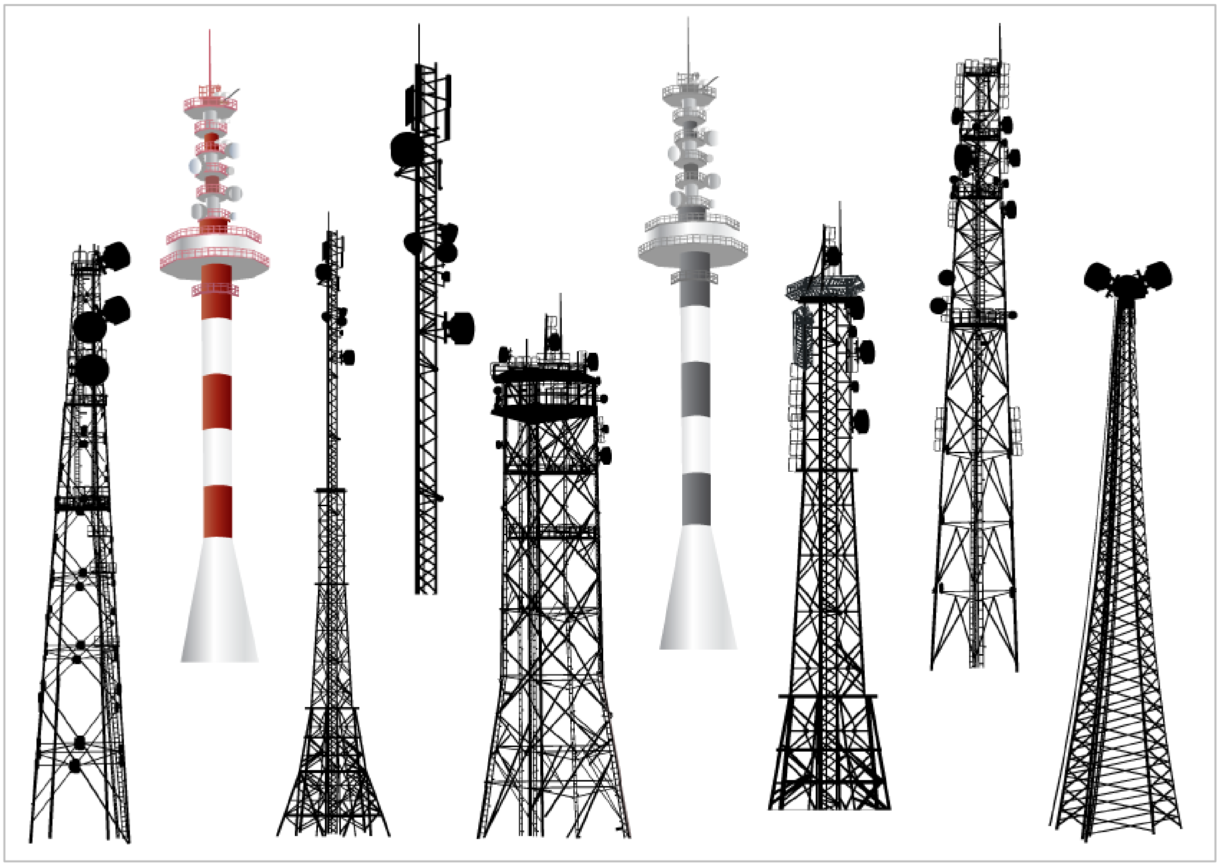
Tallest Tower

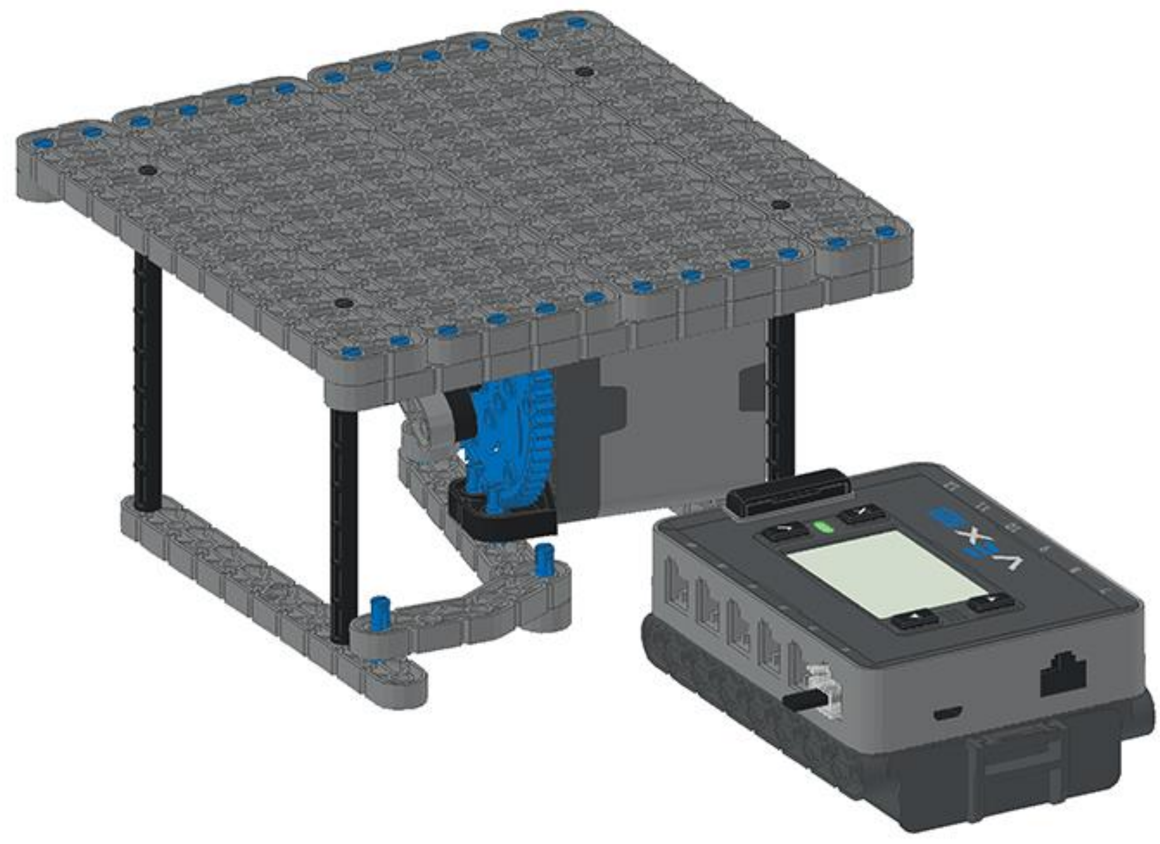


Make the tallest tower that can stay together in an earthquake!
Track your progress in your engineering notebook.

SPARK
SEEK

Discover new hands-on builds and programming opportunities to further your understanding of a subject matter.

