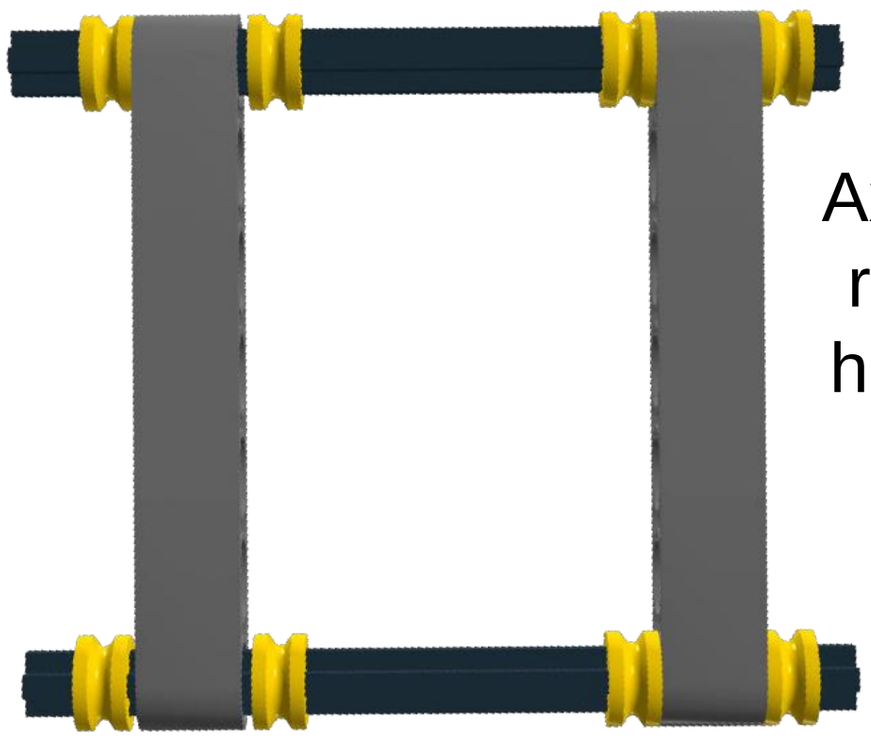




Sturdy Structures

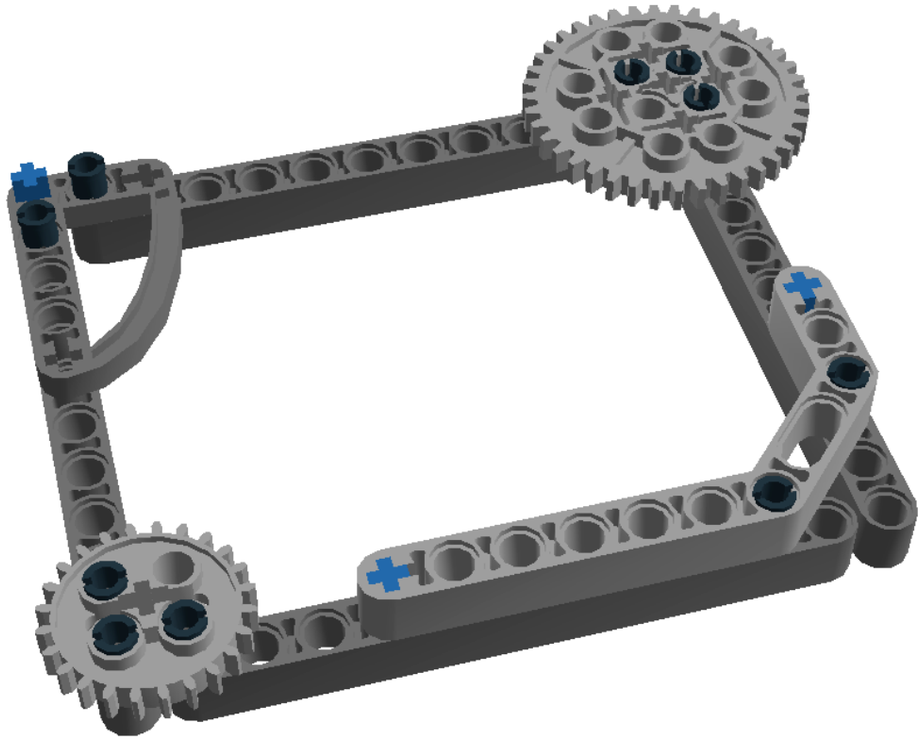






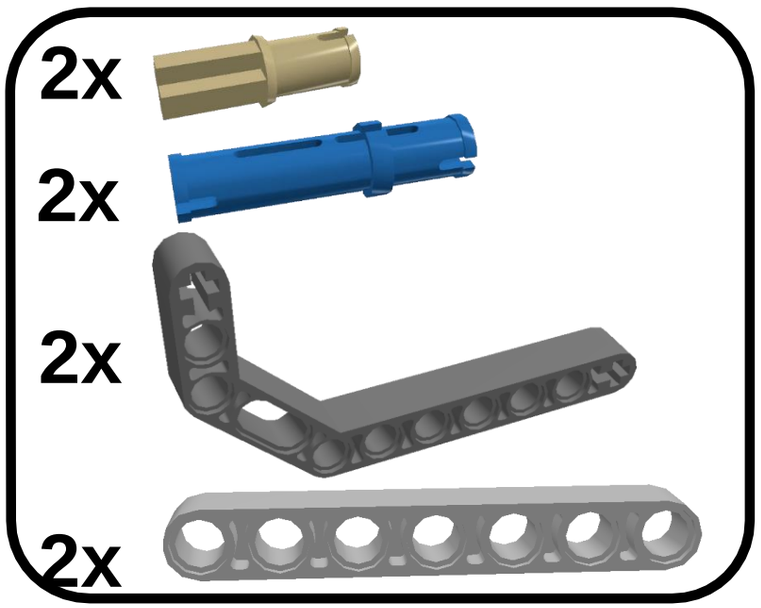
Axles will be free to rotate through the holes in the beams

Other Ways to Reinforce Corners

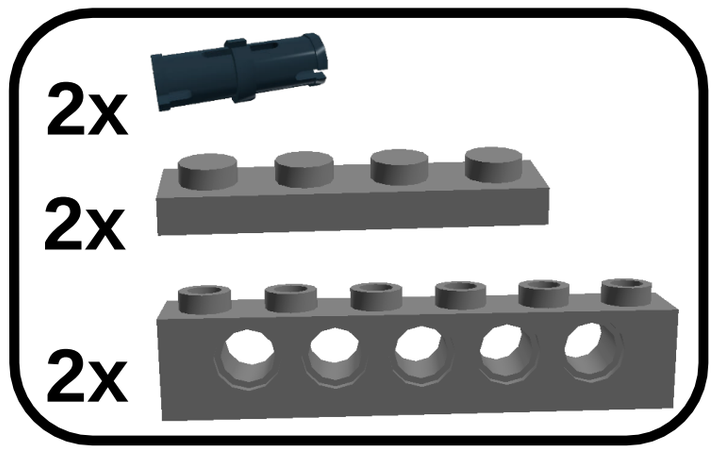


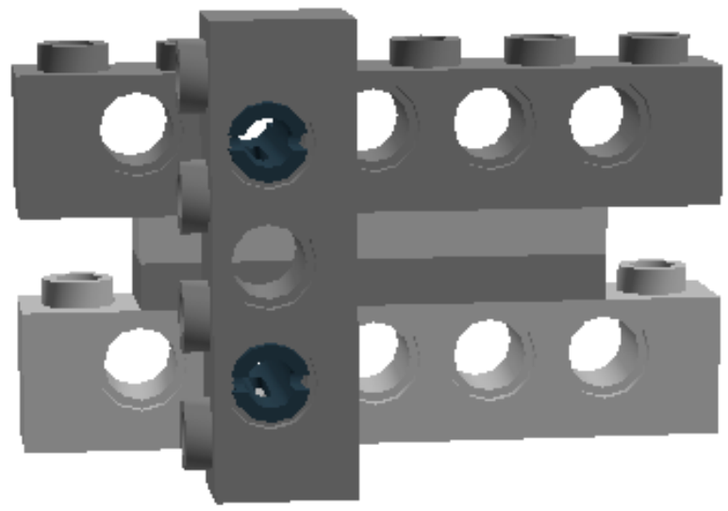
Sturdy Structures

Arch



Bracing With Bricks

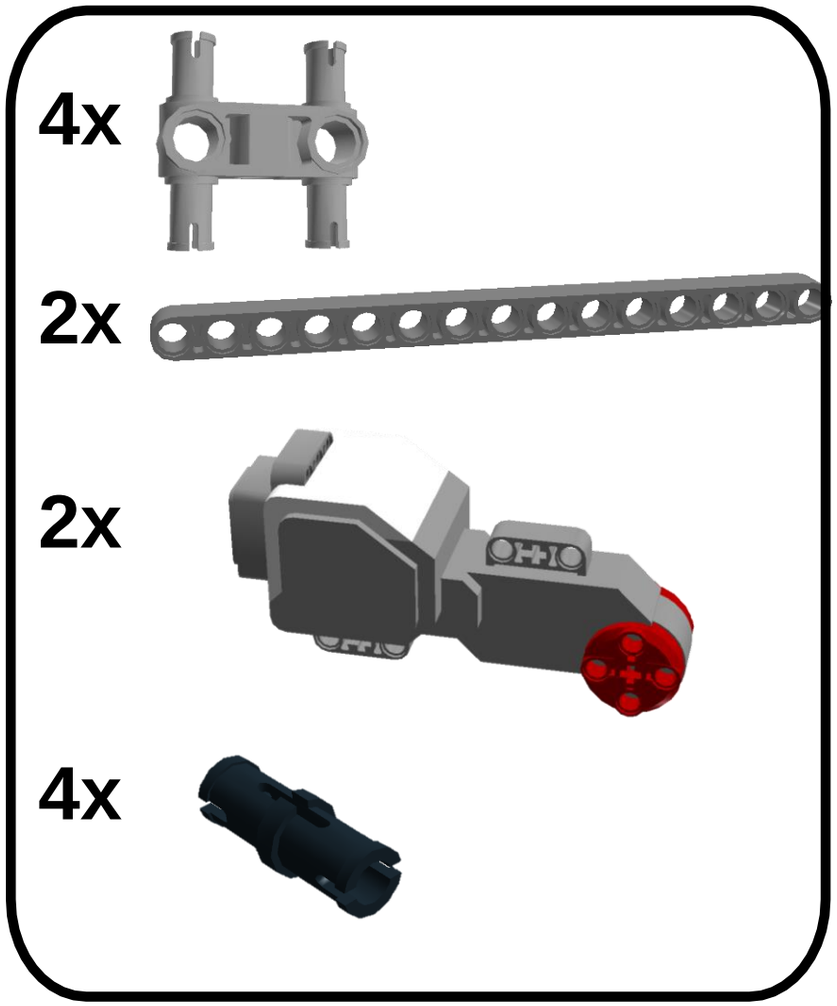




Bracing a stack of bricks in this way will keep the structure more rigid and less likely to break apart

Simple Sturdy Motor Attachments

Two Step Motor Attachment



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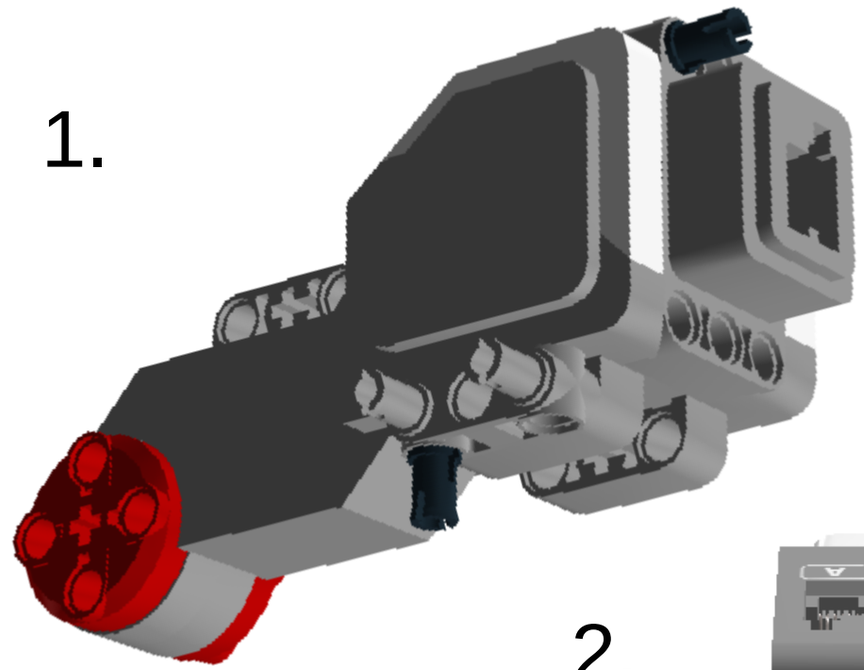

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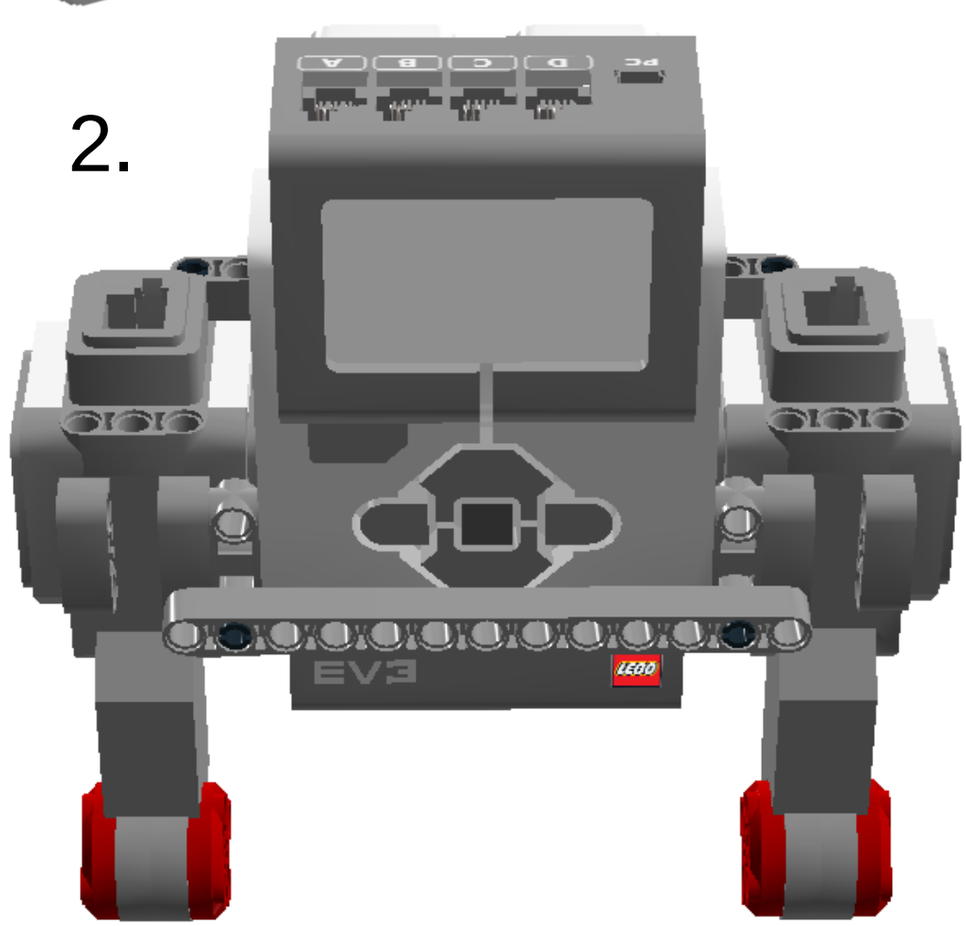
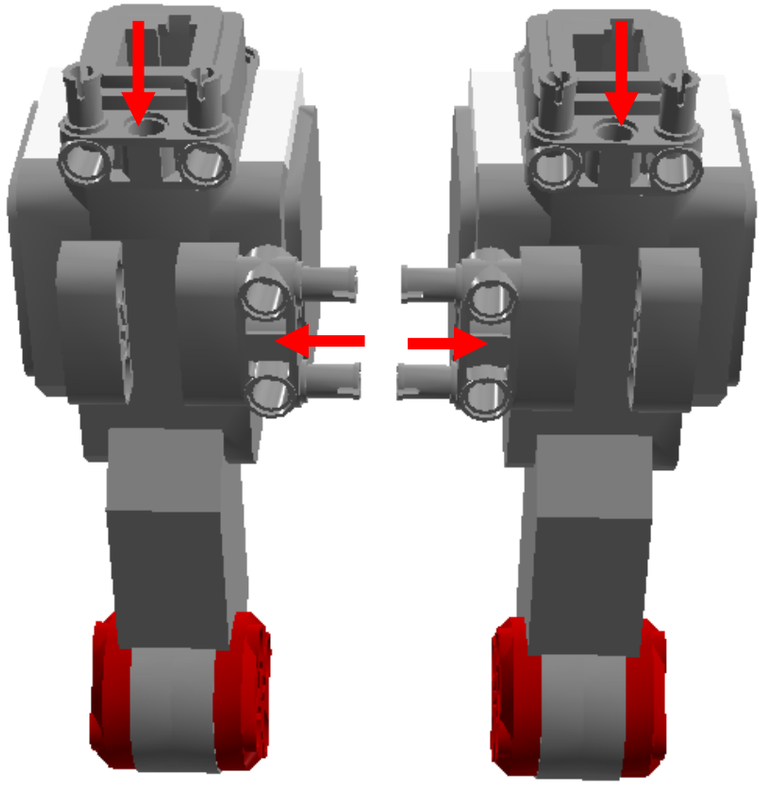
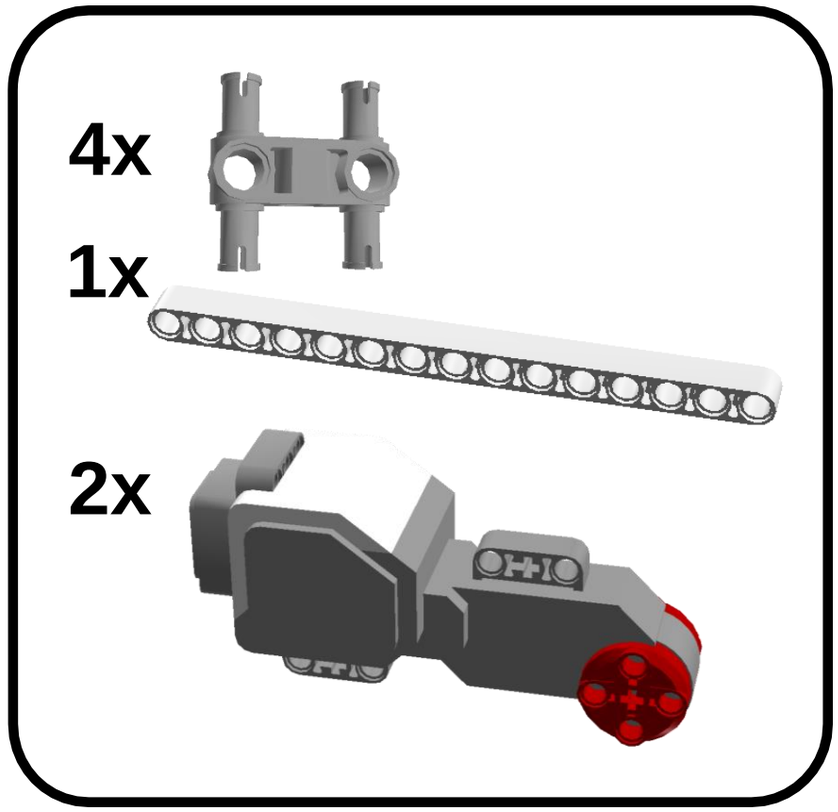


Simple Sturdy Motor Attachments

1.





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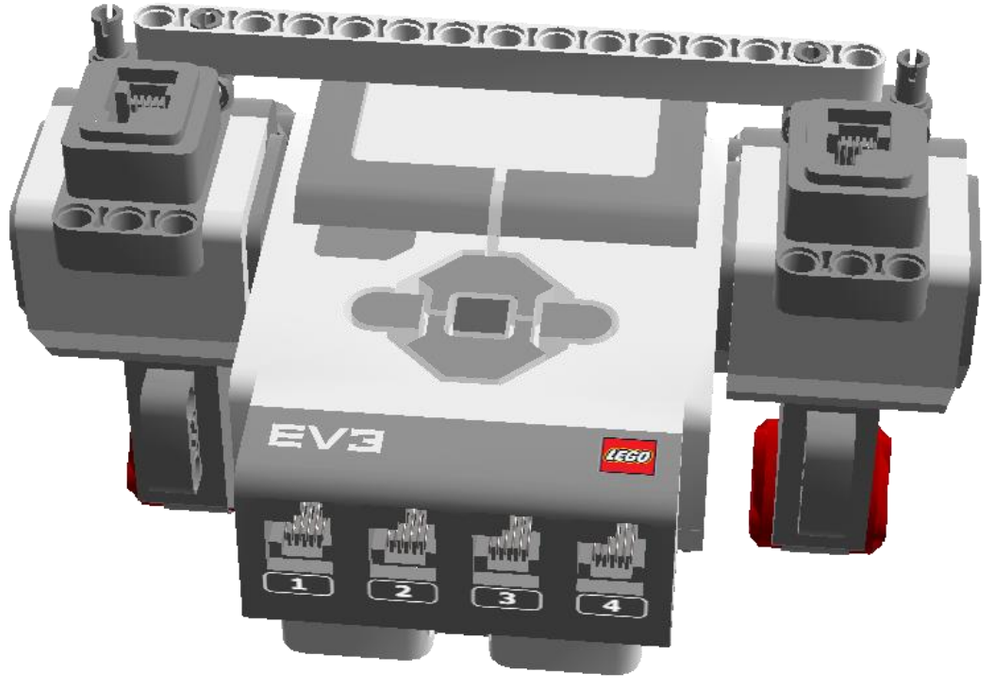
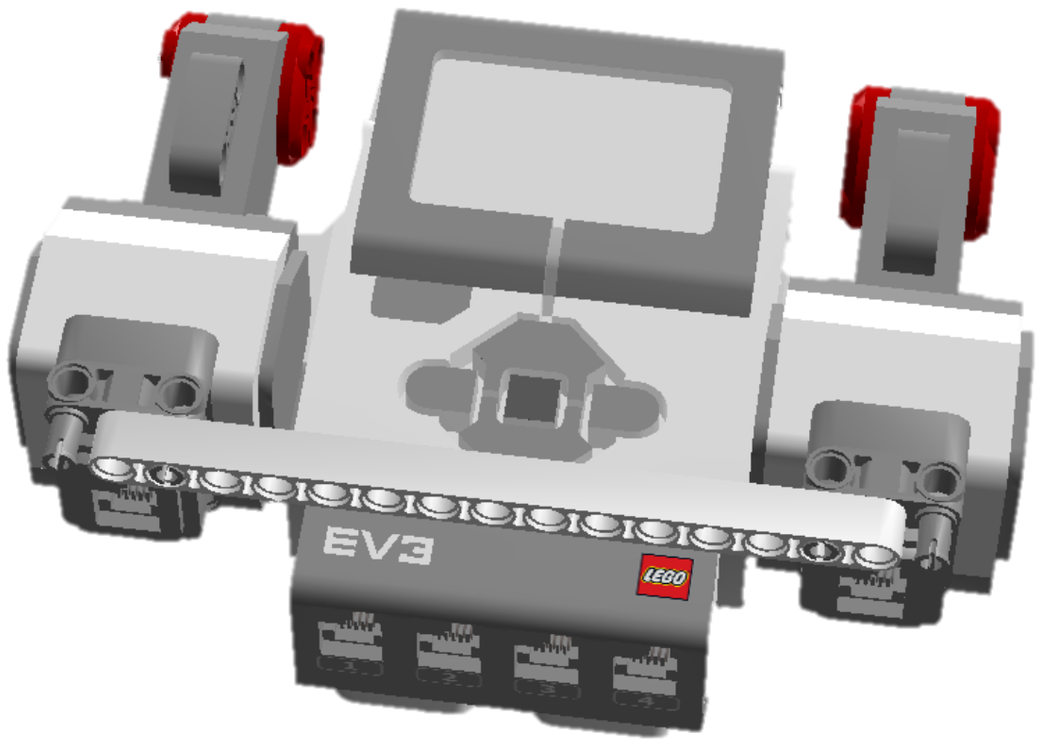


or

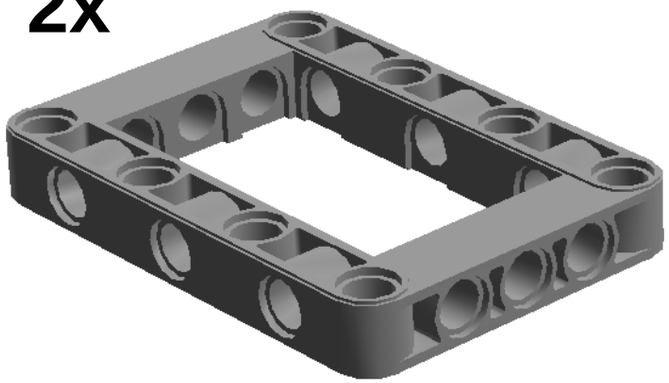


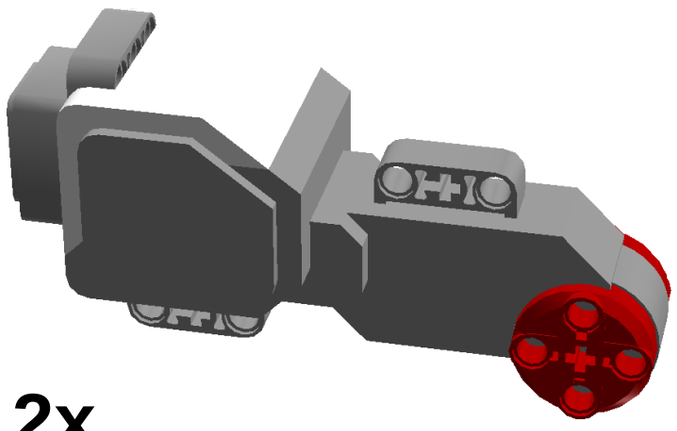
Simple Sturdy Motor Attachments

Wide Back Motor Attachment

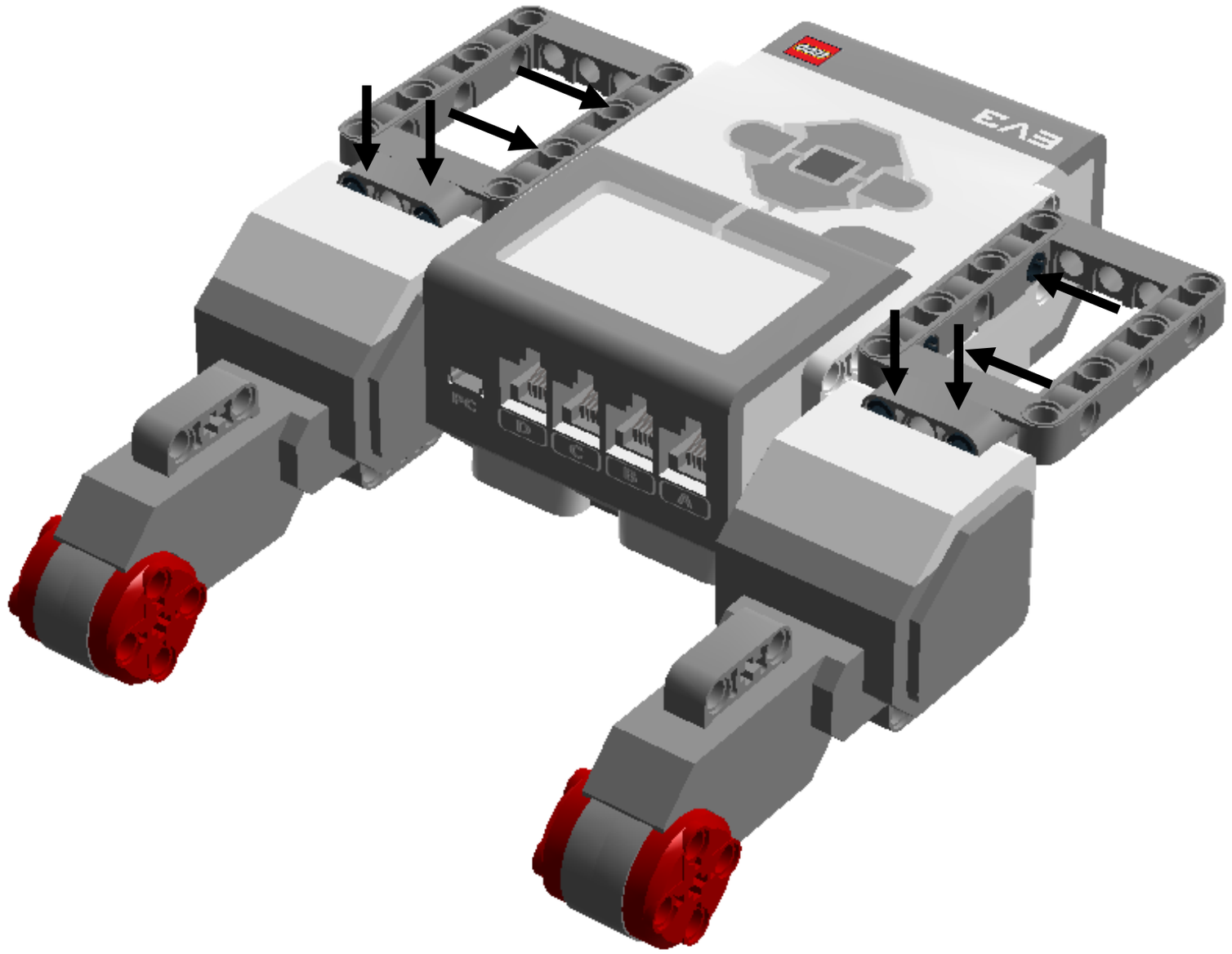
8x

2x



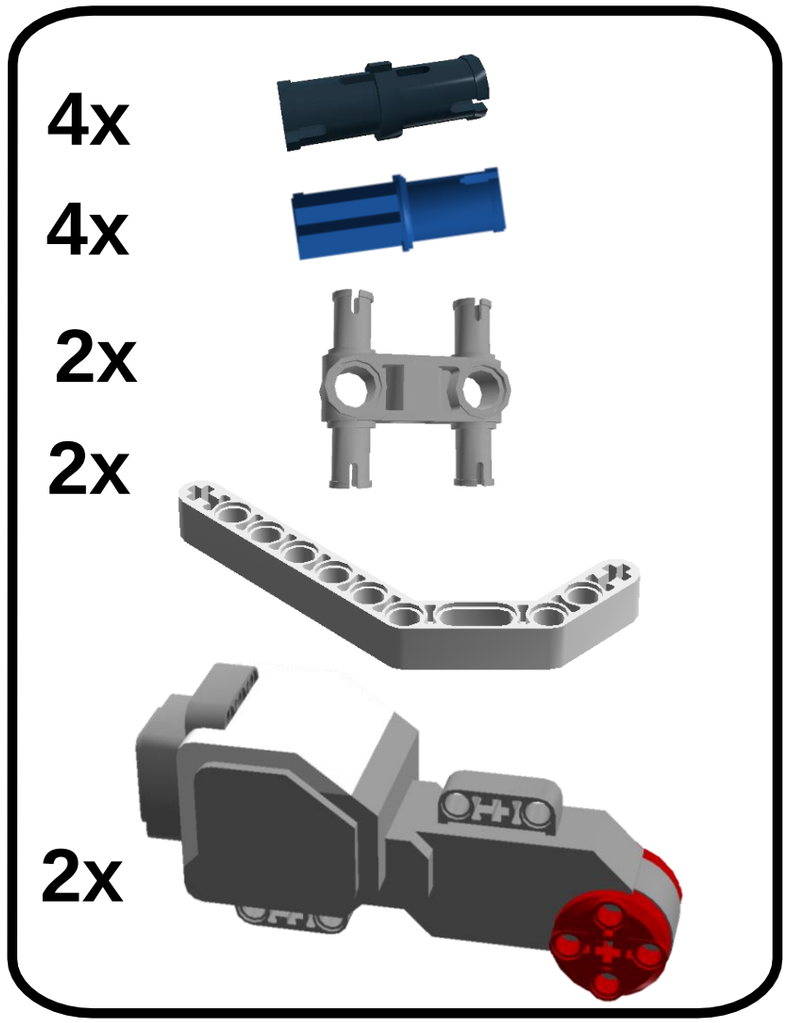


2x

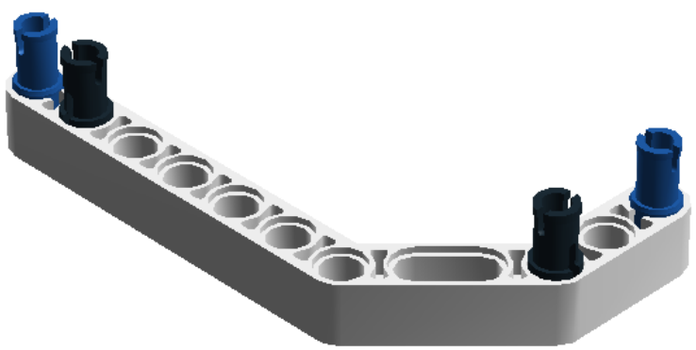


Arrows indicate locations of black pegs

Simple Sturdy Motor Attachments



1.