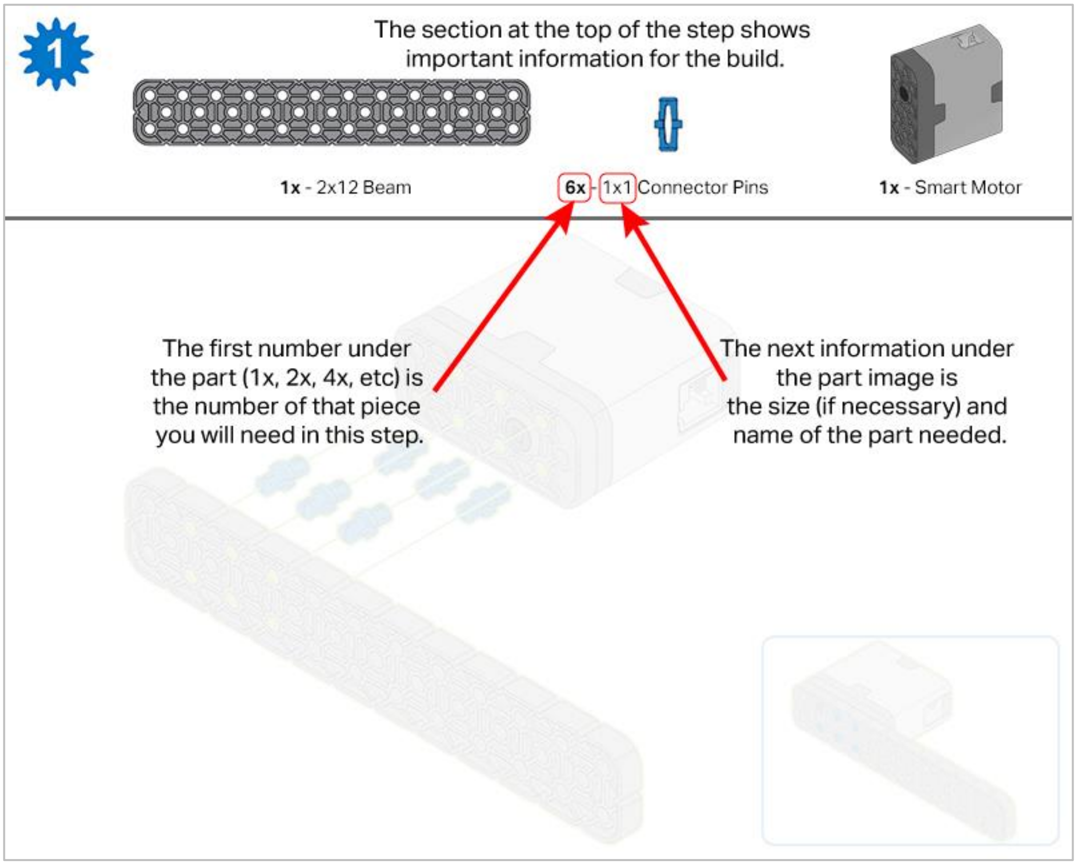
The Completed Look of the Build

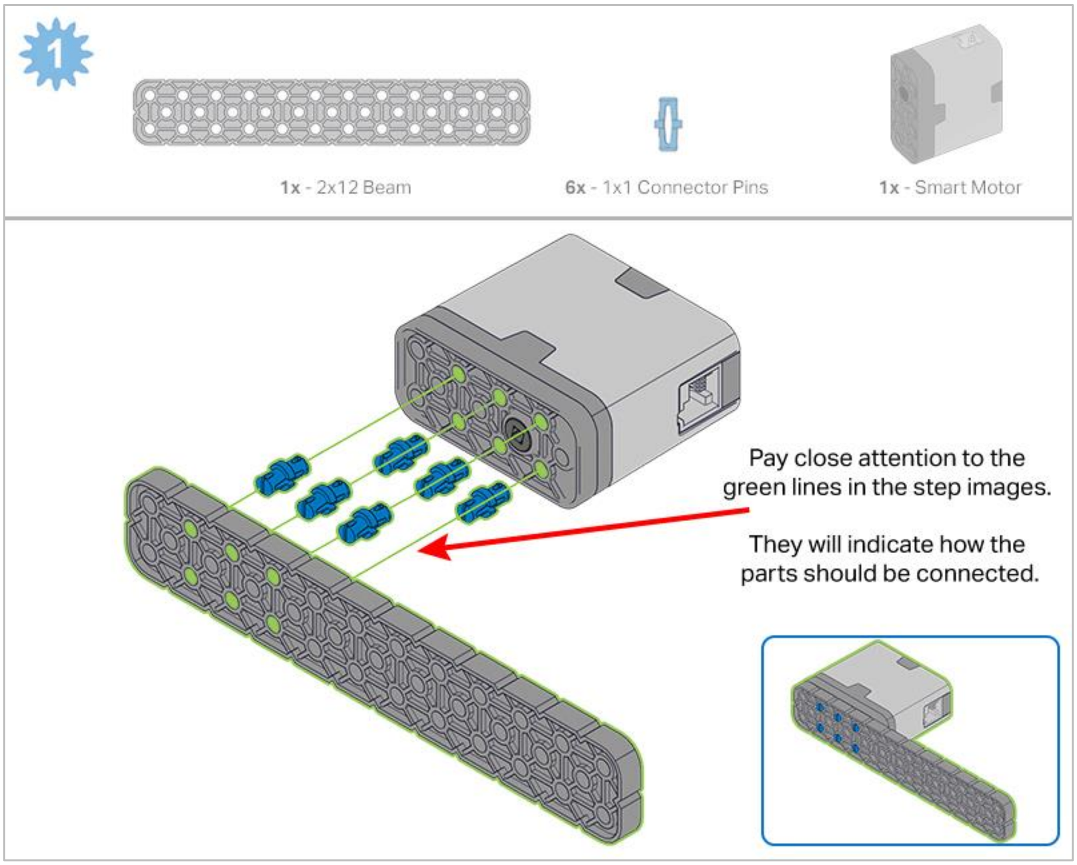


Completed Earthquake Platform

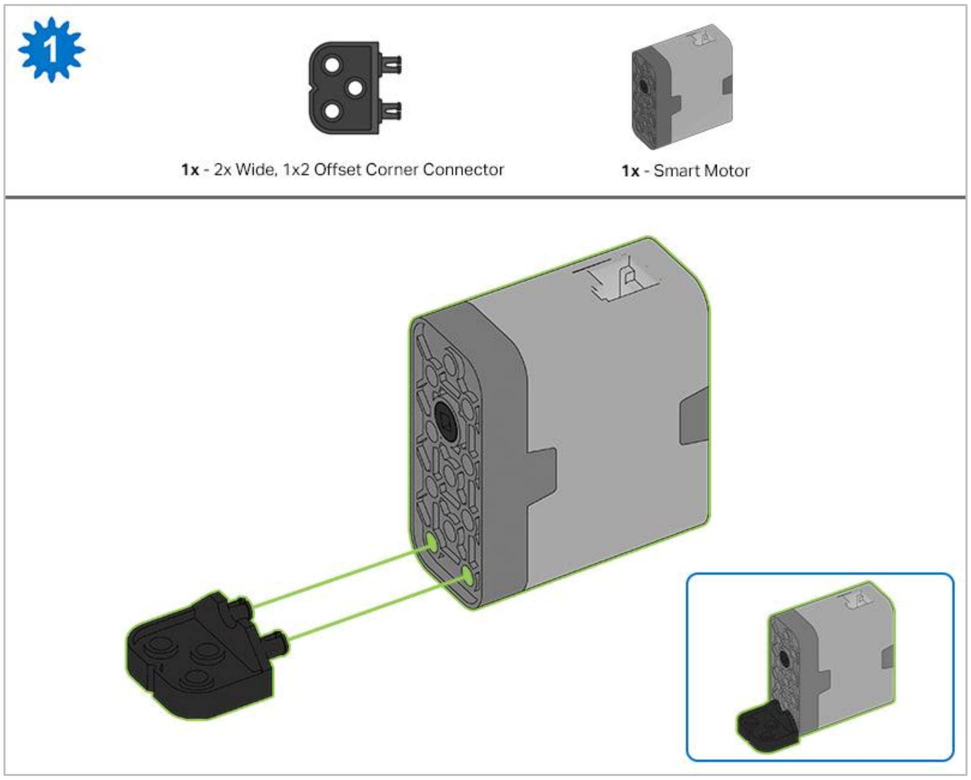
The Earthquake Platform simulates an earthquake for your tower. You will place your tower on top of this platform to test its durability.