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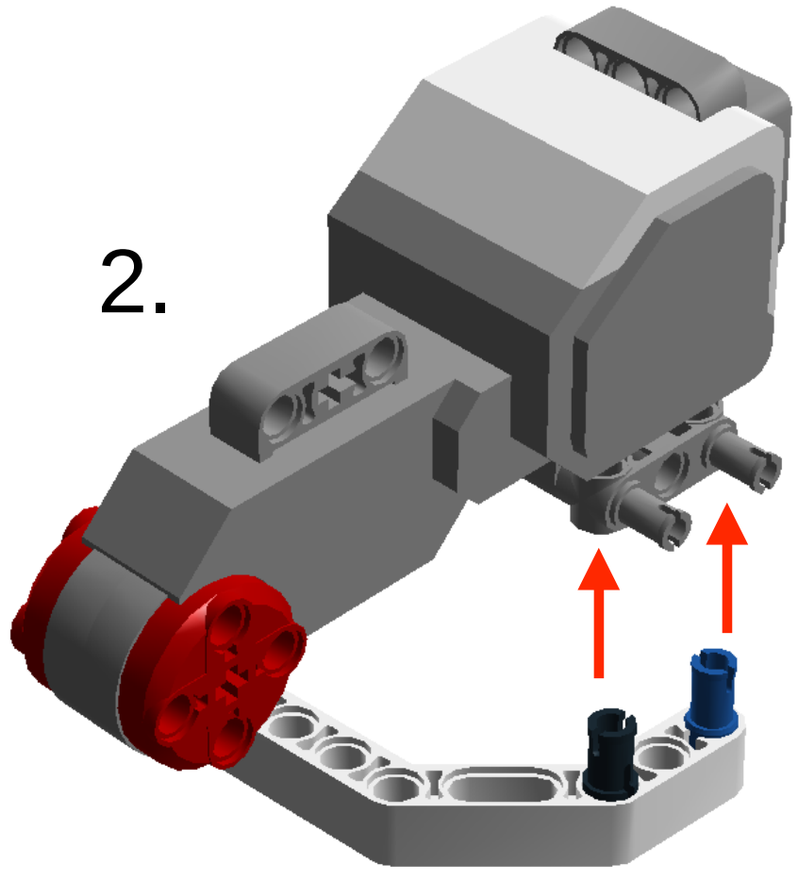
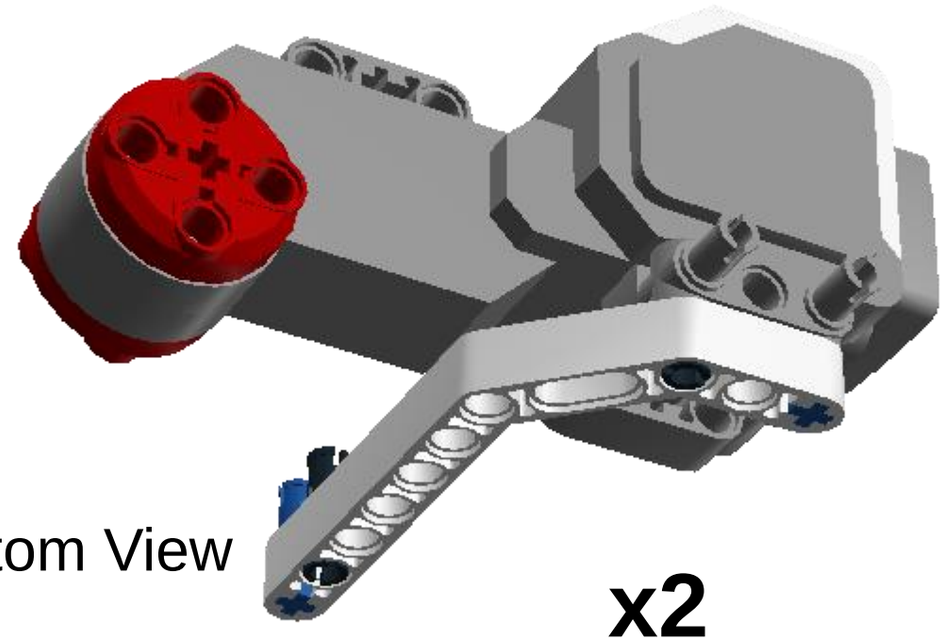


Side View

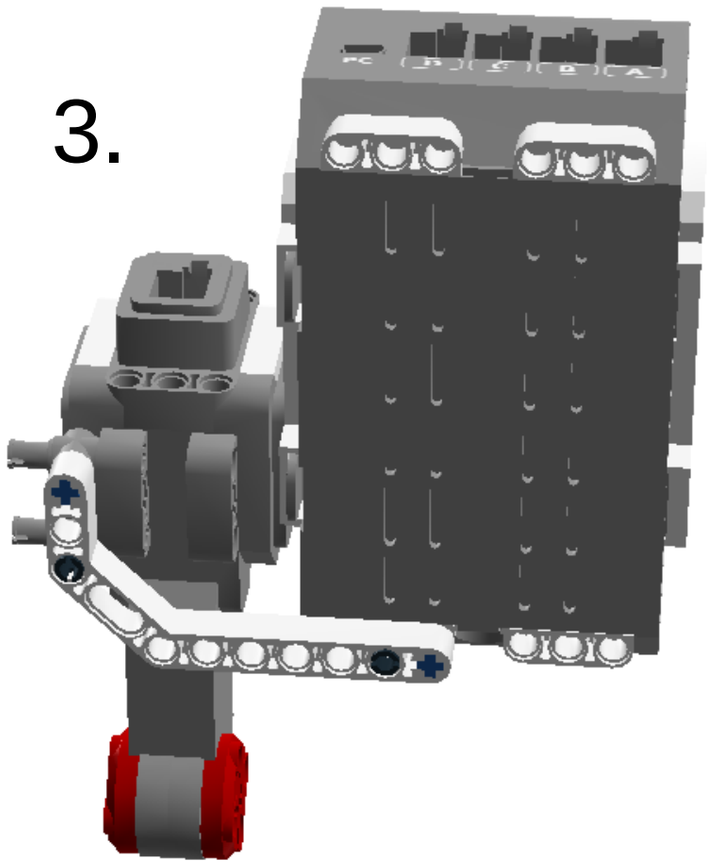


Bottom View

x2

Simple Sturdy Motor Attachments

3.



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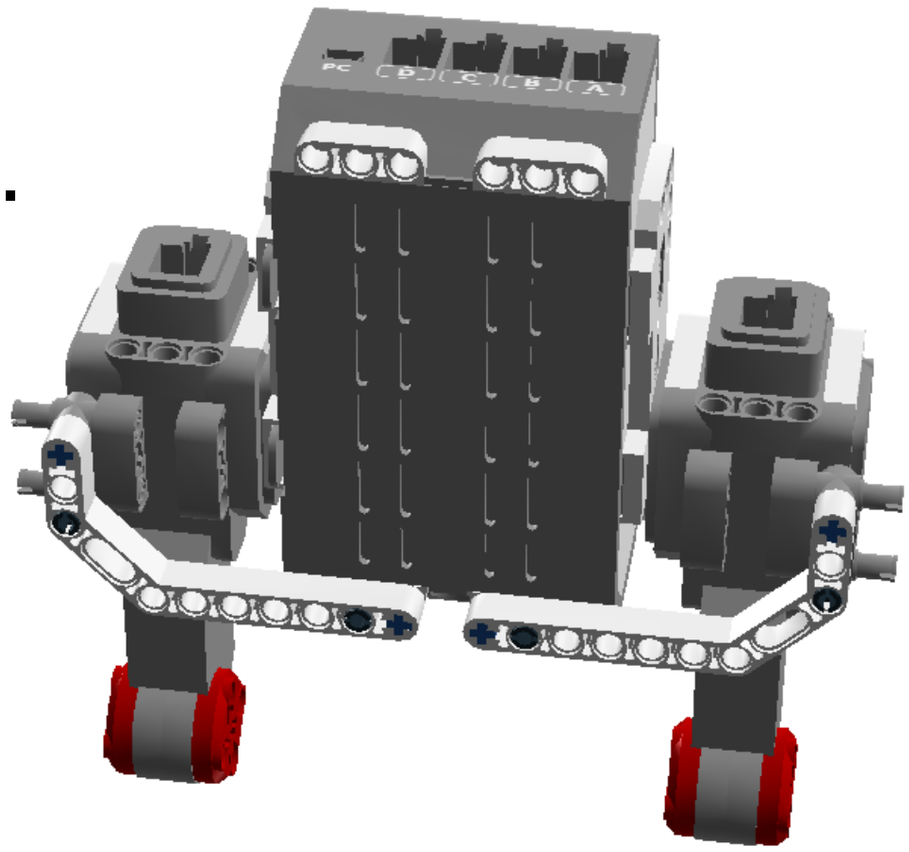
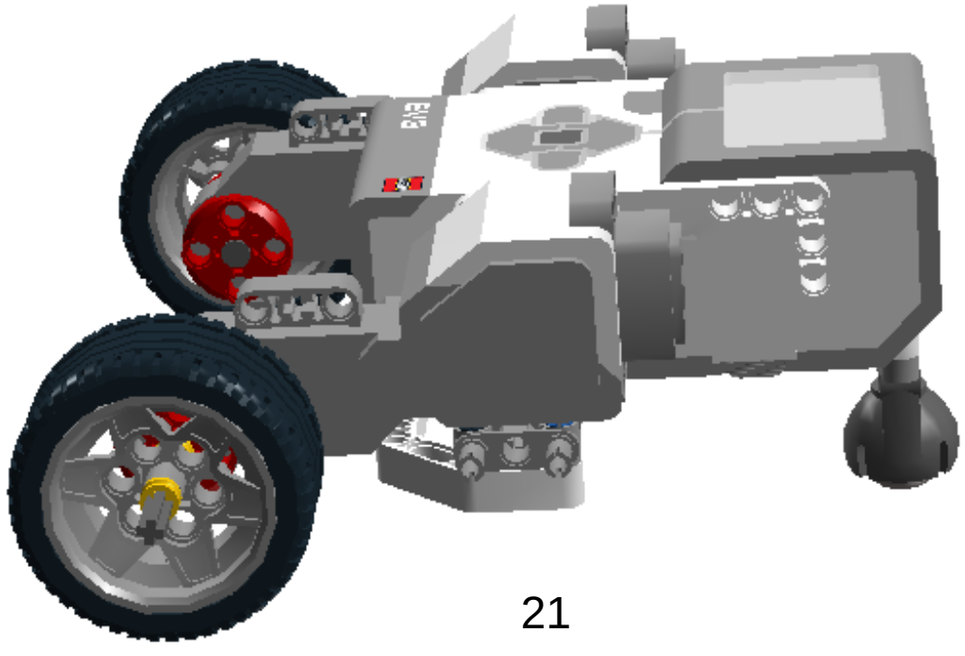


Adding Wheels

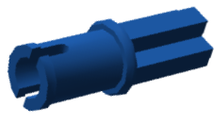


Make sure that you position your wheels so that the brick does not drag on the ground

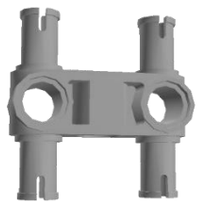
See page 27 for more front end attachments

Simple Sturdy Motor Attachments

Underside Motor Attachment 1

2x 

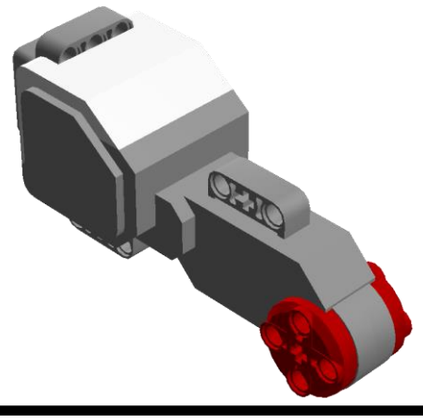
10x 

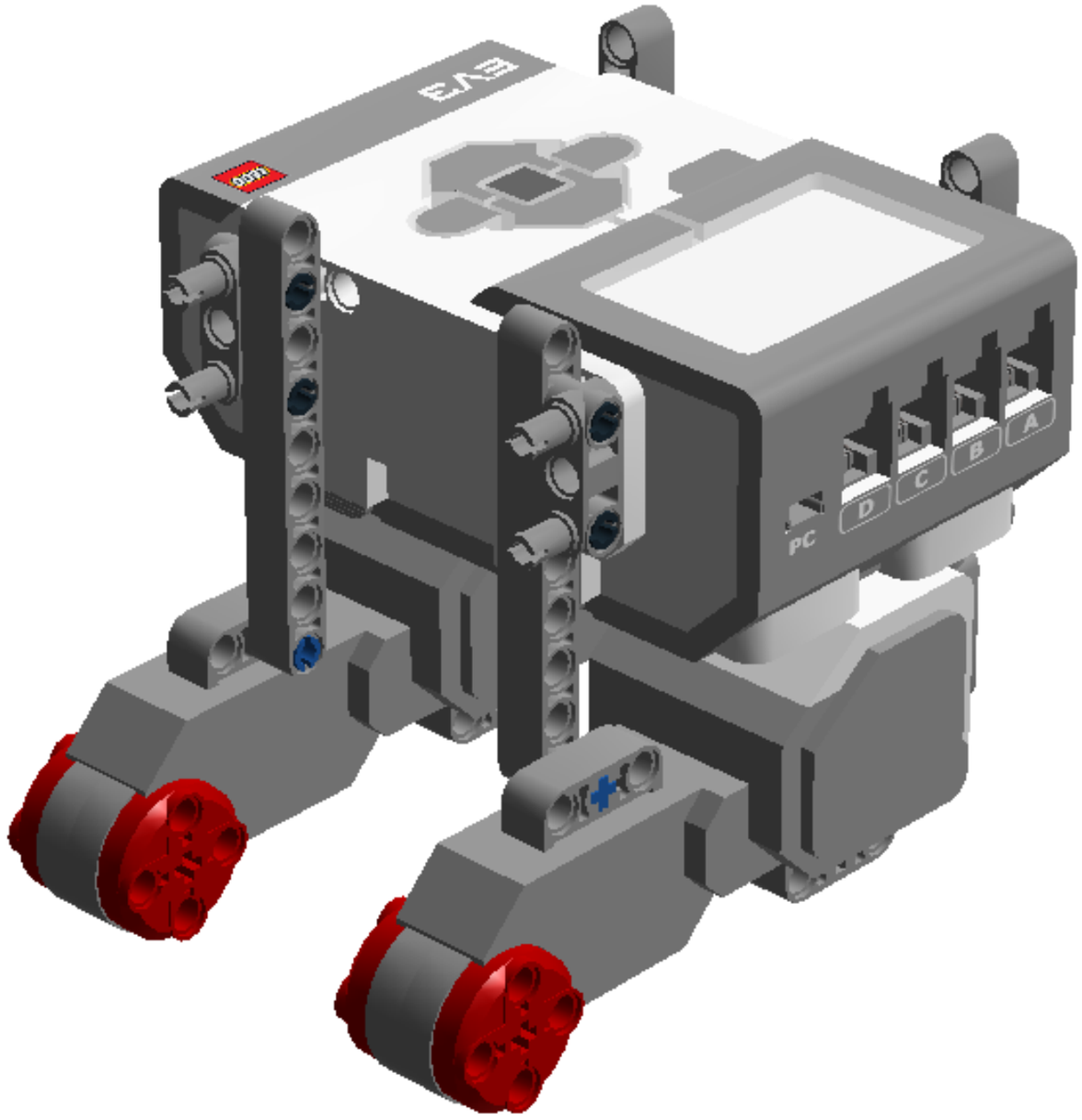
4x 

2x 

2x 

1x 

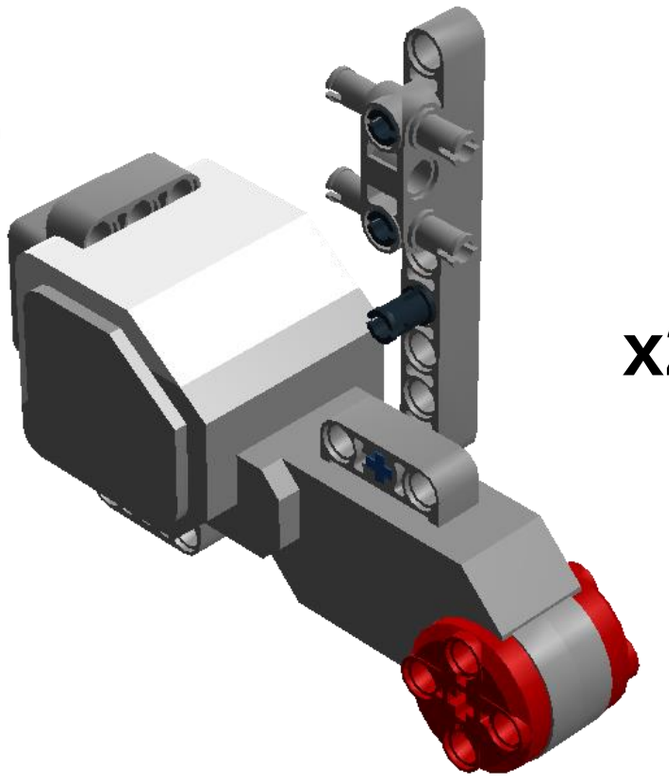
2x 



Simple Sturdy Motor Attachments

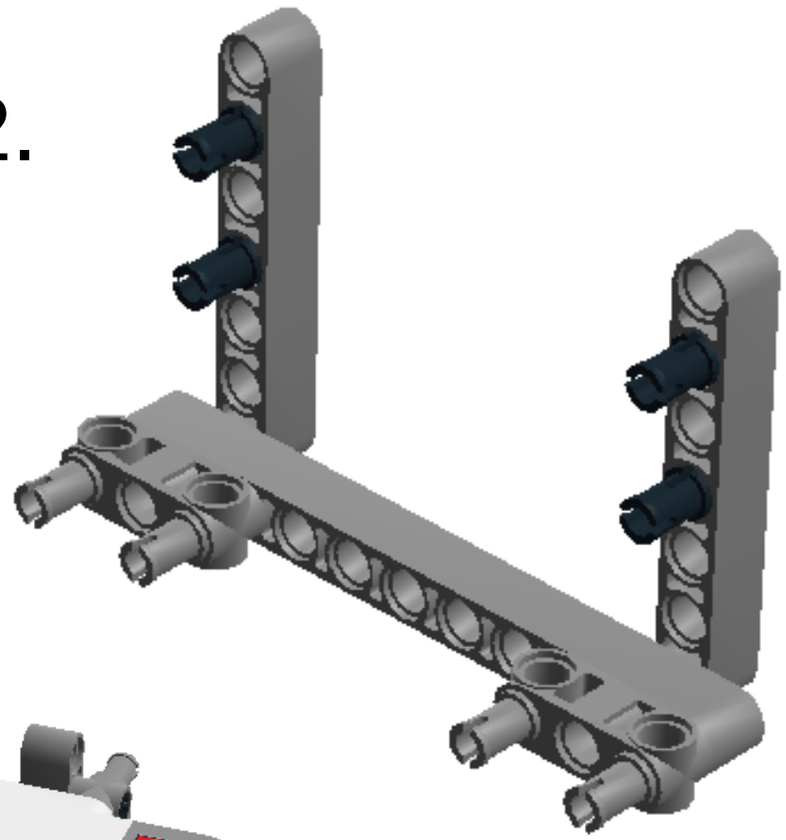
Underside Motor Attachment 1

1.



x2

2.



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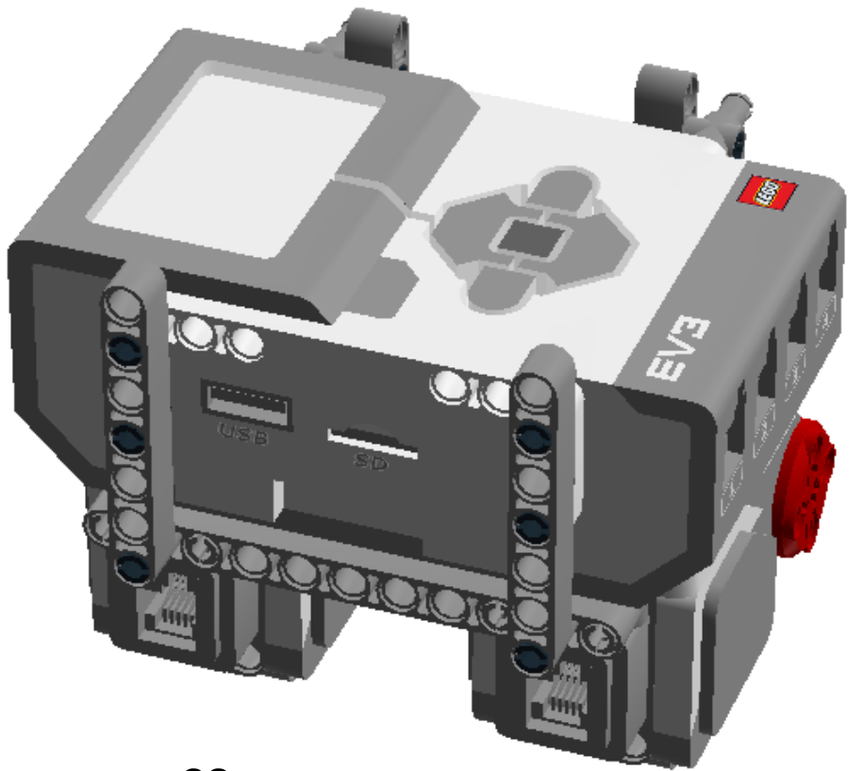
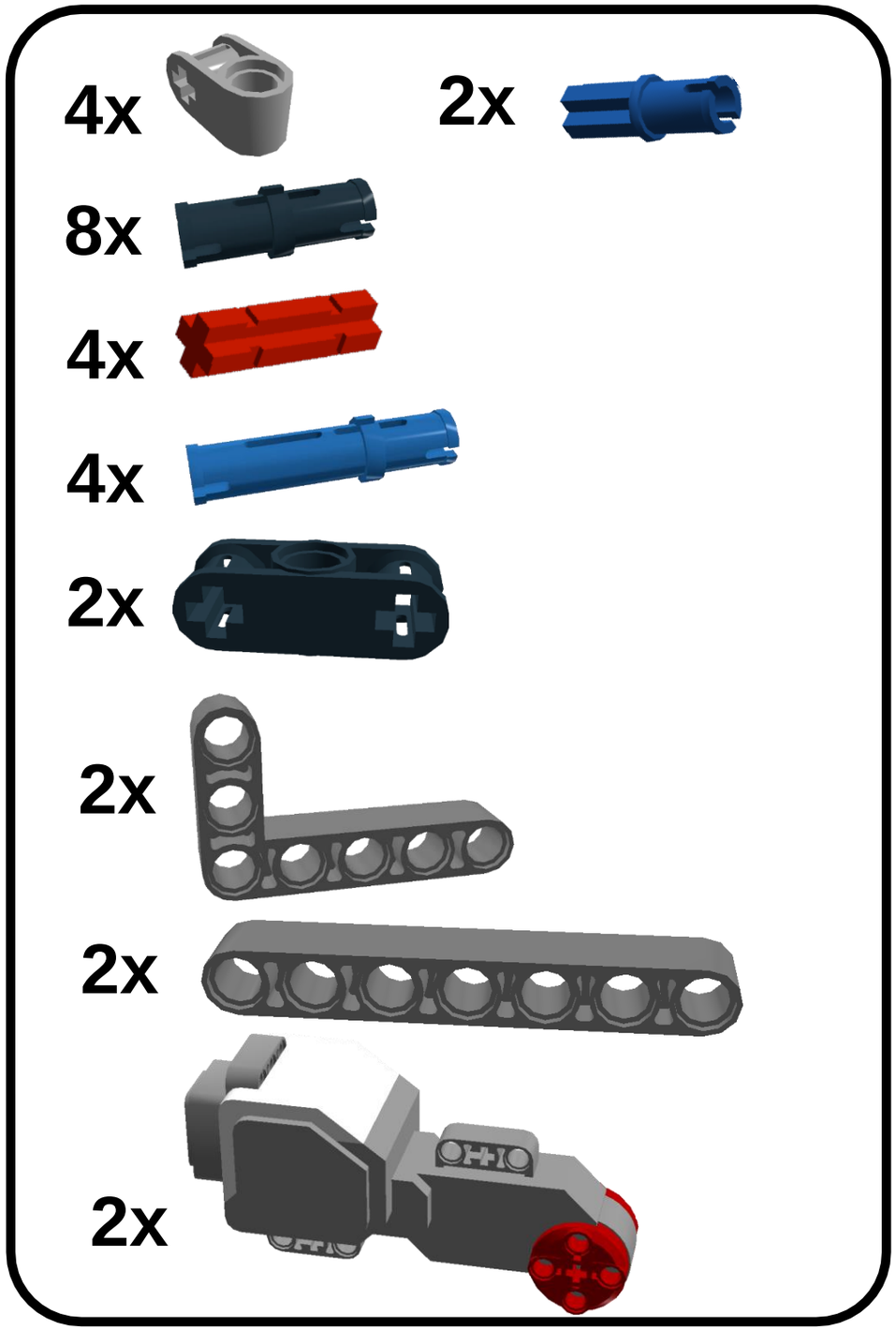
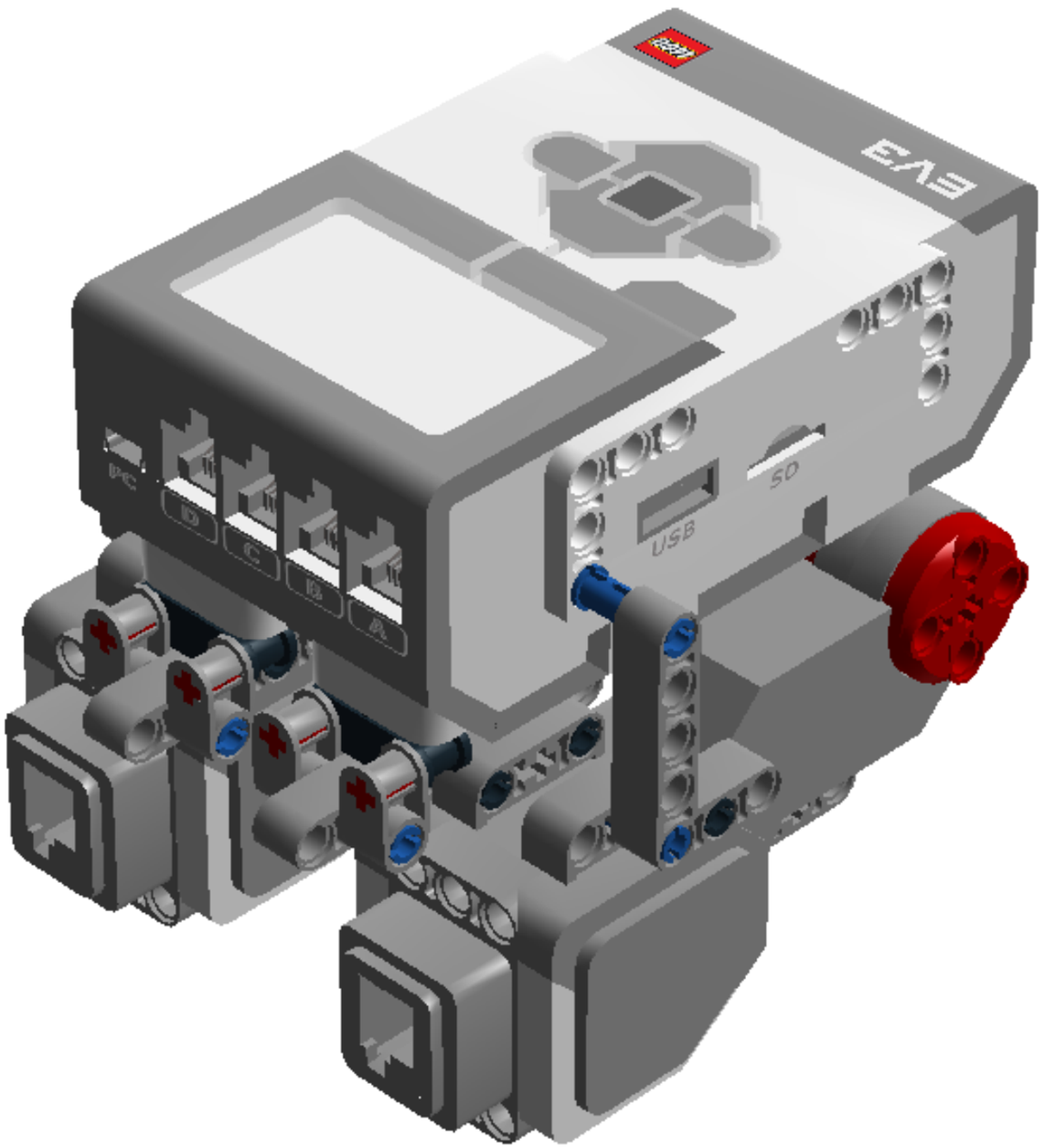


Simple Sturdy Motor Attachments

Underside Motor Attachment 2

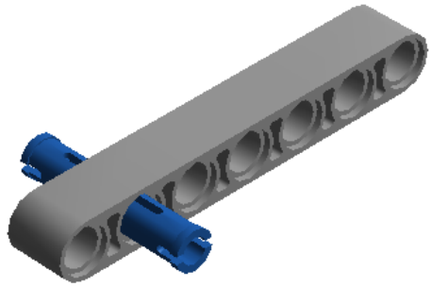




Simple Sturdy Motor Attachments

Underside Motor Attachment 2

1.



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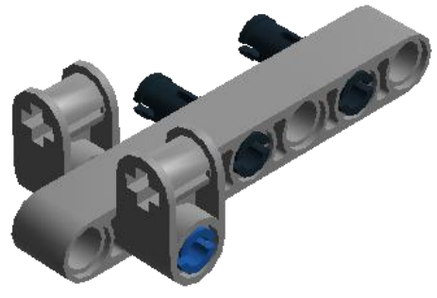

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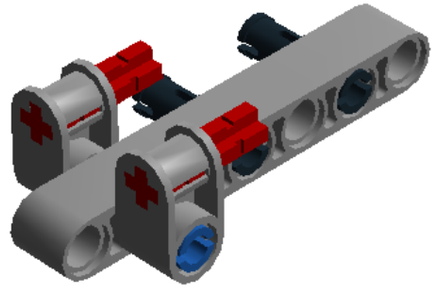
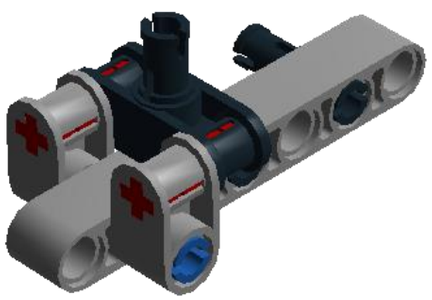
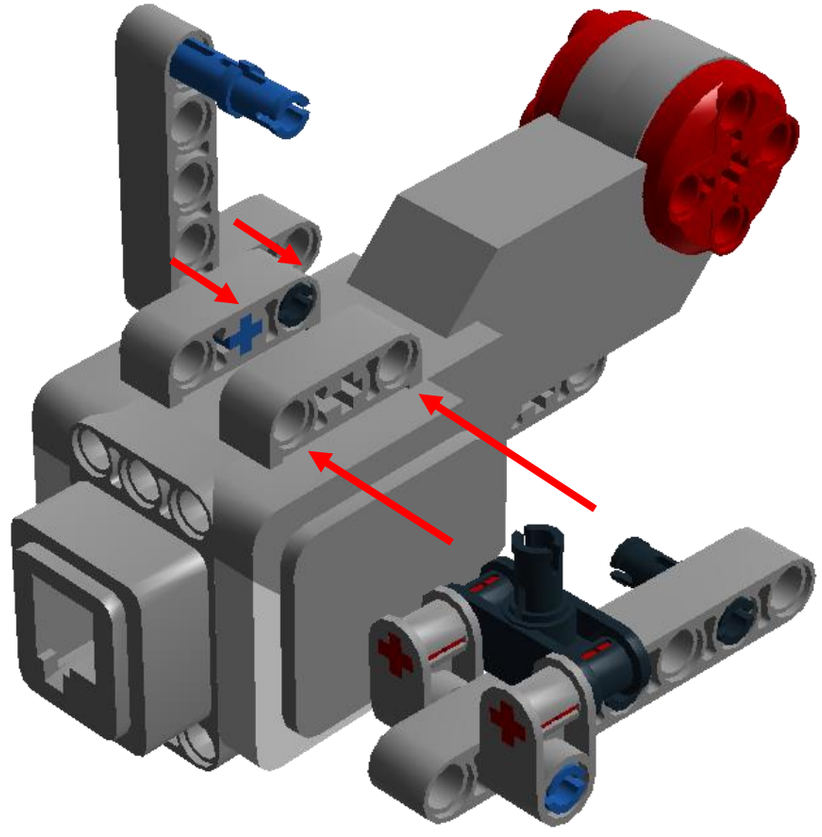


4.



5.

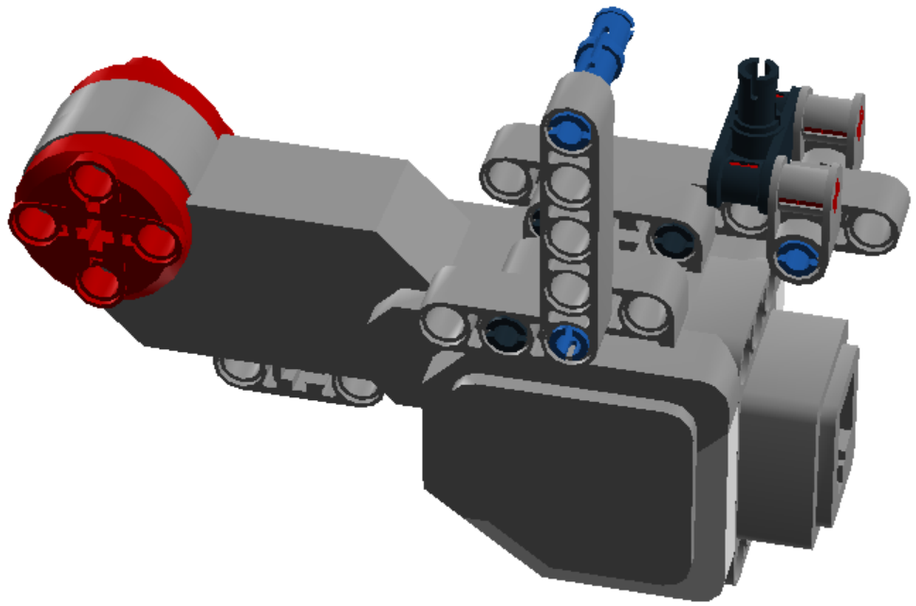
6.



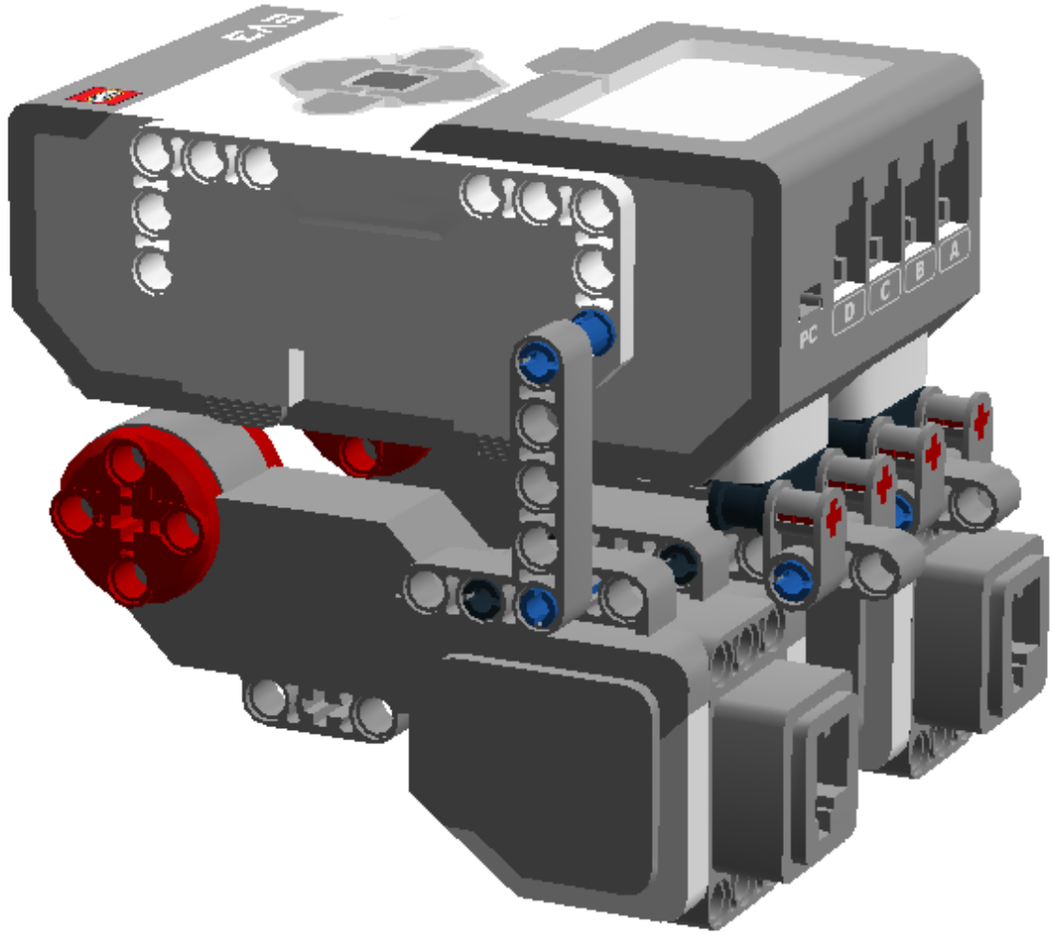
Repeat steps 1-6 for the second motor

Underside Motor Attachment 2

6.



7.