Build Instructions

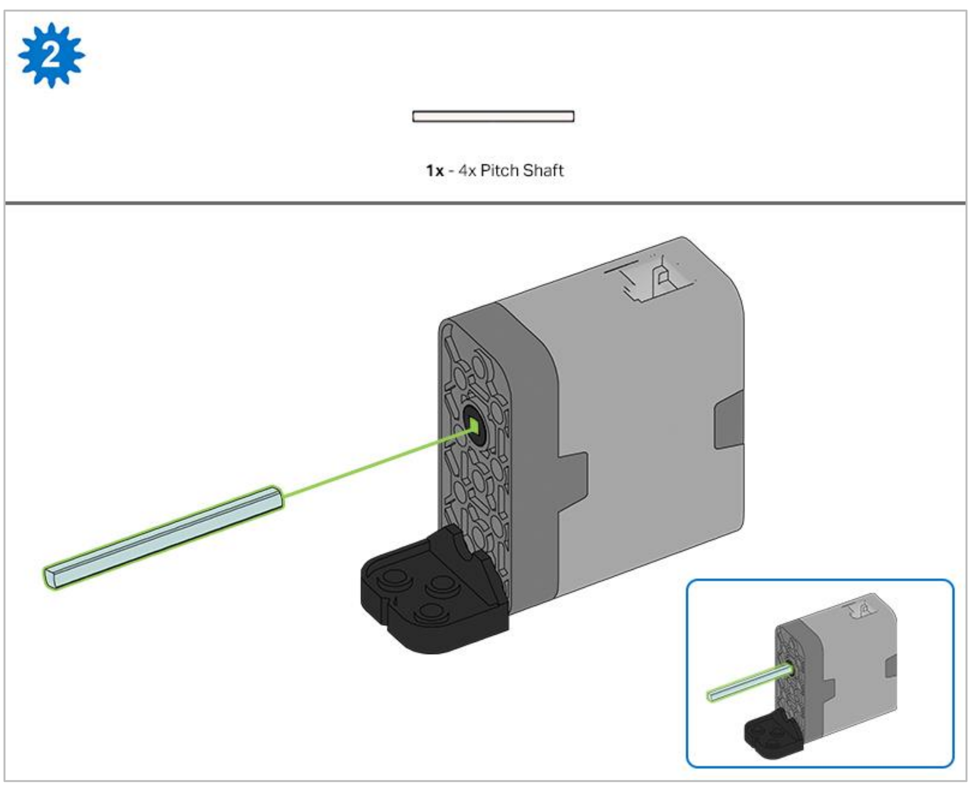




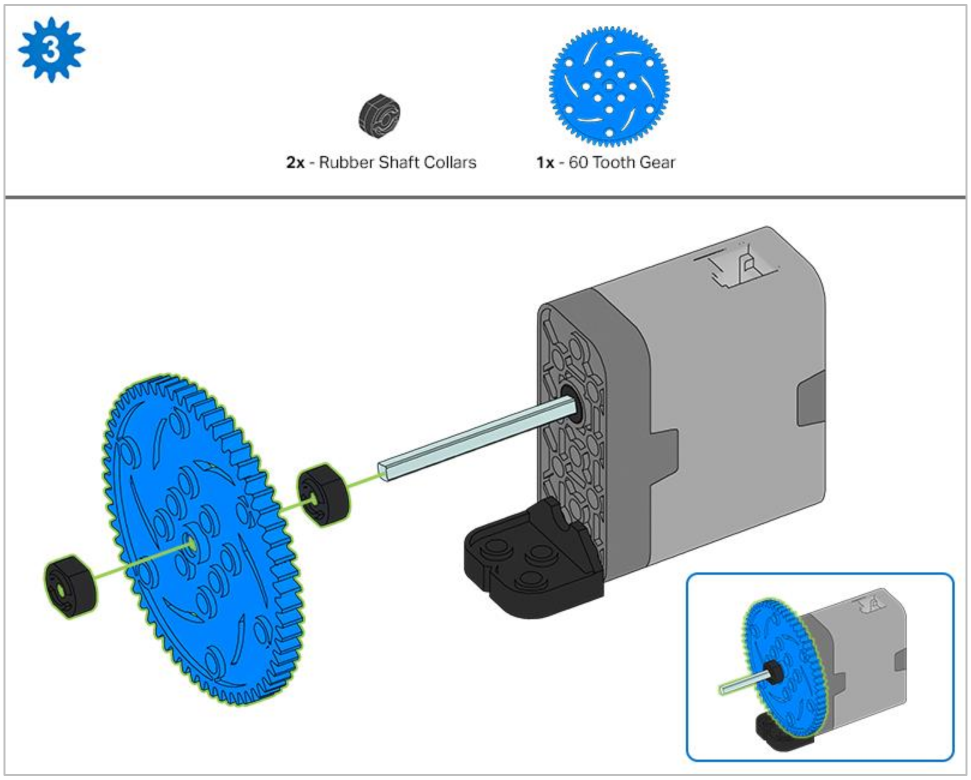
Count all pieces before starting your build and have them readily available.



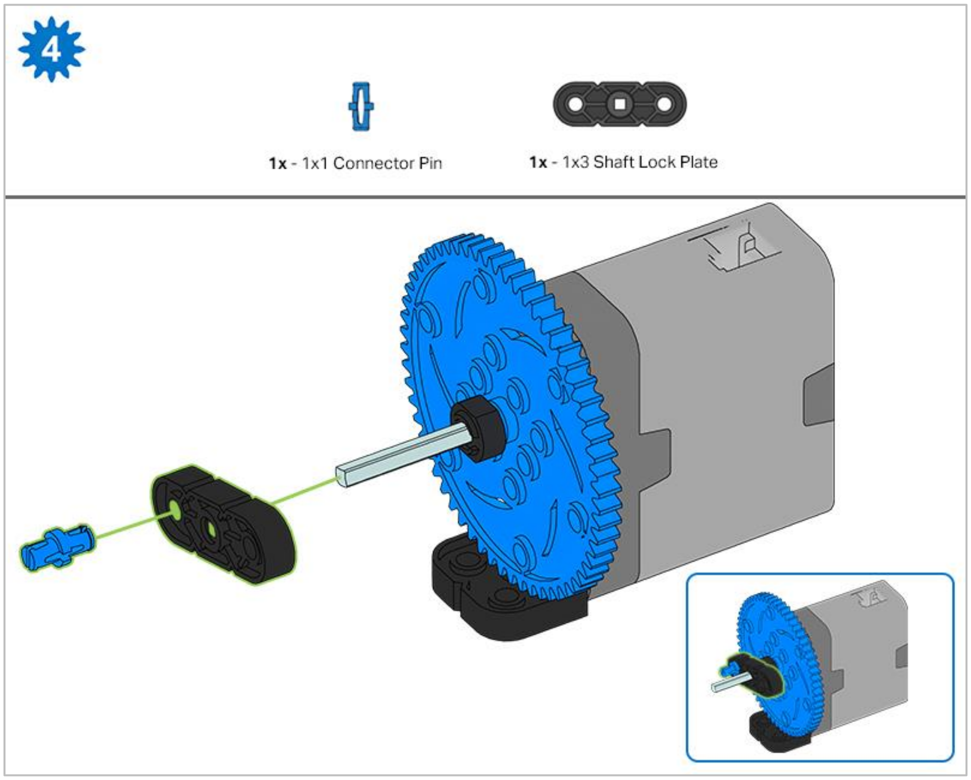
Make sure to attach the Smart Motor to the 2x Wide 1x2 Offset Corner Connector at the bottom two holes of the motor. Connect the motor with the port facing up so that the Smart Cable can be attached later.



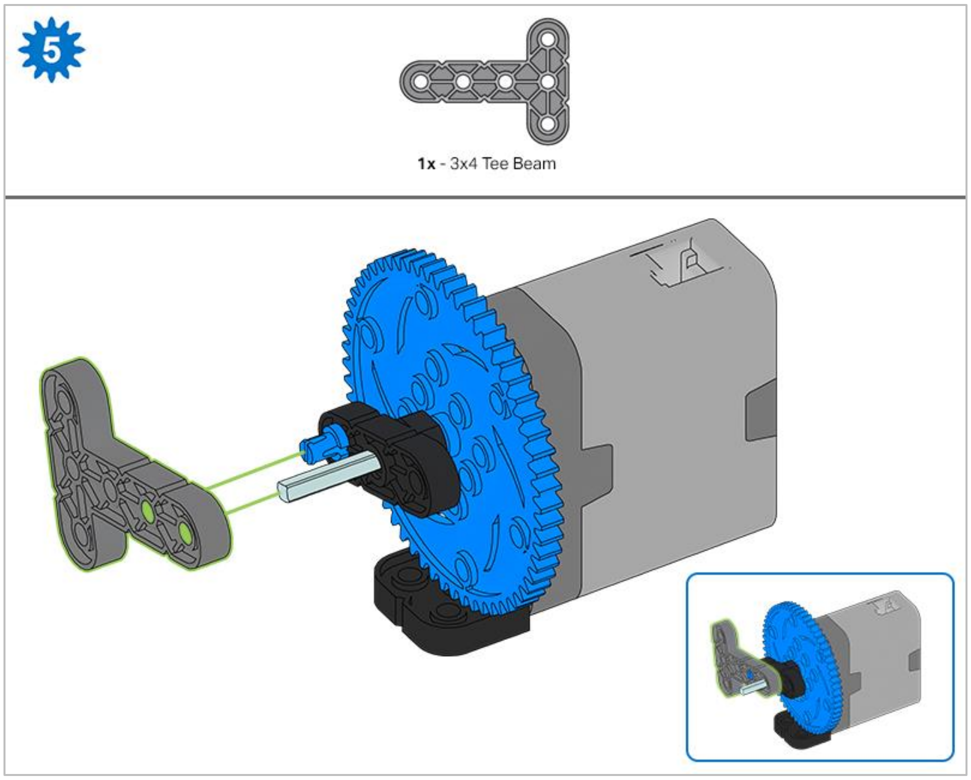
When adding the 4x Pitch Shaft, twist the pitch shaft to check for tension while turning. If it spins freely, it is not properly inserted into the motor.



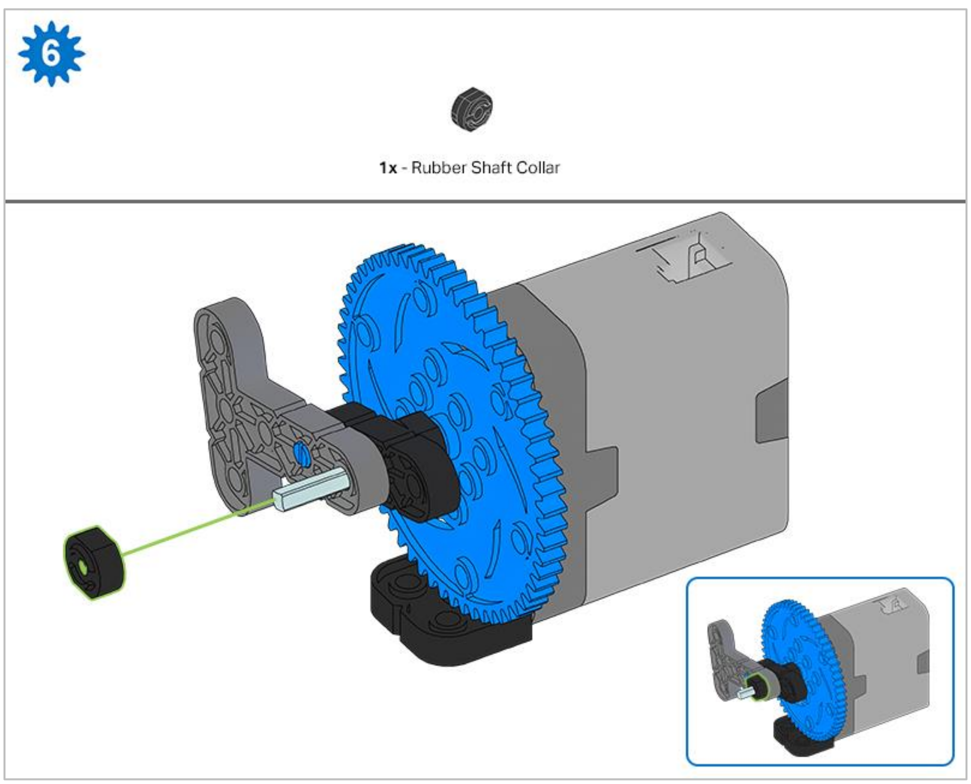
Make sure to attach the 60 Tooth Gear to the 4x Pitch Shaft at the center of the gear to avoid uneven turning.



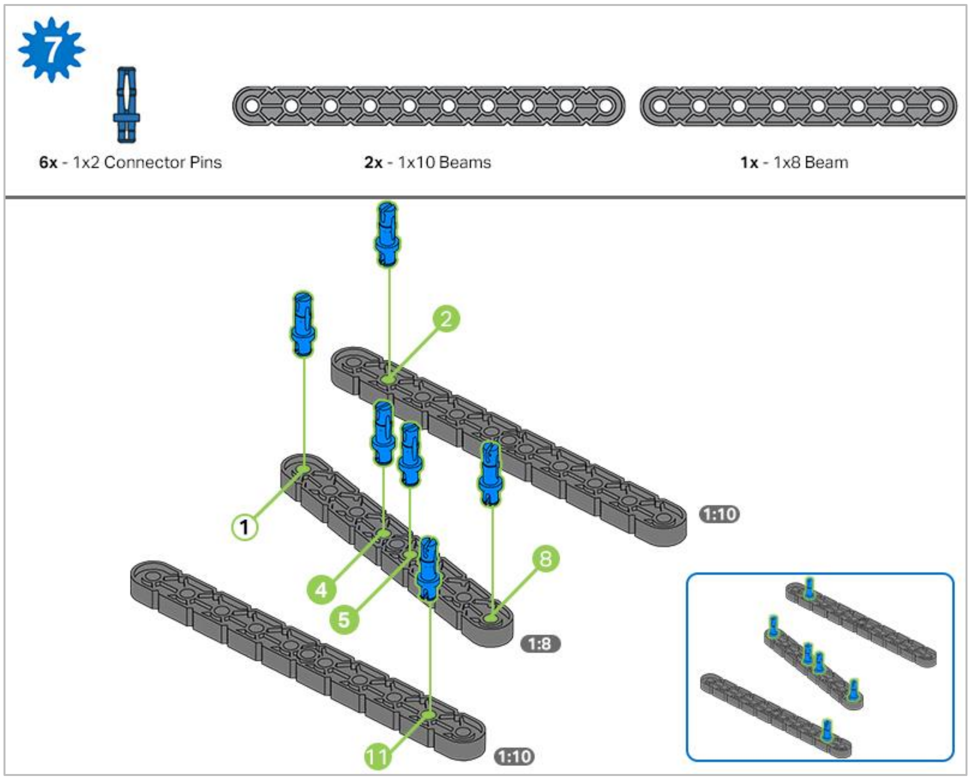
It may be easier to insert the 1x1 Connector Pin into the 1x3 Shaft Lock Plate before inserting it on to the 8x Pitch Shaft.



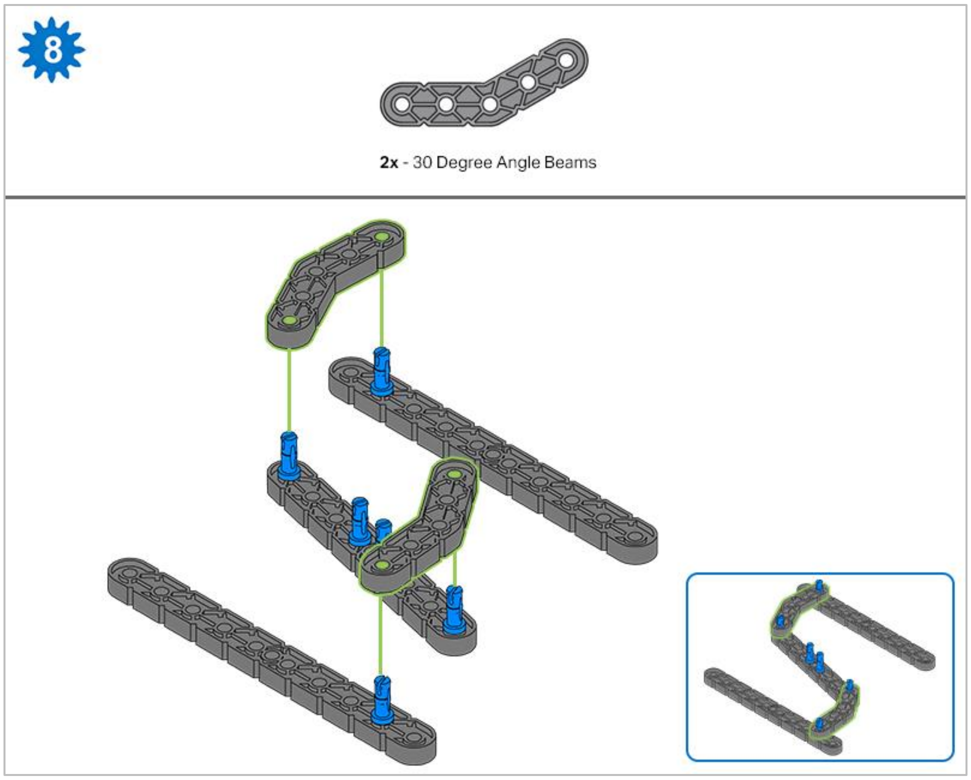
Make sure to push on the 3x4 Tee Beam until the 1x1 Connector Pin locks into place in the Tee Beam.



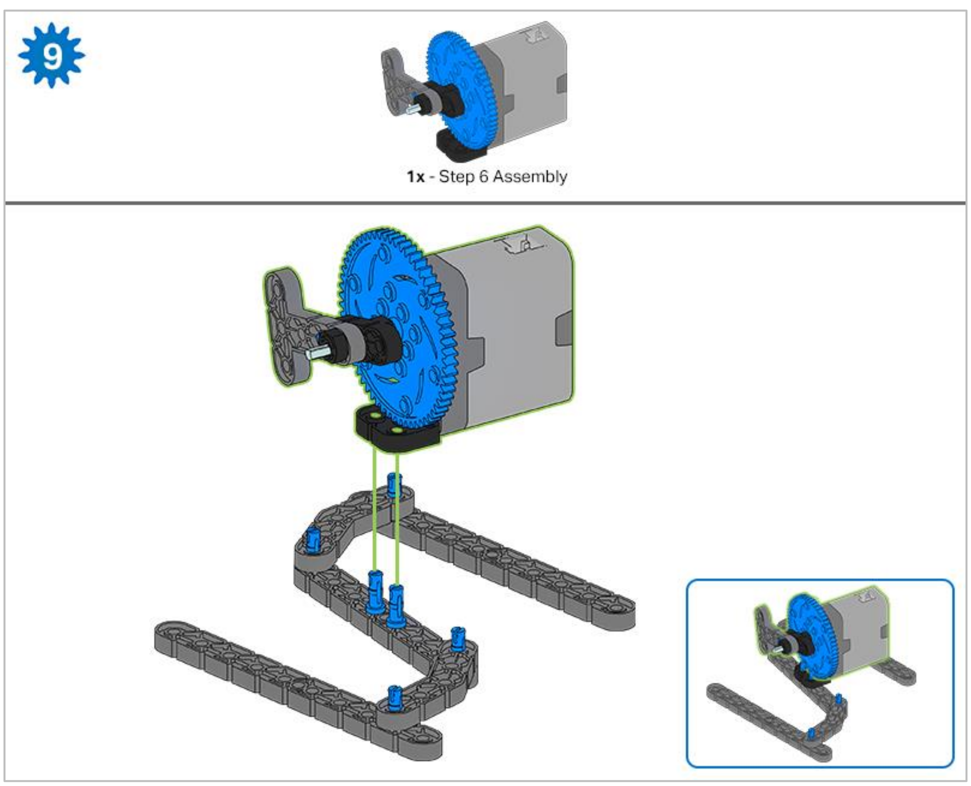
Push the Rubber Shaft Collar firmly so that it is up against the Tee Beam.