Simple Sturdy Motor Attachments

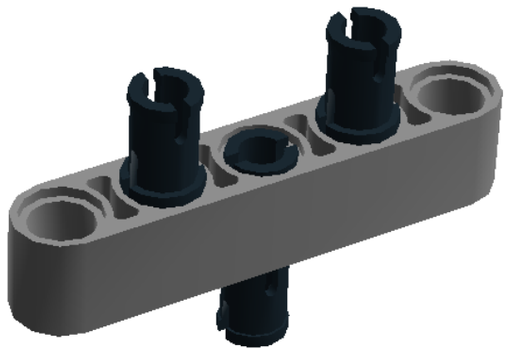
Front End Attachments: Caster Ball

3x

1x

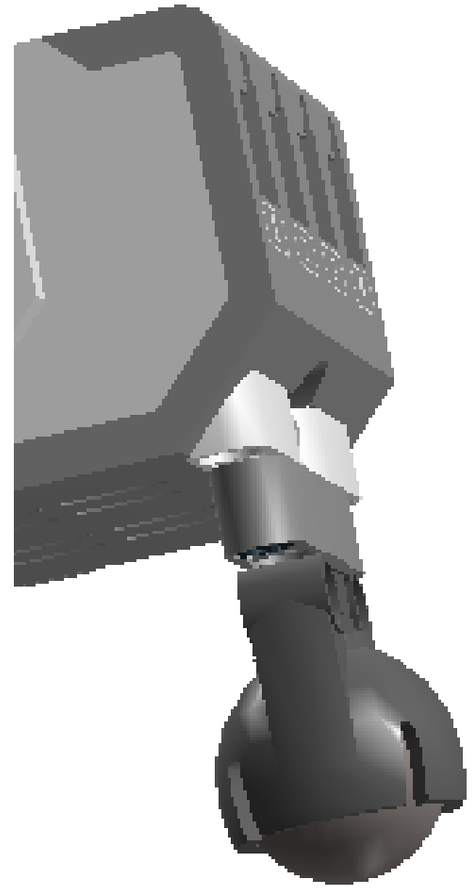
1x

1.



2.

3.

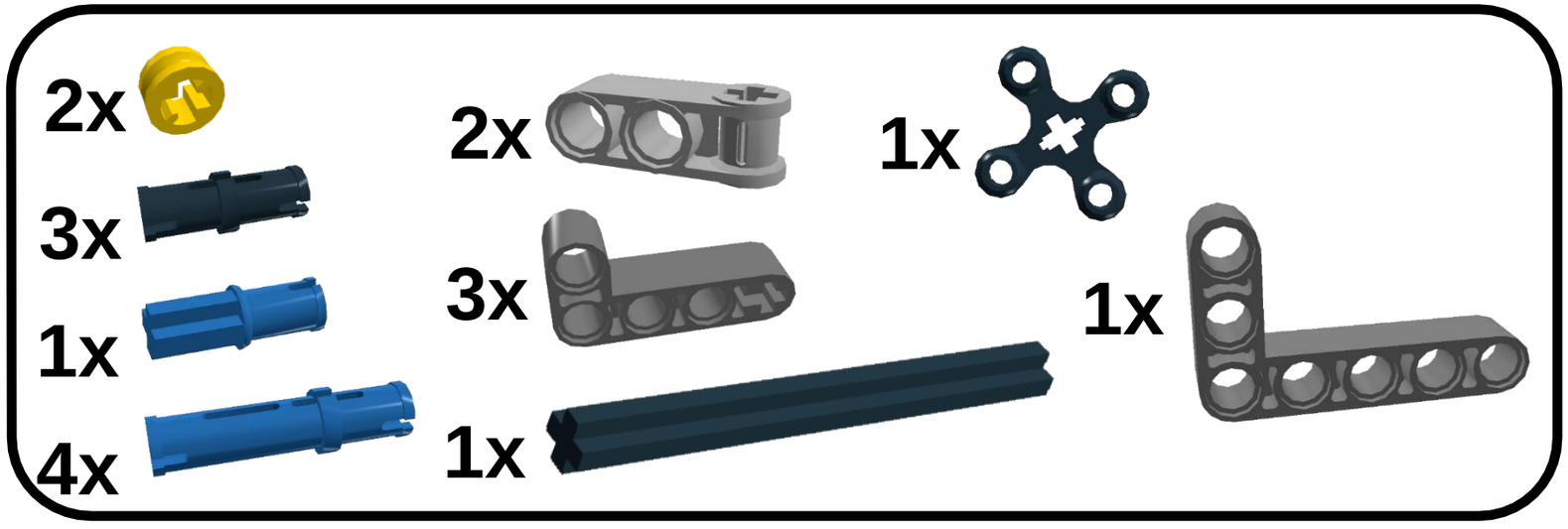


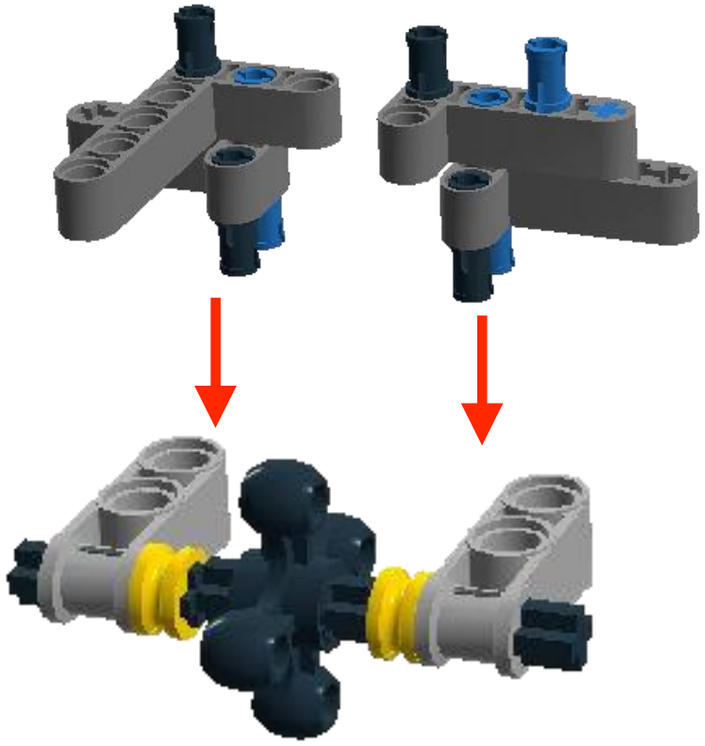
For increased stability, increase the number of points of attachment by using more pegs

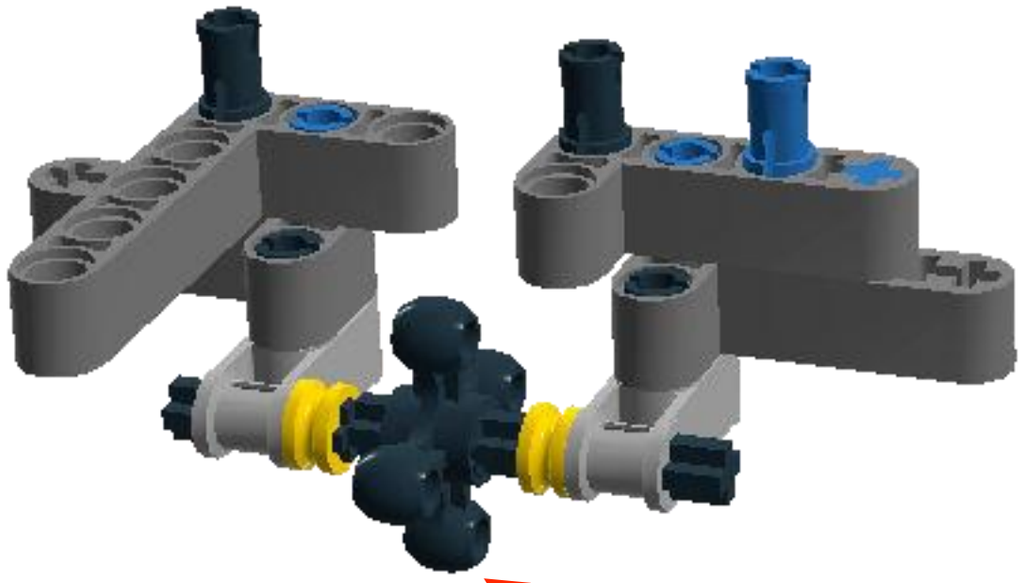
Simple Sturdy Motor Attachments

Other Front End Attachments

Sliding Front



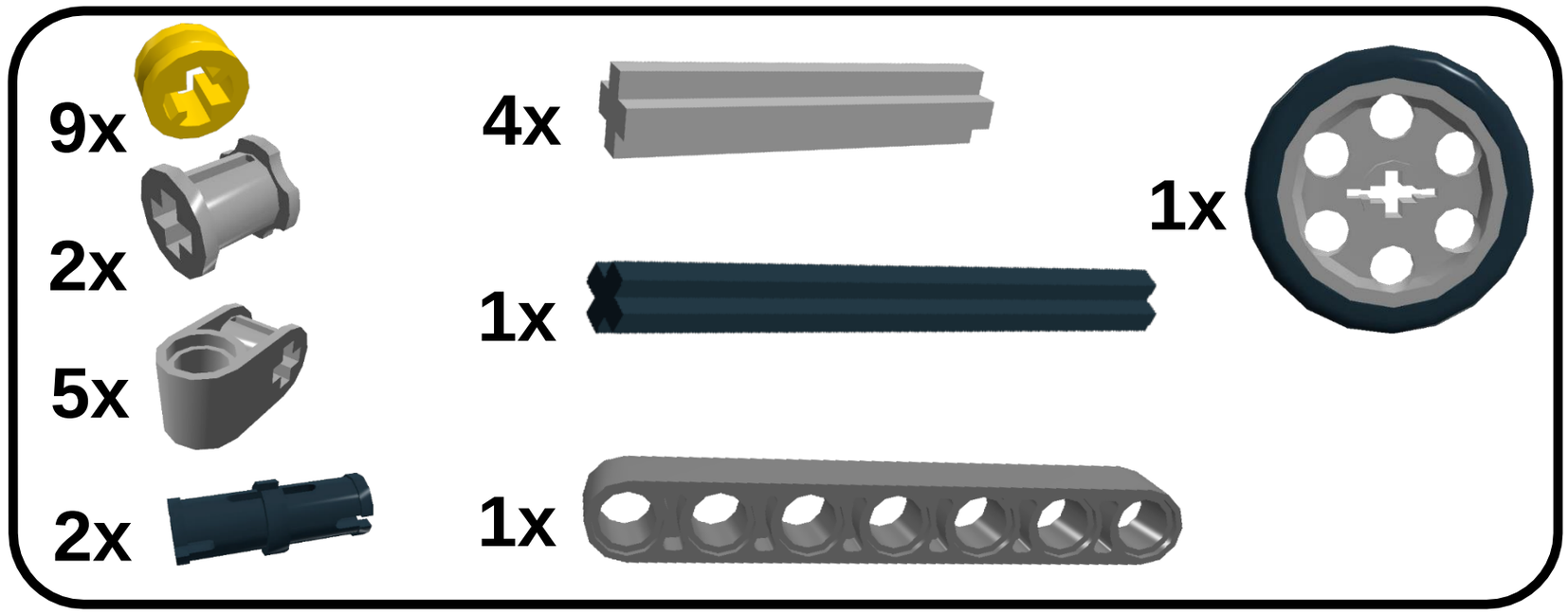




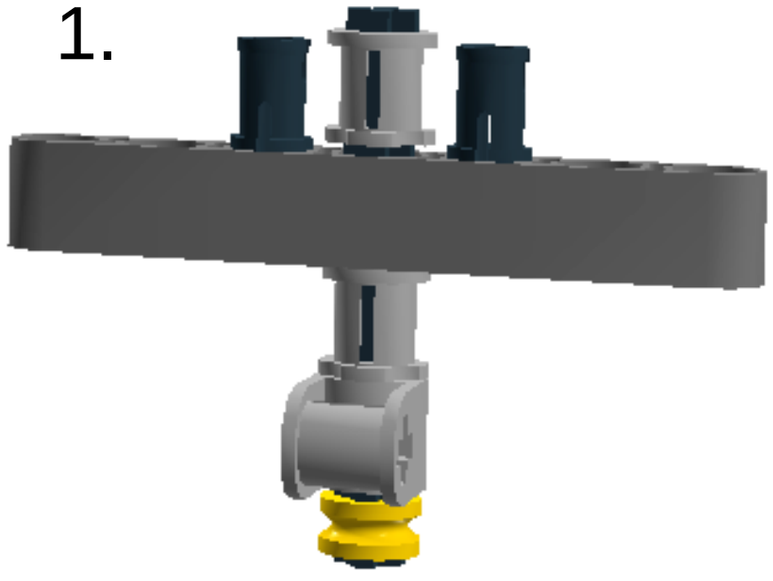
The knob wheel will slide along the ground allowing the car to turn without using a wheel

Simple Sturdy Motor Attachments

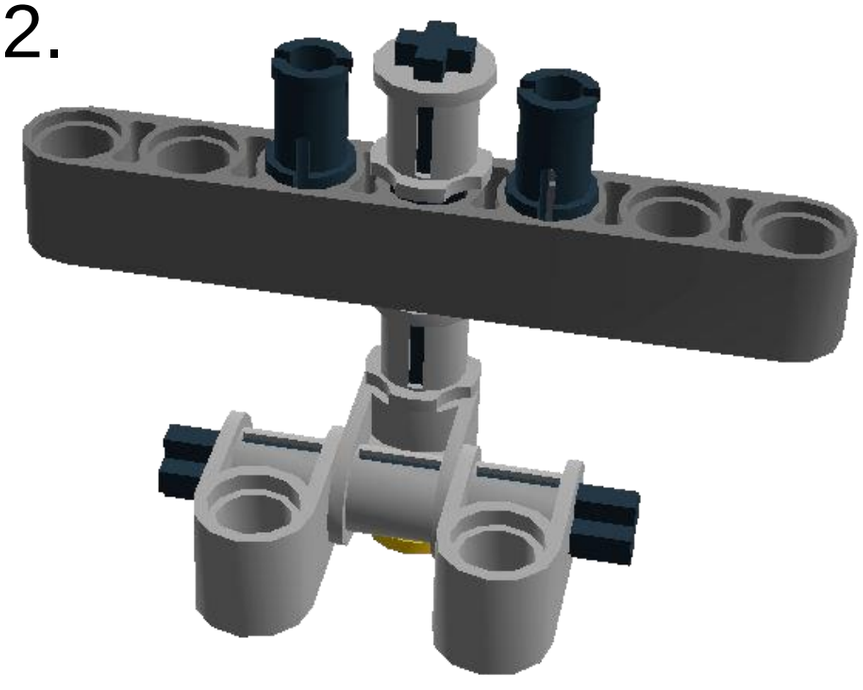
Swiveling Front



1.

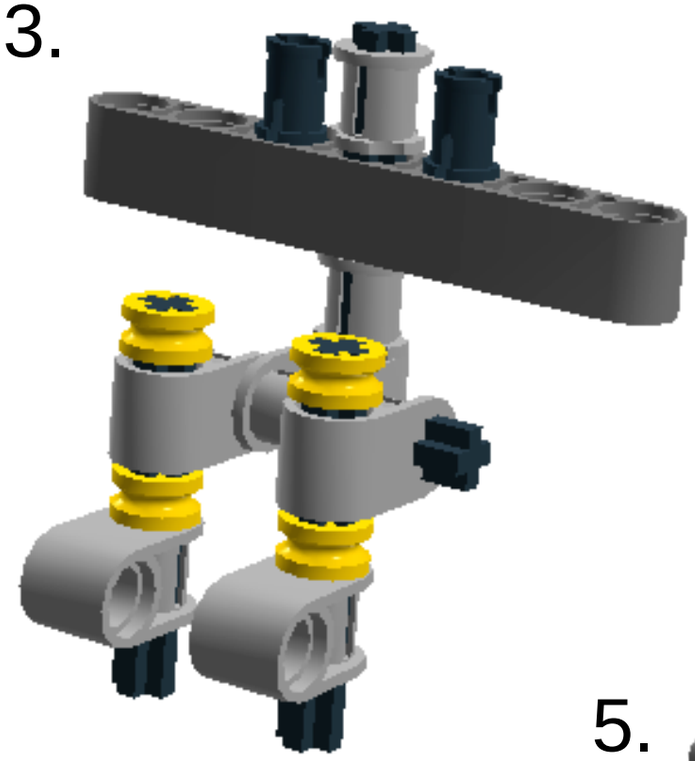


2.



Simple Sturdy Motor Attachments

3.



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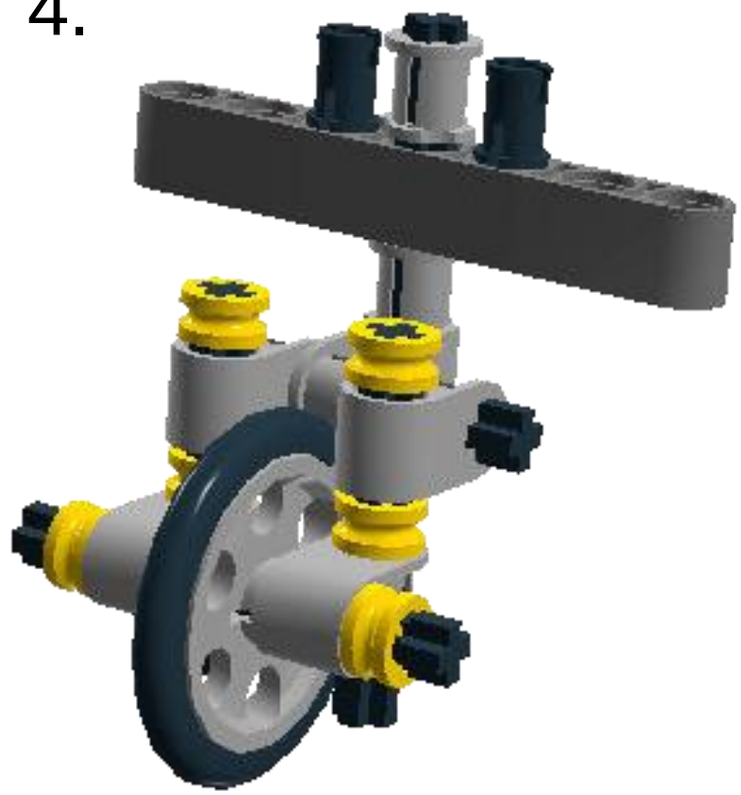
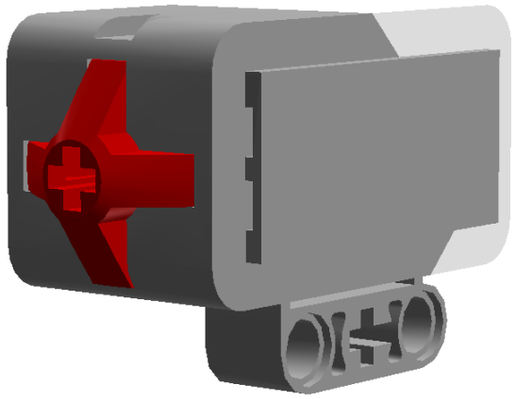


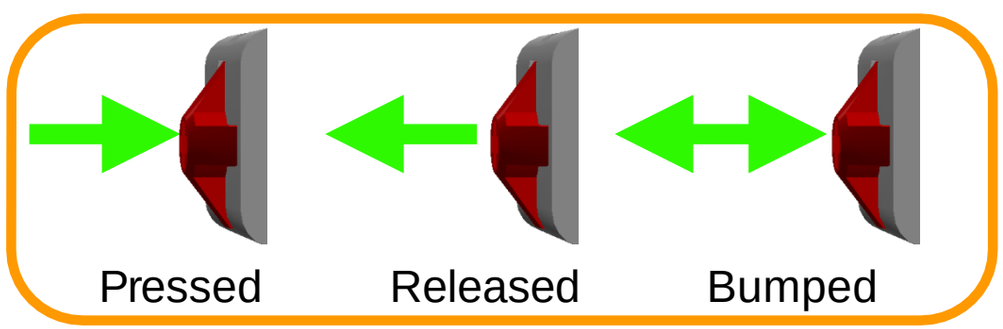
5.

EV3 Sensors

Touch Sensor

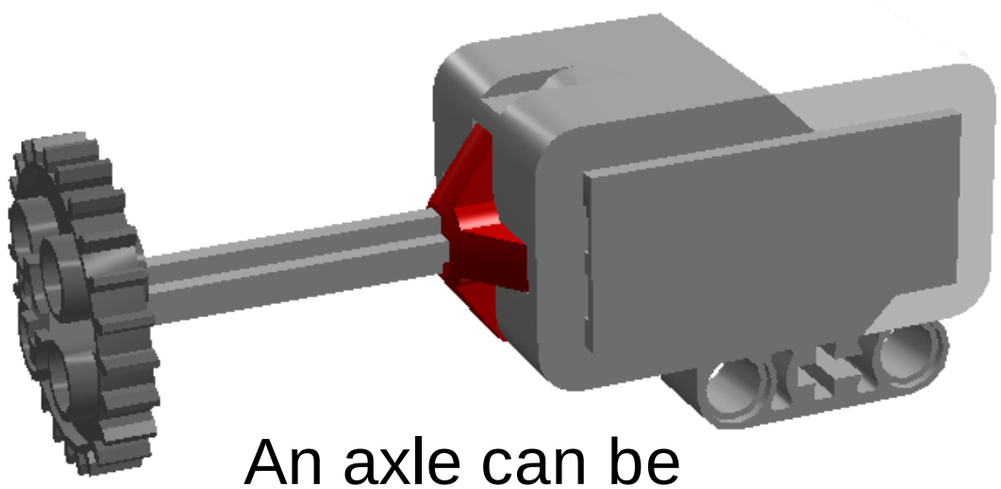


- Acts as a switch
- Can be activated when it is pressed, released or bumped



<u>Useful for</u>

- Changing direction when an obstacle is bumped into
- An On/Off switch



An axle can be inserted in the touch sensor to increase the range of touch

EV3 Sensors

Gyro Sensor

- Detects the rate of rotation on a plane
- Using the rate of rotation, the sensor can also detect angle rotated
- Works best when side with curved arrows is perfectly parallel to the plane of rotation

<u>Useful for</u>

- Measuring the rate of rotation of a robotic arm
- Measuring the total angle a car rotates during a turn

When using the Gyro sensor, always be sure to calibrate it.
To calibrate the Gyro sensor first placing your creation on a table and then gently unplugging the Gyro sensor from the EV3 at the brick connection and then plugging it back in to the same port.

EV3 Sensors

Color Sensor

- Detects different levels of ambient light as well as the light intensity of different colors

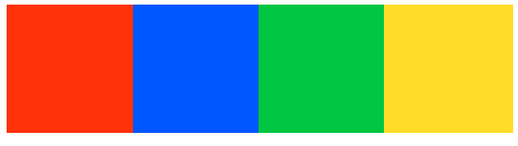
Ambient light - mode in which the light sensor detects the light intensity of its surroundings
Reflected light - mode in which the light sensor can detect the intensity of light reflected off certain colored surfaces

Useful for

- Responding to light/dark
- Following a dark line on a white paper
- Reacting to or sorting by different colors

Reflected light mode detects different colors in this way

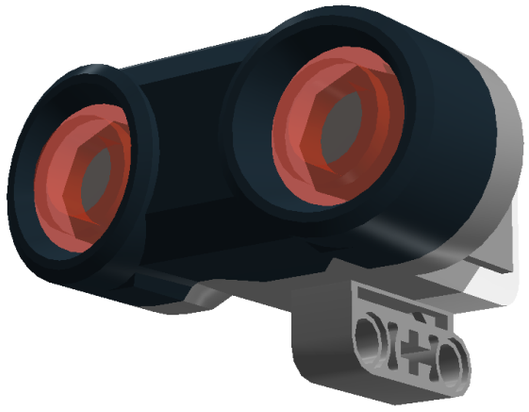
Colors you see



Light sensor detects

EV3 Sensors

Ultrasonic Sensor



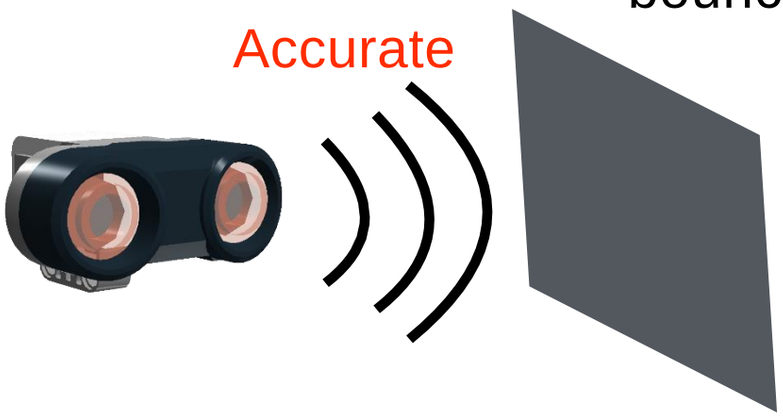
- Uses ultrasonic waves to compute its distance from objects up to 255cm (8.4ft) away
- Detects flat, smooth surfaces better than rough, curved ones

Useful for

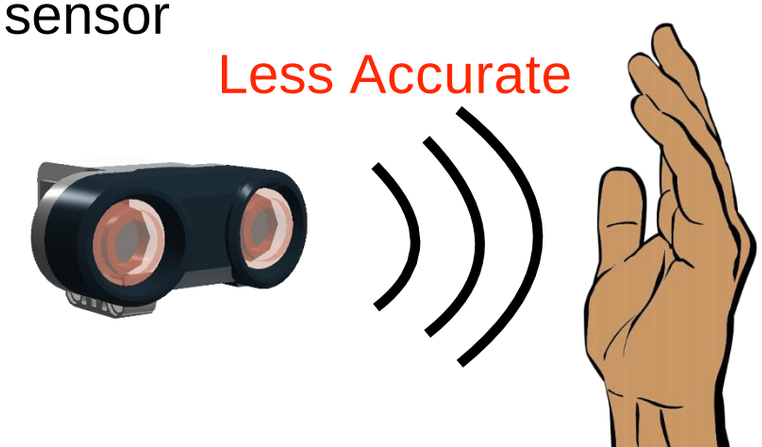
- Sensing walls and obstacles before they are reached
- Navigating a maze without hitting the walls

Waves will scatter when they bounce off a curved or bumpy object, such as your hand, and will not bounce straight back to the ultrasonic sensor giving less reliable readings

Accurate

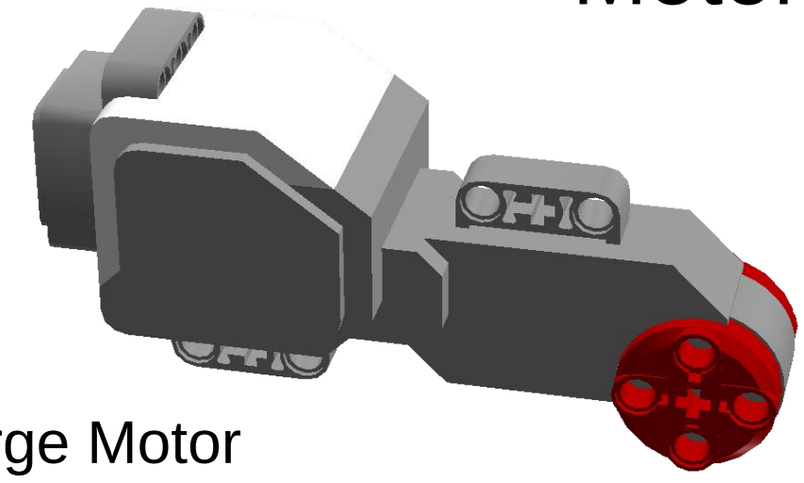


Less Accurate

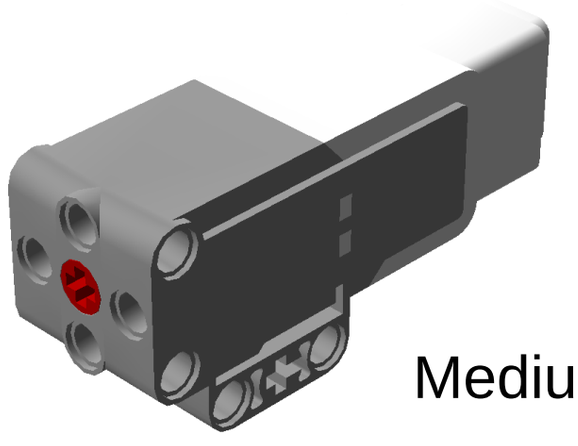


EV3 Sensors

Motor Rotation Sensor



Large Motor



Medium Motor

- Motors can detect how many rotations they have turned
  - Robots can be programmed to perform an action when a specified number of rotations has been reached
- Rotations be expressed in number of rotations or degrees, with 360° representing one full rotation

Useful for

- Computing distance traveled
- Traveling for a predetermined distance

The direction the motor is spinning is represented by the sign of the number of rotations or degrees

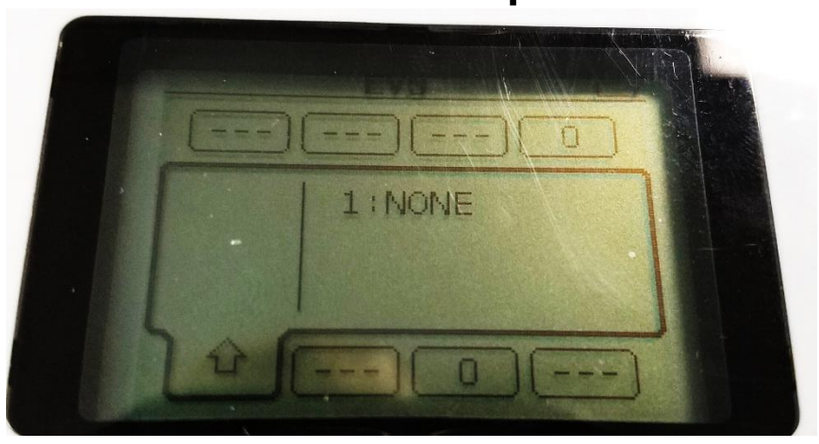
-150° and 150° is the same length spin but in opposite directions

EV3 Sensors: Viewing Sensor Input on the Brick

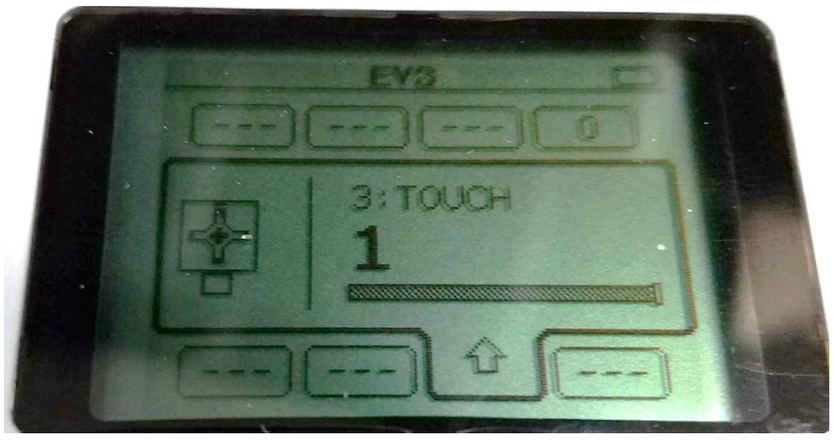
You can use the brick to view how certain stimuli are read through each of the sensors

Select “ Port View”

Scroll using buttons to select a port



Scroll to select a sensor



EV3 Sensors: Viewing Sensor Input on the Brick

Touch Sensor

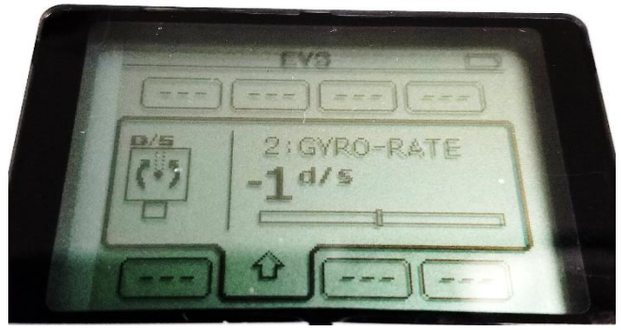
Pressed

Released

The touch sensor has two states: pressed and released.

Gyro Sensor

Angle (degrees)



Rate (d/s)

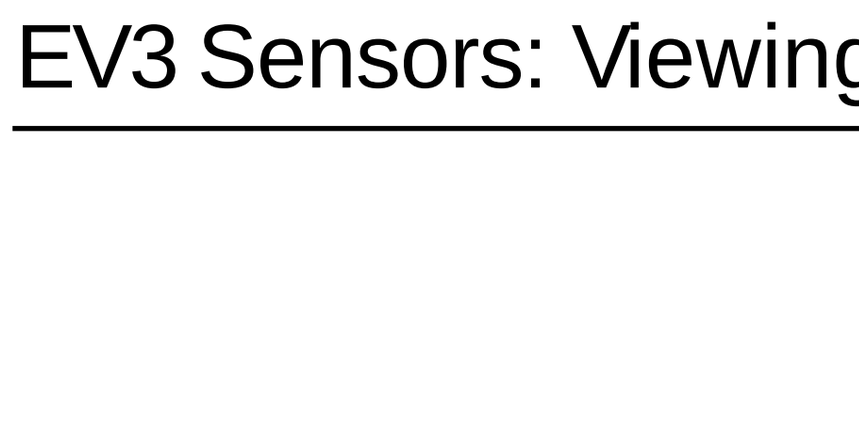
The gyro sensor displays its readings as degrees or as degrees/sec depending on selected mode (ANG or RATE)

Use this value to determine how much your creation has rotated or the rate at which it is rotating.