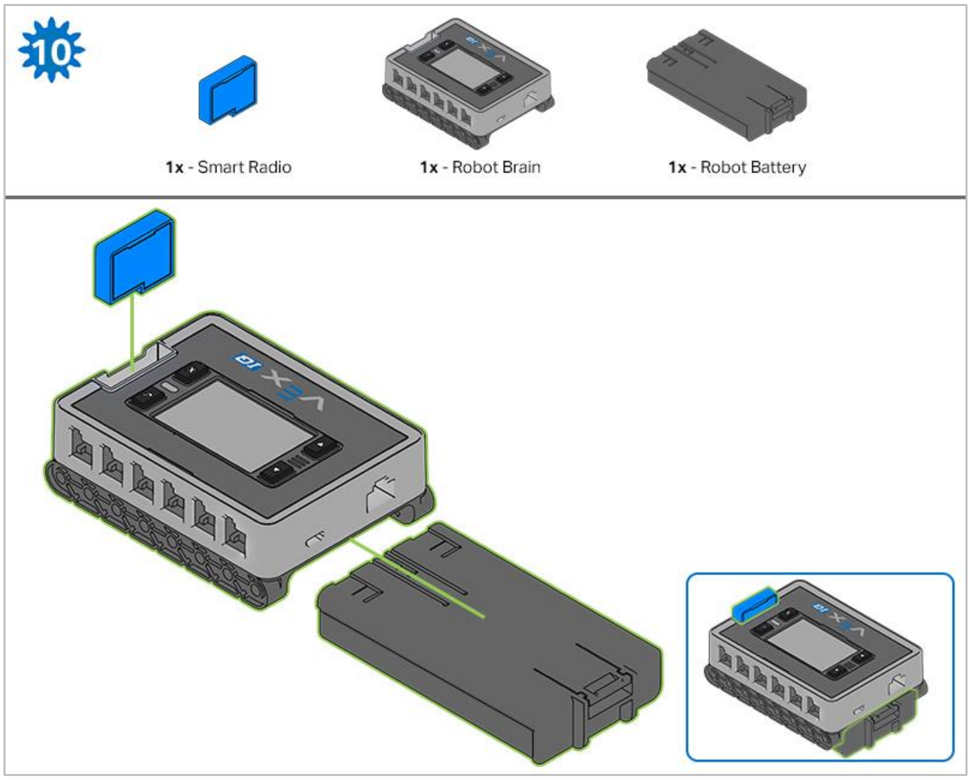
Insert the shorter side of the 1x2 Connector Pins into the 1x8 and 1x10 Beams. Make sure to note that the 1x2 Connector Pin is inserted into the second hole of the 1x10 Beam and not the end. Make sure to insert the 1x2 Connector Pins into the fourth and fifth hole of the 1x8 Beam and not in the hole directly in the center of the Beam.



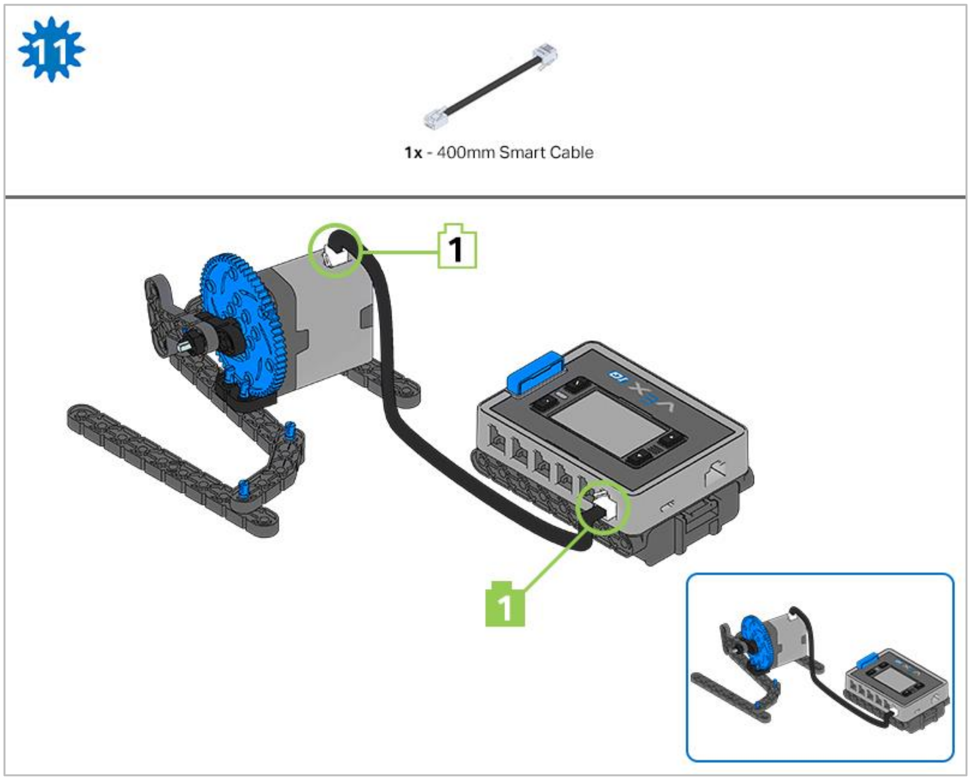
Make sure to push all the way down on the 30 Degree Angle Beams so that they are touching the 1x8 and 1x10 Beams.



Note that the gear is behind the 1x2 Connector Pins.



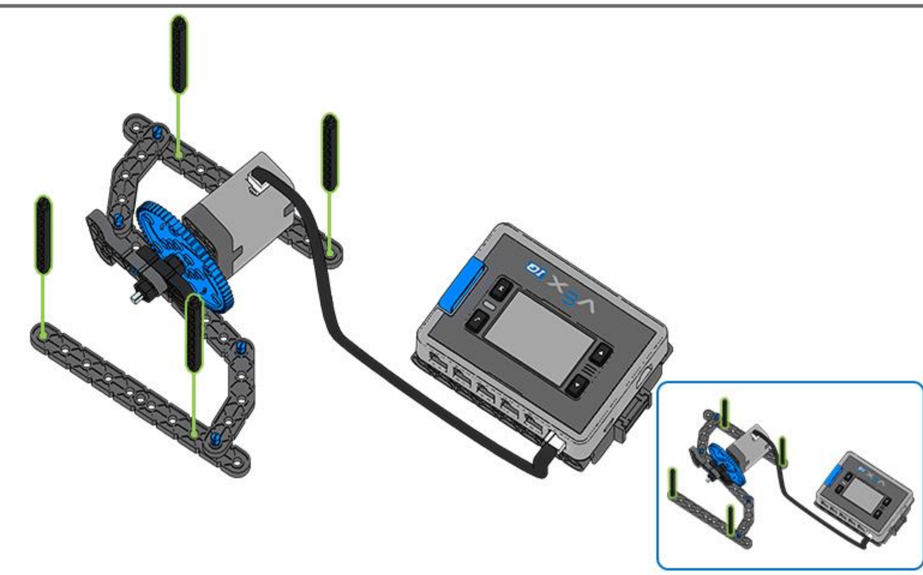
It is best to insert the Smart Radio before inserting the charged Robot Battery.



Be sure that the Smart Cable is properly inserted into the Smart Motor and into Port 1 on the Robot Brain.

12

4x - 6x Pitch Standoffs



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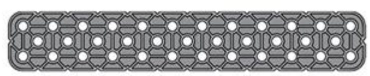
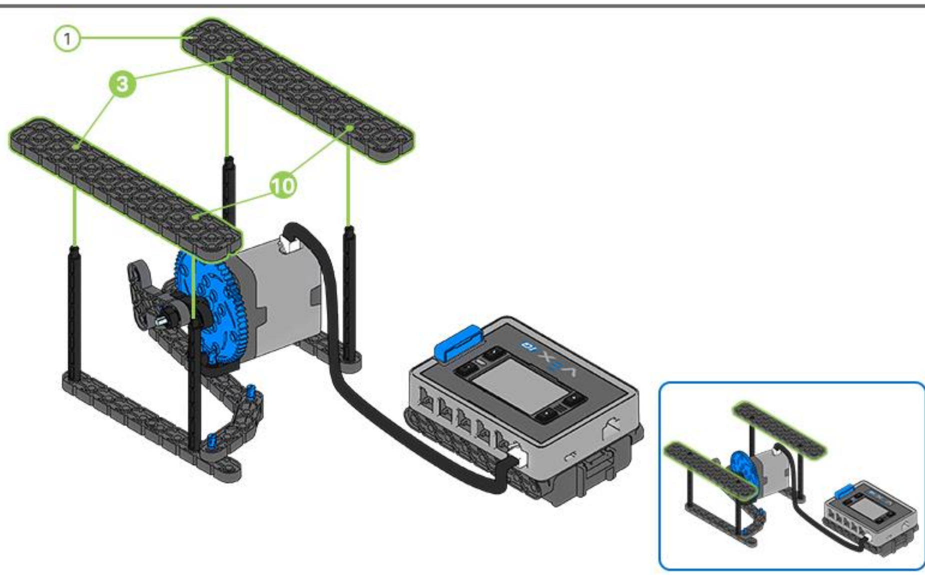
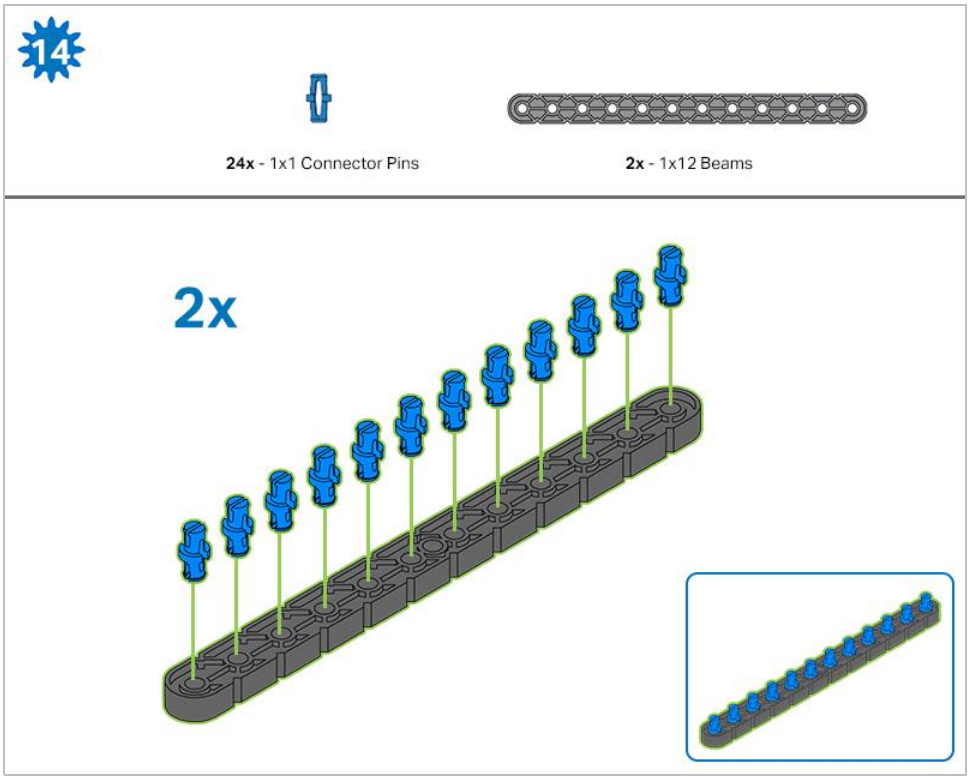


2x - 2x12 Beams

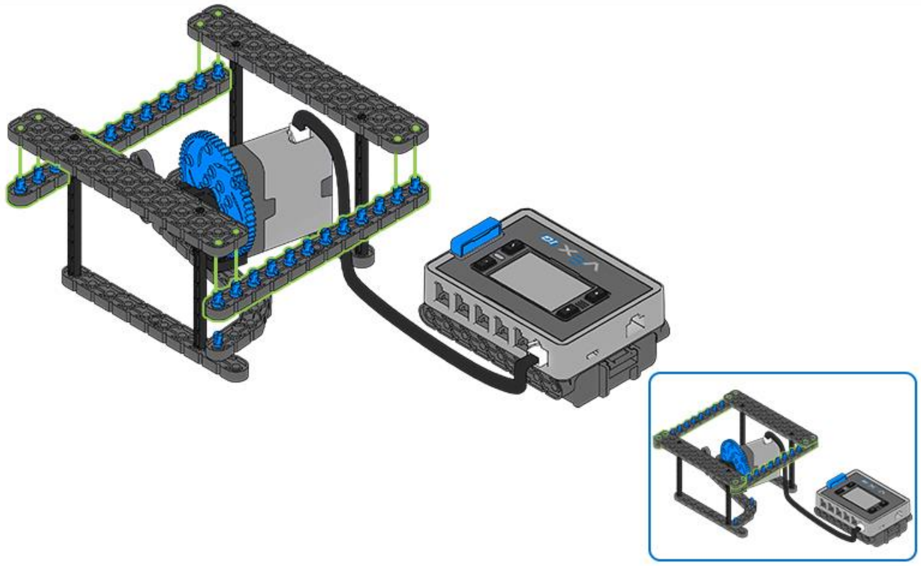




Steps 14-16, Be sure that all pins are securely pushed into beams.

15

1x - Step 14 Assembly



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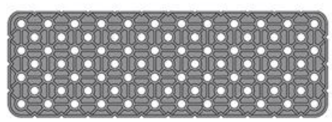
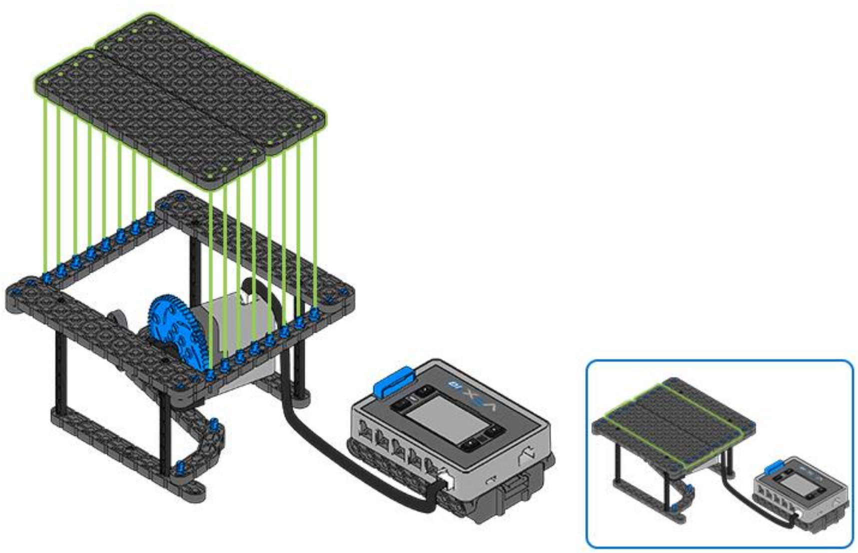


2x - 4x12 Plates



Exploration

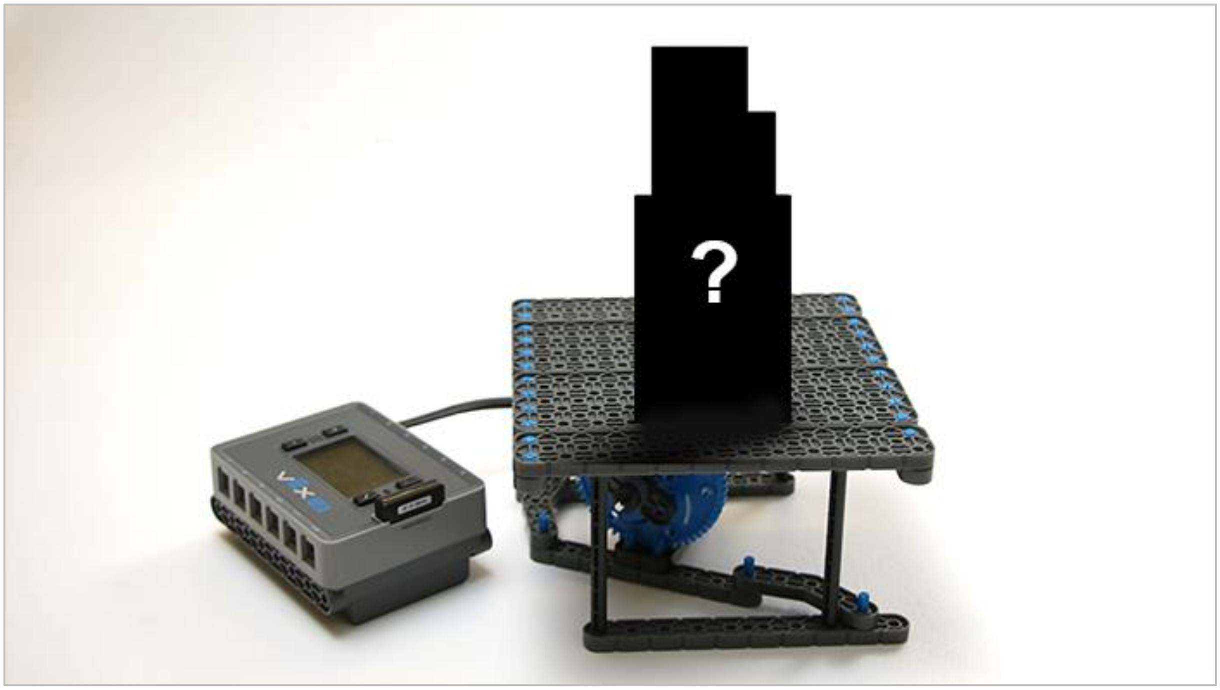
Now that you've finished the build, test what it does. Play with your build and then answer these questions in your engineering notebook.

- How do you think the Earthquake Platform will simulate an earthquake?
- Are there any parts of the Earthquake Platform that you think are weak or could be reinforced better?
- What other applications could a build like this be used for?

Test your build, observe how it functions, and fuel your logic and reasoning skills through imaginative, creative play.

15-Minute Tower Build

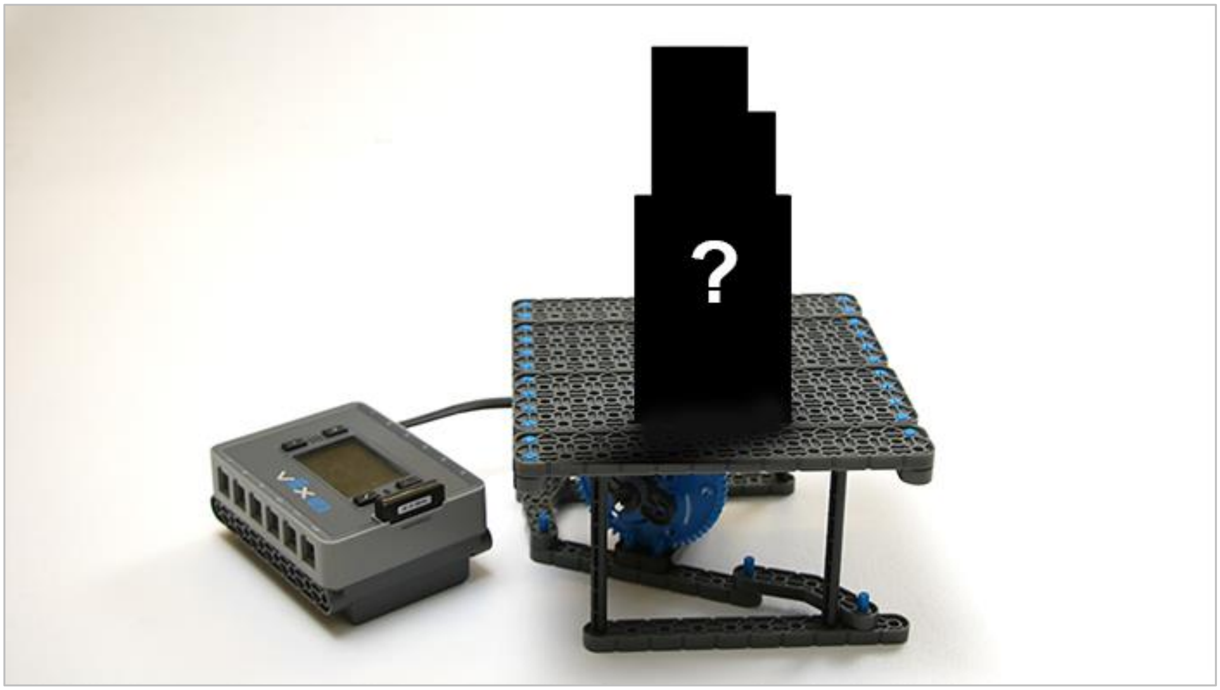
1. Building the Tallest Tower



A tower on the Earthquake Platform

Build the tallest tower that you can in 15 minutes. It will be the first version of your tower.