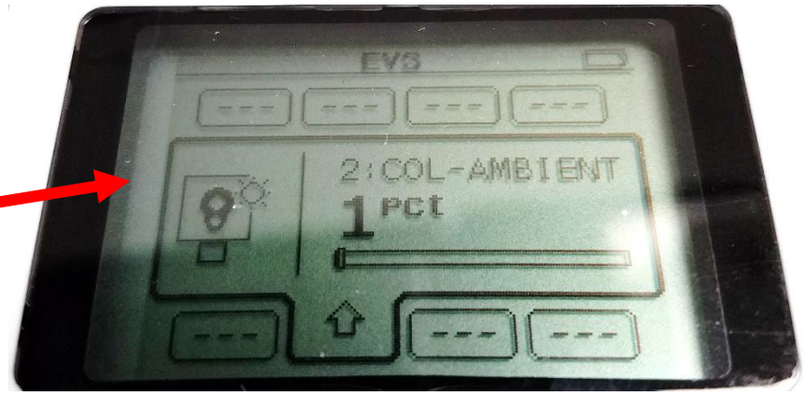
EV3 Sensors: Viewing Sensor Input on the Brick

Color Sensor

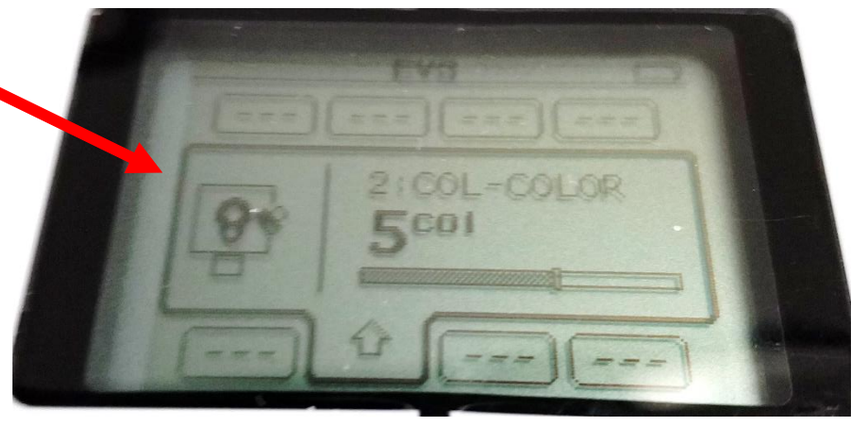
Select either “Reflected light” mode, “Ambient light” mode or “Color” mode



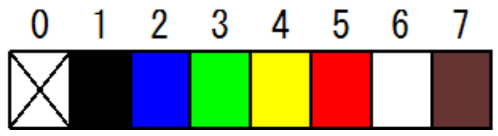
Use Reflected mode to determine what percent value corresponds to a particular color



Use Ambient mode to determine what percent value corresponds to the level of light in a certain part of the room



Use Color mode to determine what number value corresponds to a particular color using the key below



- Ambient light and reflected light levels will both be represented with a percent value
- Color mode will be represented by a number value

EV3 Sensors: Viewing Sensor Input on the Brick

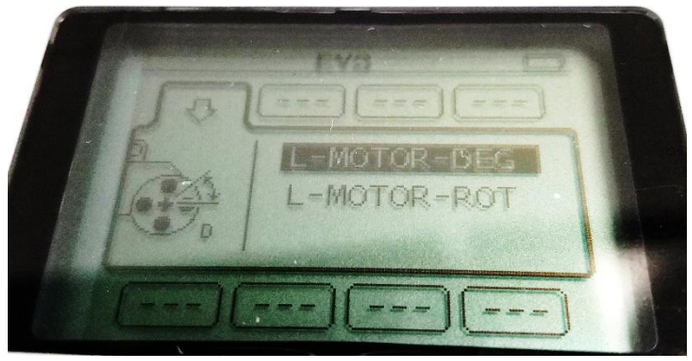
Ultrasonic Sensor

Select either “Ultrasonic inch” mode or “Ultrasonic cm”

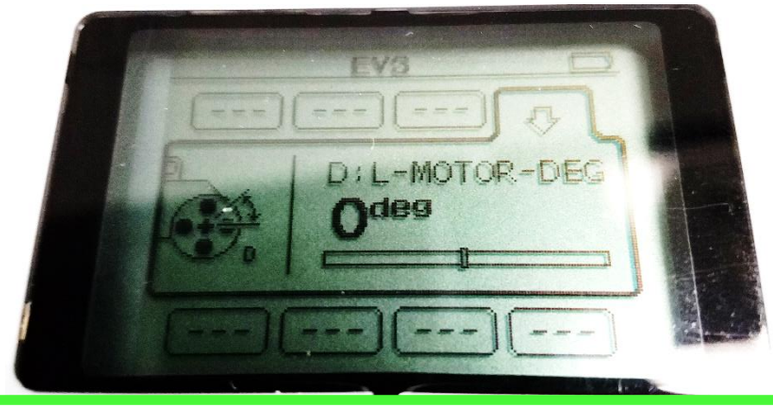
The distance from the object will be displayed in either centimeters or inches

Motor Rotation Sensor

Select either “Motor rotations” mode or “Motor degrees”



The amount the motor has rotated will be expressed in either degrees or whole number rotations.



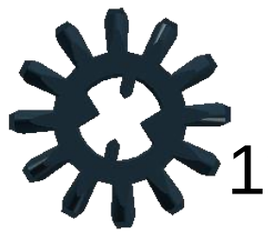
*This icon on the left will differ but the output format is the same for both Large and Medium motors.

Using Gears: Gears Overview

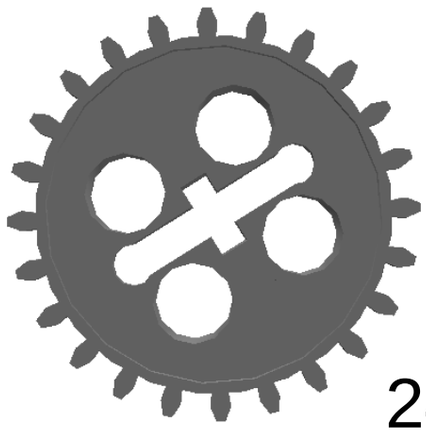
8 Tooth

20 Tooth Bevel

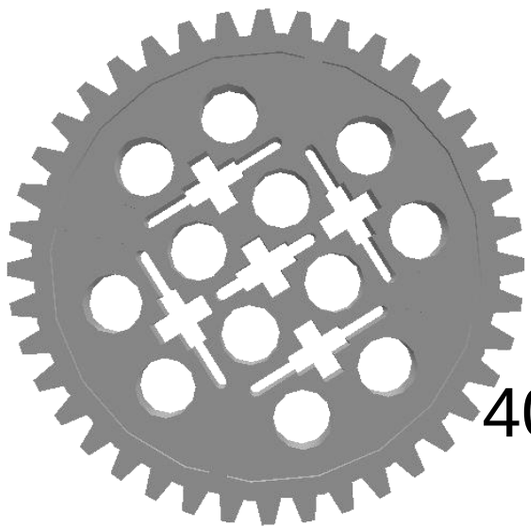
36 Tooth Bevel



12 Tooth Bevel

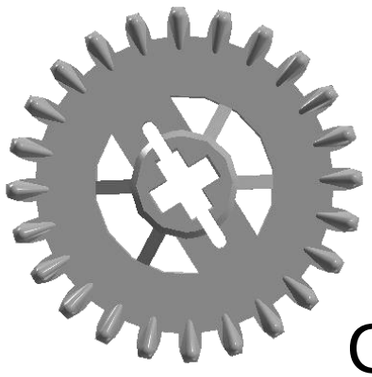


24 Tooth



40 Tooth

16 Tooth

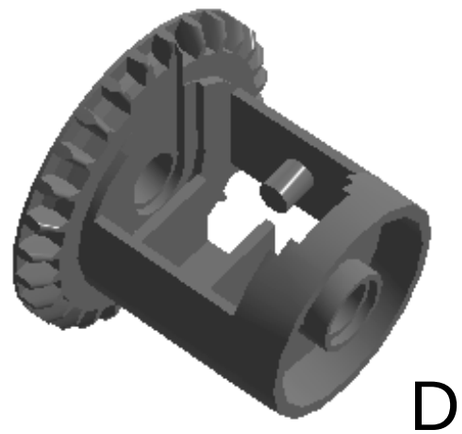


Crown Gear

Using Gears: Gears Overview

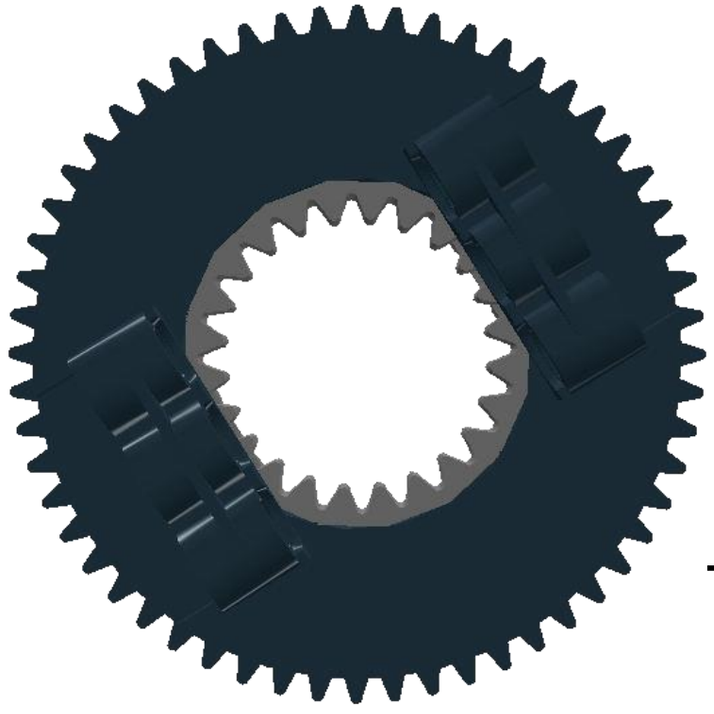
Worm Gear

Knob Wheel



Differential

Gear Rack

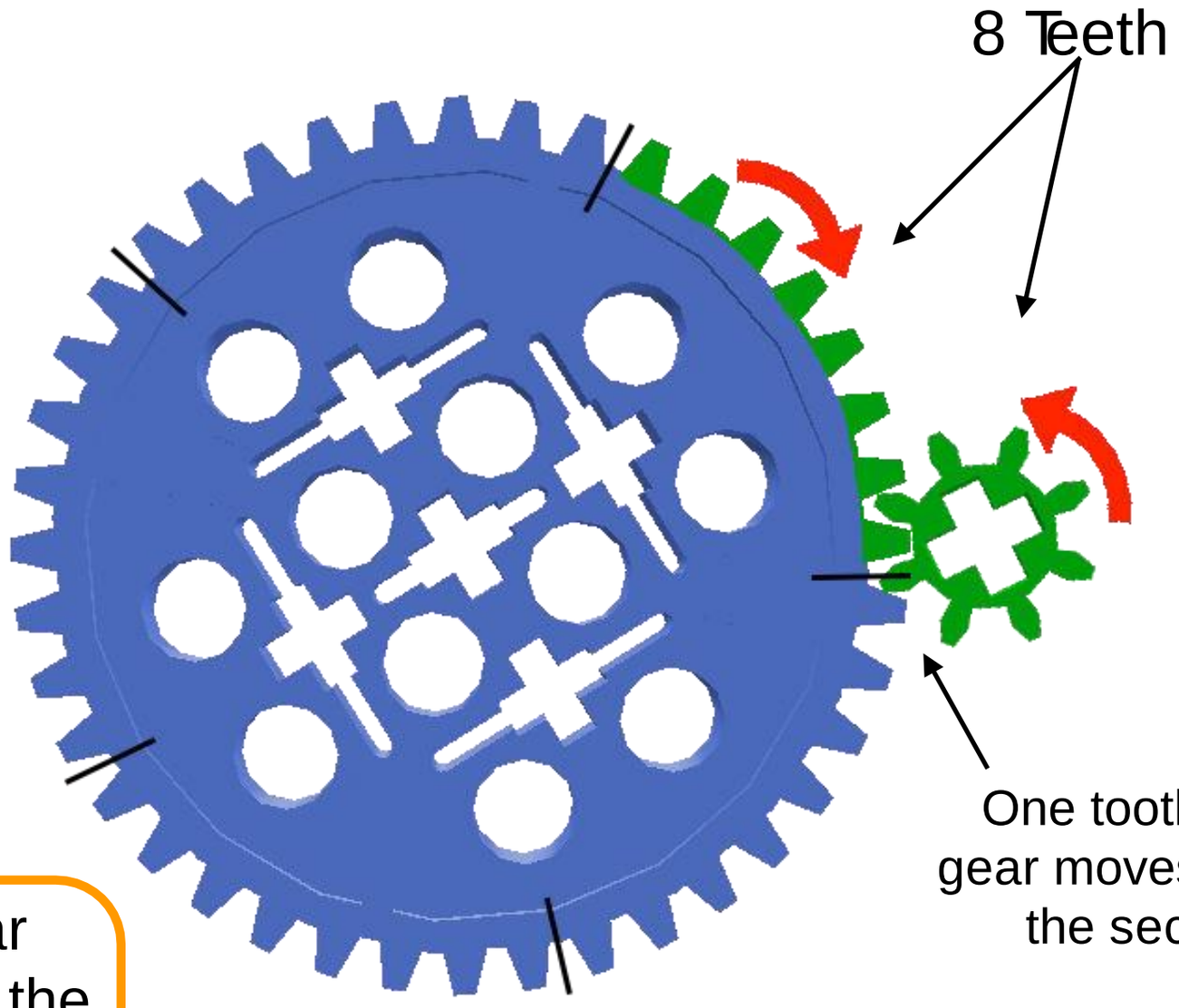


Turntable

Using Gears: Gears Overview

How the Sizes of Gears Compare

- The 40 tooth gear has 5x as many teeth as the 8 tooth gear
- The **circumference** of the 40 tooth gear is 5x greater than the circumference of the 8 tooth gear
- Spinning the 40 tooth gear one time will cause the 8 tooth gear to spin 5 times



This will apply to any gear combination - simply count the number of teeth to determine how many times one will cause the other to spin

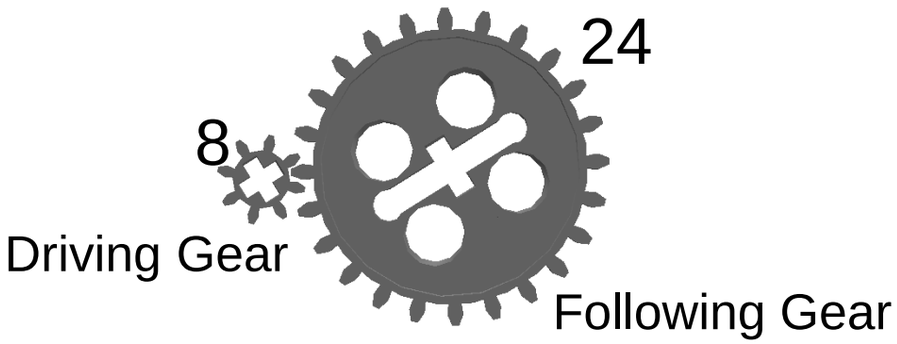
Using Gears: Gearing Up & Gearing Down

Key Vocabulary

Driving Gear - Any gear that causes another gear to spin.
The first driving gear is connected to the motor.

Following Gear - Any gear that is being spun by another gear.
The last following gear outputs the final motion of the gear train

Gearing Down

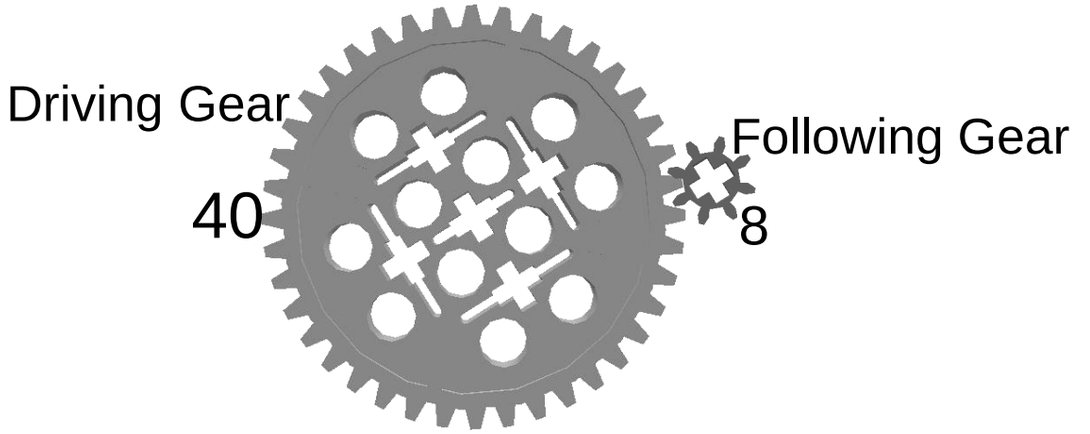


- When gearing **up**, the driving gear must be **smaller** than the following gear

In this example:

For each rotation of driving gear, following gear turns 1/3 rotations

Gearing Up



- When gearing **down**, the driving gear must be **larger** than the following gear

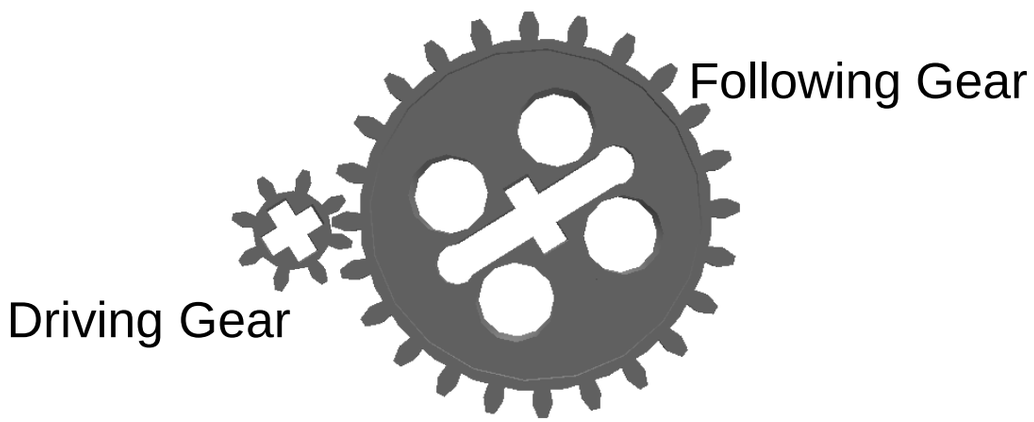
In this example:

For each rotation of driving gear, following gear turns 5 rotations

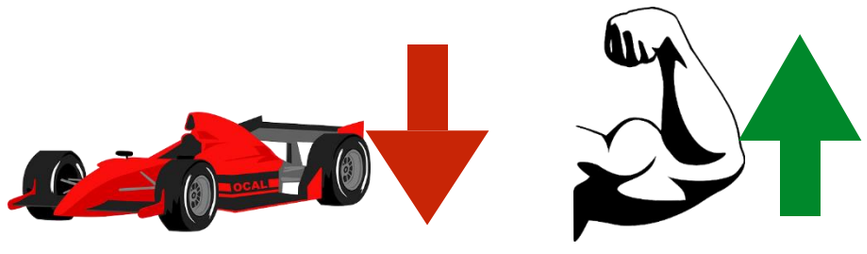
Using Gears: Gearing Up & Gearing Down

Speed vs. Power

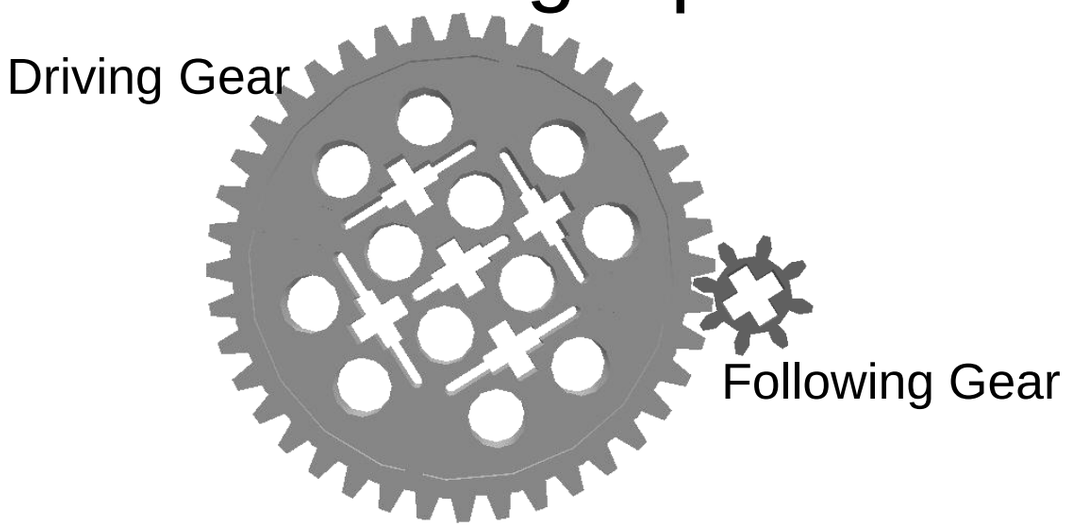
Gearing Down



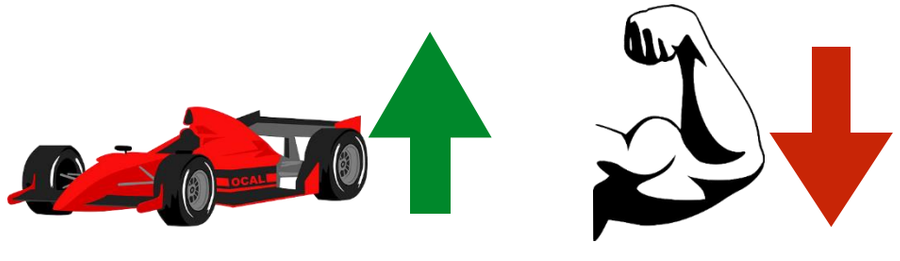
- Gearing down decreases speed, but increases power
- Allows your device to move heavier objects but at a slower speed



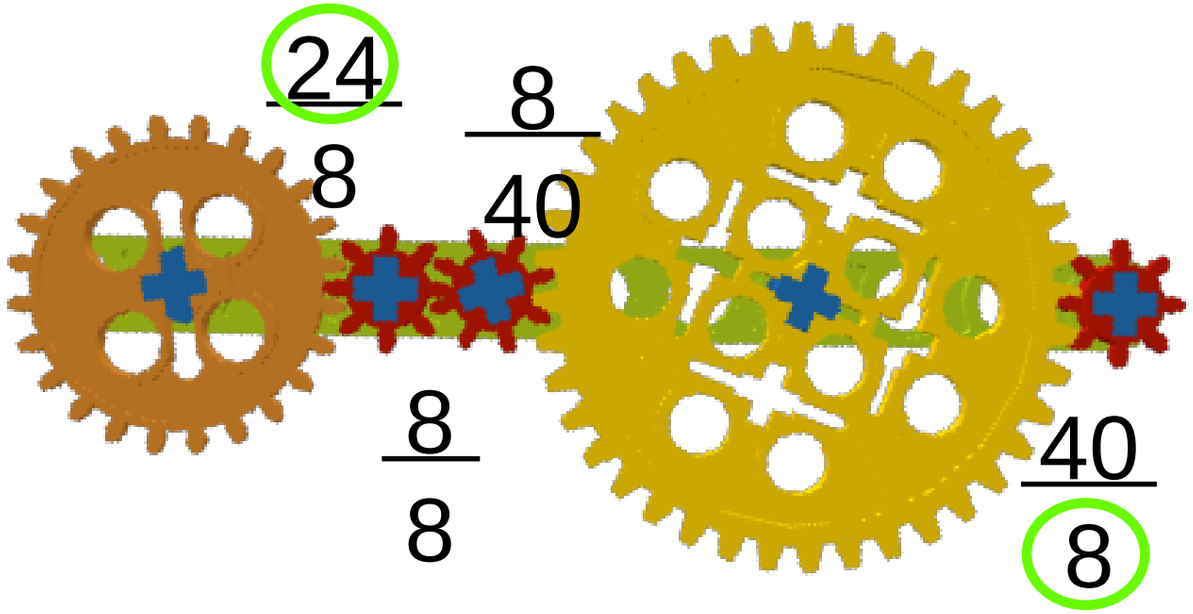
Gearing Up



- Gearing up increases speed, but decreases power
- Allows your device to operate at higher speeds but it can only move lighter objects



Using Gears: Gear Trains



Calculating Speed

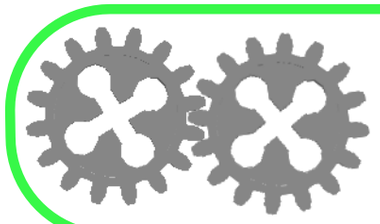
Multiply the ratio of each pair of gears in the train with the driving gear in the numerator and the following gear in the denominator

Since all the numbers in between will cancel out when they are multiplied together, simply write the ratio in terms of the first driving gear and the last following gear

$$\frac{24}{\cancel{8}} \times \frac{\cancel{8}}{\cancel{8}} \times \frac{\cancel{8}}{\cancel{40}} \times \frac{\cancel{40}}{8} = \frac{3}{1}$$

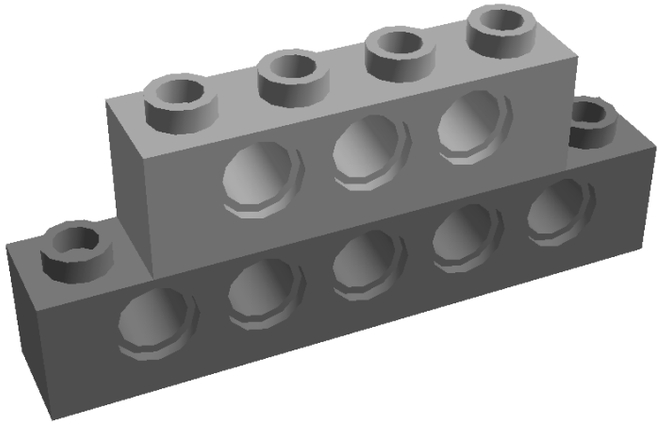
The last gear will spin 3 times faster than the first gear

$$\text{First Gear } \frac{24}{\text{Last Gear } 8} = \frac{3}{1}$$

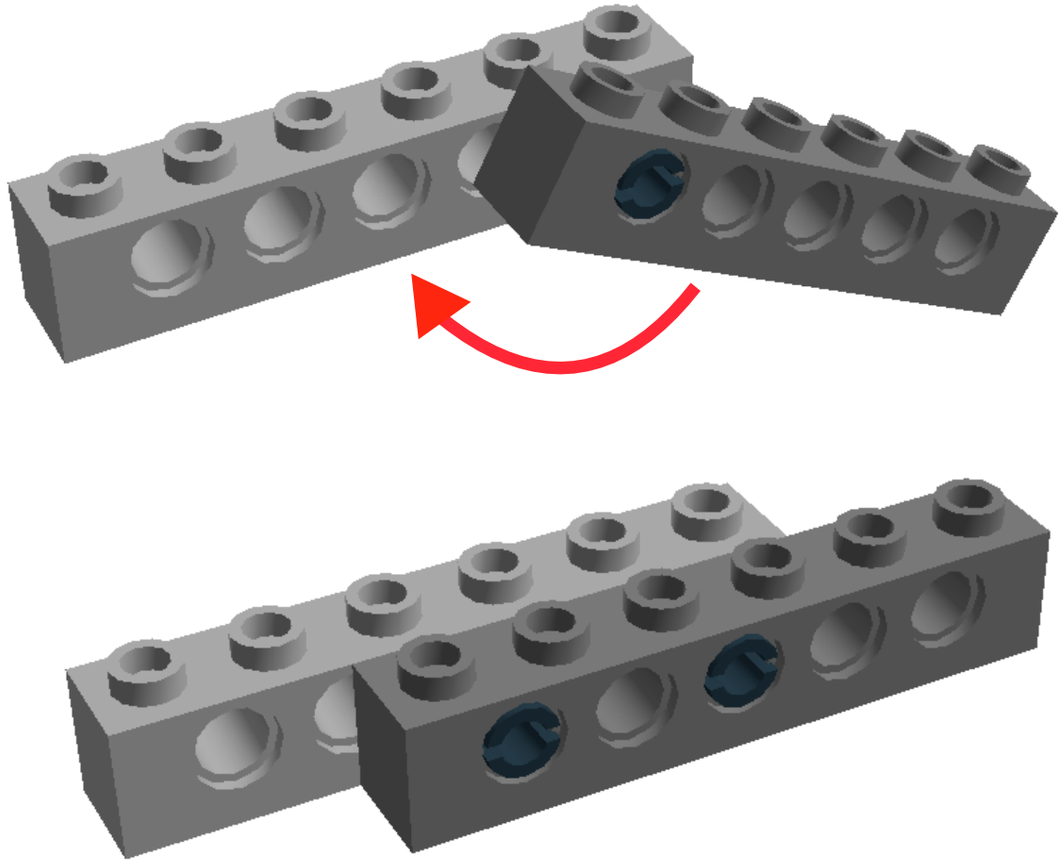


Note: 16 tooth gears will only fit with themselves along a beam, but two 16 tooth gears spans the same distance as an 8 tooth and a 24 tooth together

Additional Information: Technic Bricks

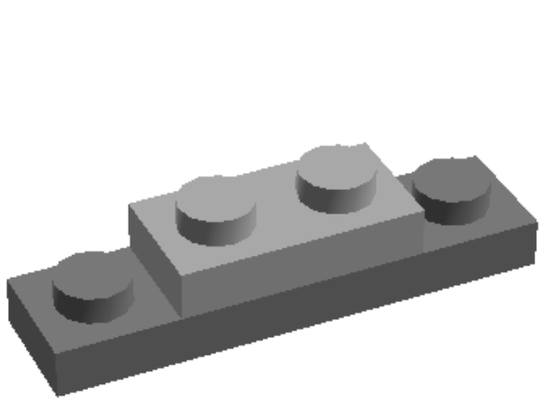


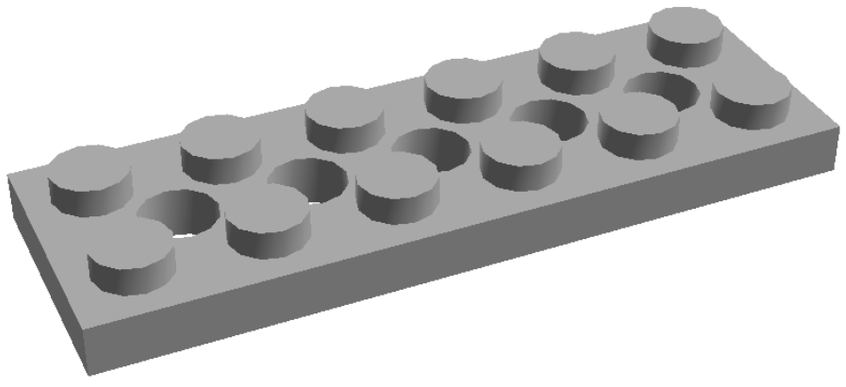
Technic bricks can be stacked or connected using connector pegs

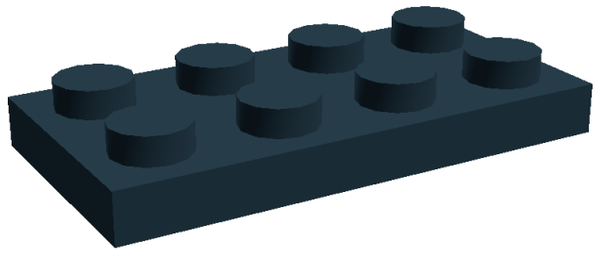


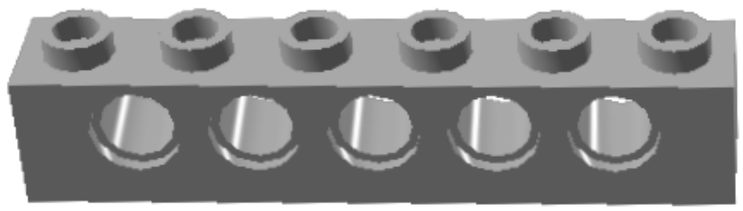
- Connecting with **one** peg will allow the bricks to rotate
- Connecting with **two or more** pegs will keep the structure rigid

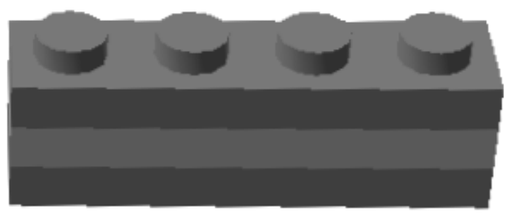
Additional Information: Plates







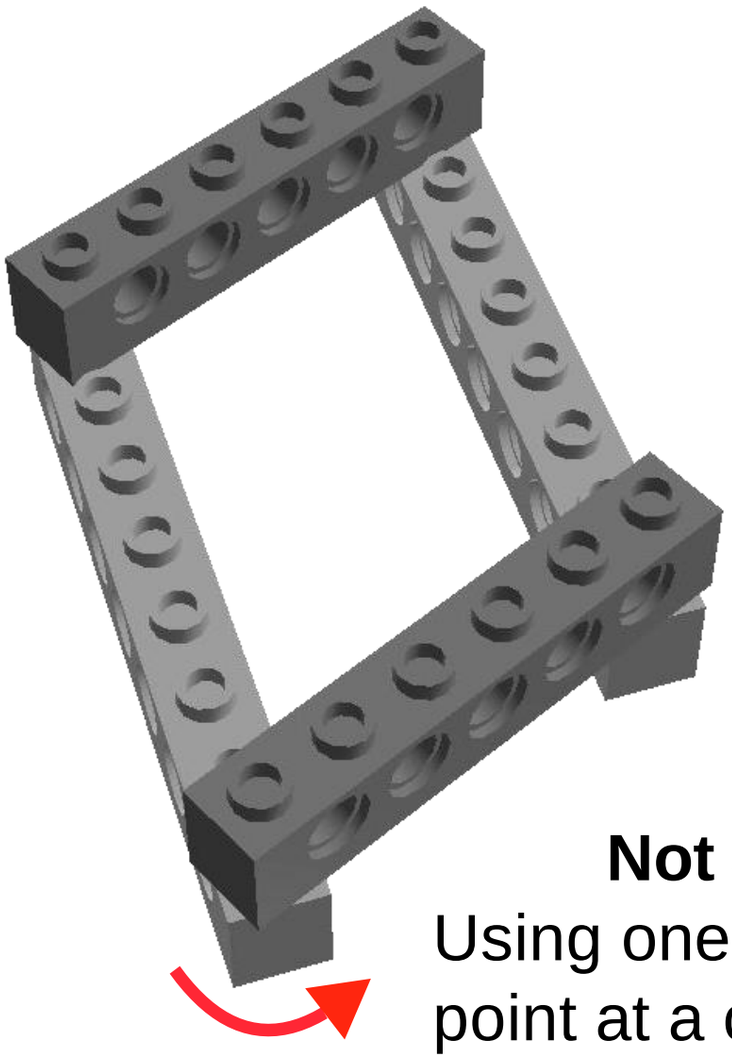




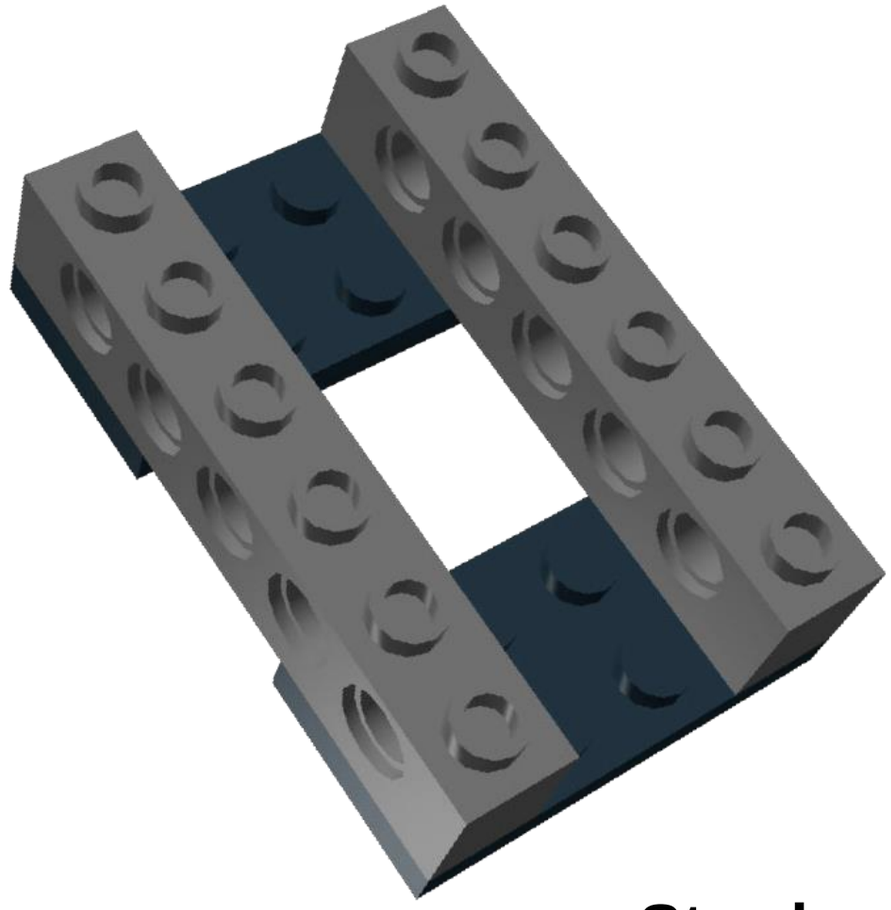
Stacking 3 plates is the
height equivalent of one brick

Additional Information: Sturdy Structures

Stacking Bricks & Plates



Not Sturdy
Using one connection point at a corner allows the corner to rotate



Sturdy
Using a plate creates two connection points at each corner which will keep the structure rigid