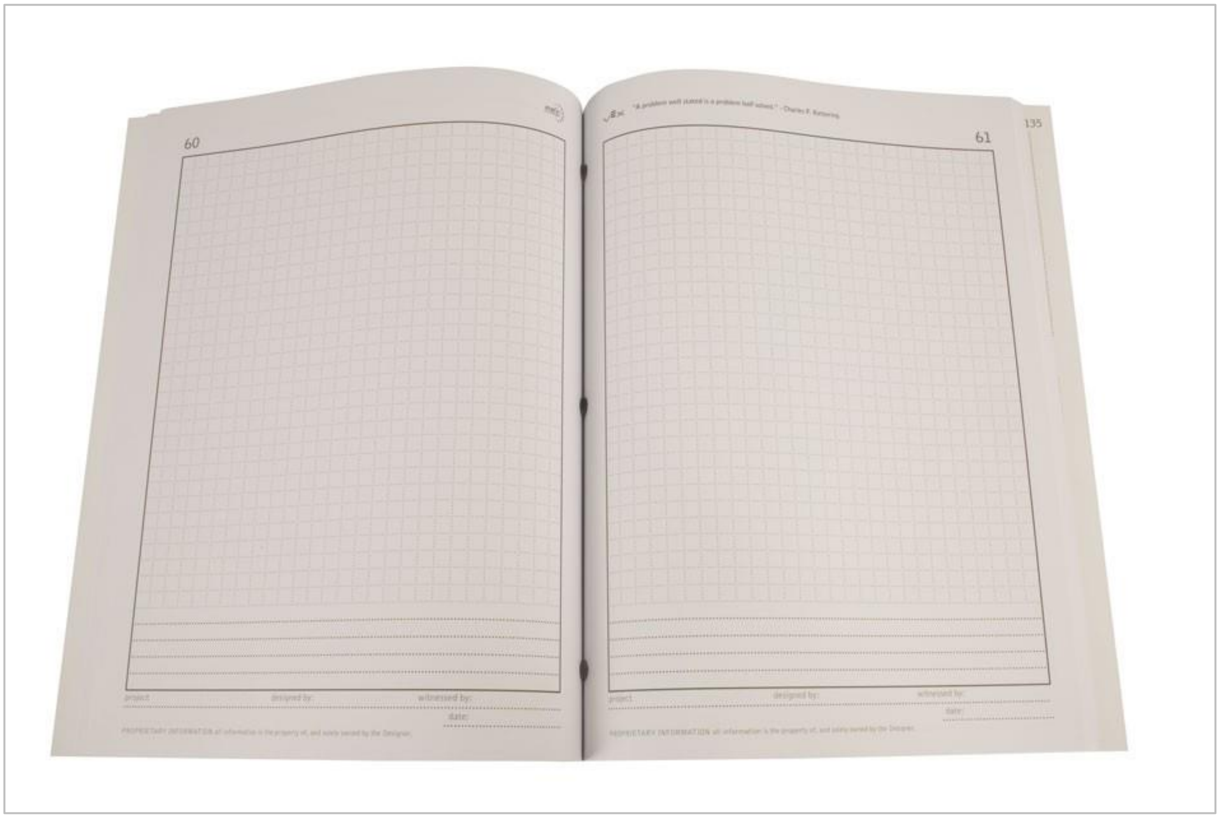
2. Reflecting on the Design of Your Tower



A tower on the Earthquake Platform

Now that you have built the initial version of your tower, take a step back and reflect on your design. Consider all of the parts of your tower's design and how they work together.

3. Writing in your Engineering Notebook



Engineering Notebook

The Recorder will document the progress of the design in the engineering notebook. Take a moment to write the following in the engineering notebook:

- Today's date
- The name of your project (for example, "Tallest Tower")
- Names of everyone who worked on the project (you, teammates, etc)
- A one or two line description of what you built
- Two or three things you like about your design
- Two or three things that you don't like about your design
- Two or three things you would improve on your design if you had more time

Reinforcing or Bracing Structures

Examples of how steel structures use reinforcement for stability

Reinforcing Your Design

Steel structures like the ones pictured have several connections between the main structure. This allows the design to be strengthened and creates more stability. If the main structures were only connected in one area, then it will be at risk for failure if that one connection fails.

This is why you will find structures like buildings, bridges, and homes have several braces to reinforce their structure.

Iterative Design

The big, bad wolf tries to blow down the three little pigs' houses.

Improving Your Design

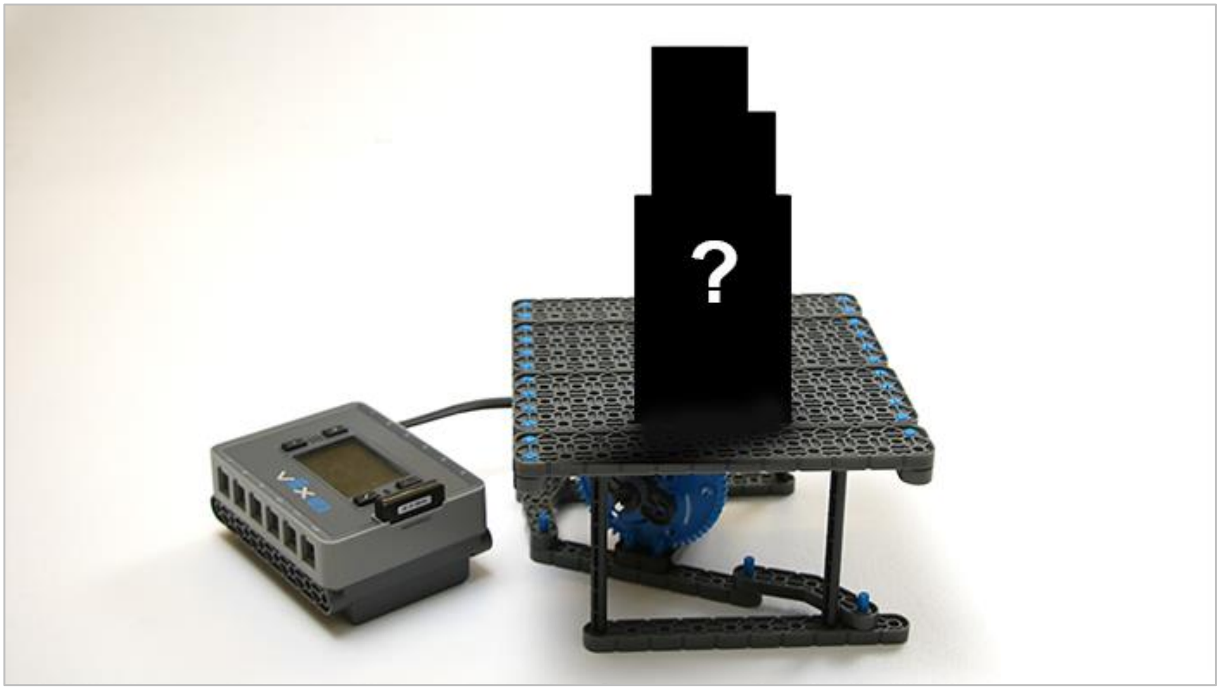
In the children's story The Three Little Pigs, the pigs build houses to protect themselves from a wolf. Each pig uses a different material to build their house: straw, sticks, and bricks. The wolf tries to blow down the houses with his powerful breath.

The house made of straw gets blown down immediately. It is not strong enough to withstand the wolf's breath. The house made of sticks is a little stronger, but also falls down. The brick house withstands the wolf's power, and the wolf gives up.

To make sure your building is as strong and sturdy as you want, you should try multiple different designs. Test your first design and see what works and what doesn't. Write down your ideas, then make some changes that you think might improve the design. Test again and see what happens. This process is called *iterative design*. After several versions (*iterations*) of your design, you will find out what ideas work better, and what to avoid.

Round 2: Improve Your Design

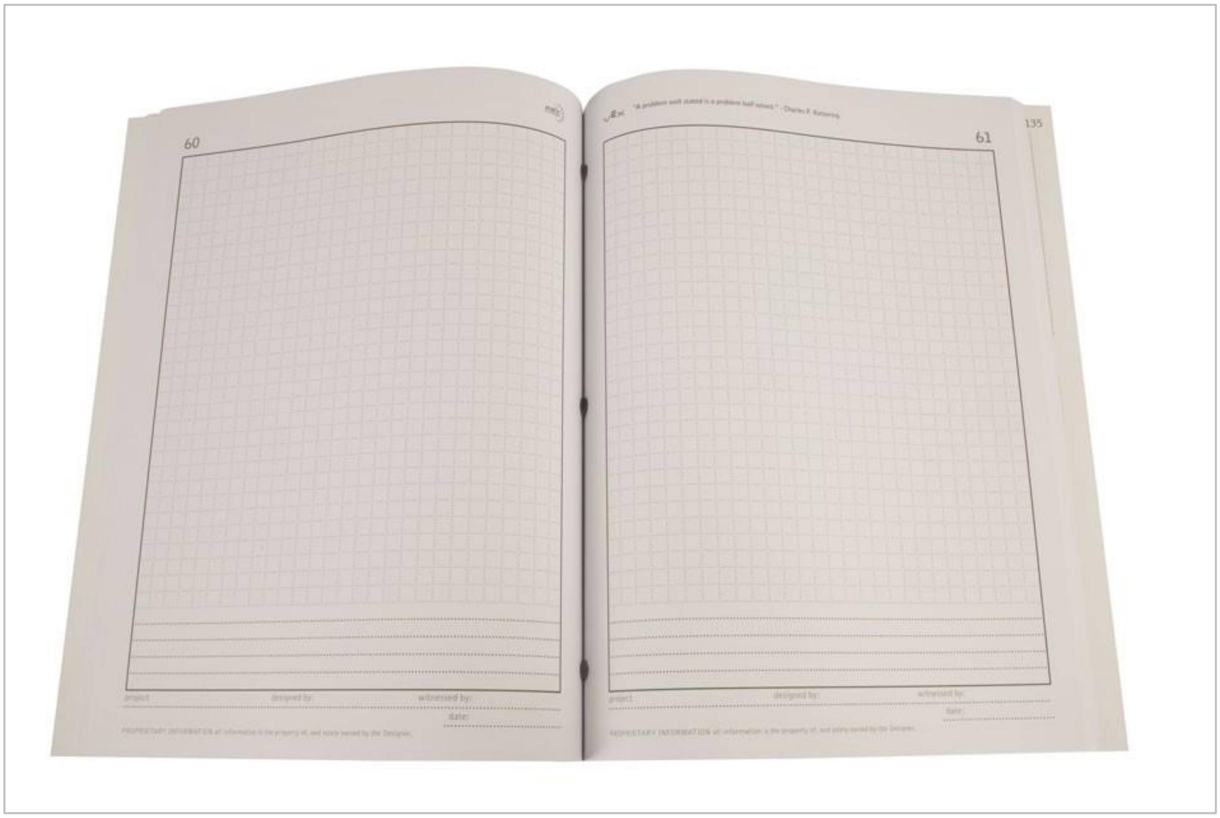
4. Improving Your Tower



A tower on the Earthquake Platform

Take 15 minutes and improve your tower to be as tall and strong as possible.

5. Recording Your Findings



Engineering Notebook

Now that you have made improvements to your design and built your new tower, the Recorder should take a moment to add the following to the engineering notebook:

- Today's date
- A one or two line description of the improvements you made
- Two or three things you like about your design
- Two or three things that you don't like about your design
- Two or three things you would improve on your design if you had more time

SPARK

APPLY

Become a 21st century problem solver by applying the core skills and concepts you learned to other problems.

How Skyscrapers Are Made

The different shapes of skyscrapers in a city make a unique skyline

Strength and Shape are Important

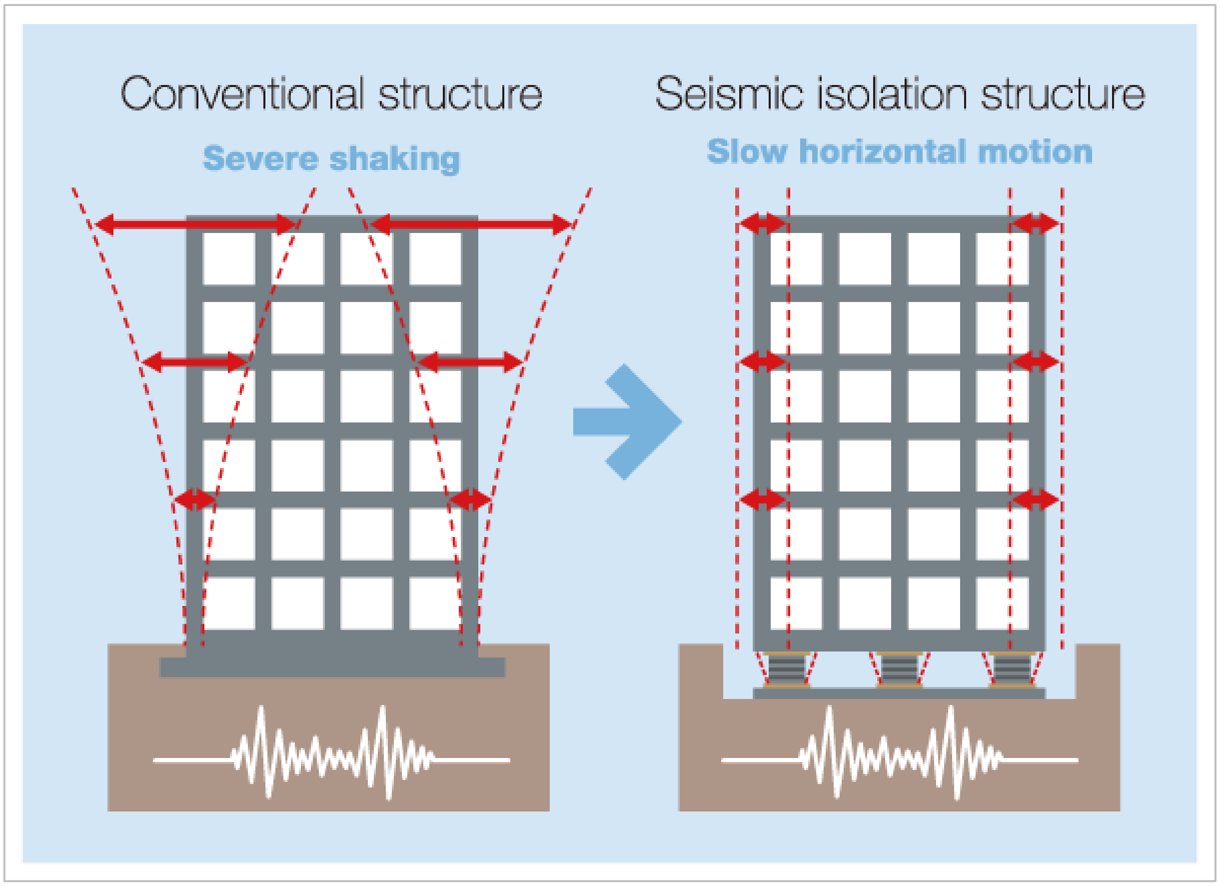
Seeing buildings tall enough to pierce through the clouds is awe-inspiring. As technology improves, humans build skyscrapers that are even taller than before.

Building tall buildings means overcoming gravity. Early humans used very heavy materials like stone to make strong buildings. Stone buildings cannot be skyscrapers though, because the structure cannot support that much weight. Inventions like steel and concrete, and techniques for using them together in building foundations allow buildings to reach skyscraper heights.

The shape of the building also matters. In the picture, you can see that the buildings are never wider at the top than at the bottom. A building's base needs to support the weight and also stay balanced. Natural events such as wind and earthquakes could cause the building to sway. Buildings with a wider top than their base could topple over! They must be strong and also stable to stand upright for a long time.

San Francisco and Seismic Isolators

San Francisco, in the United States of America



Normal buildings are not designed to withstand shaking. Adding seismic isolation makes them sturdier in an earthquake.

Seismic isolation helps prevent major catastrophes!

Conventional buildings are constructed with the foundation laid right into the ground. Buildings built this way will shake with the earth if an earthquake occurs there. This would cause extensive damage due to the severe shaking motion.

Seismic isolation (or *base isolation*) is when the building is built on top of pads or flexible bearings. When the building is built this way, the building structure is resting away from the ground. This allows the entire building to move in a slow horizontal motion during earthquakes. Reducing the shaking makes the building safer and sturdier in an earthquake.

Many cities in the world commonly have earthquakes, such as San Francisco. Builders there design buildings to use base isolators to make them safer. Even though this costs more money to do, the added safety is worth the cost.

Designing Stable Robots for Competitions

Stability is a valuable component of robot design

The importance of stability with competition robots

Competition robots are moving objects that must have the ability to extend, lift, and move quickly without tipping over. According to the rules, teams are not allowed to touch their robot after a match begins, so it is important to consider stability when designing a competition robot. If the robot tips over and is unable to right itself again, the team has likely lost the match.

Teams need to consider the features of their robots that are related to their stability:

- Center of gravity
- Wheel placement

- Traction
- Speed
- Strength
- Height
- Width

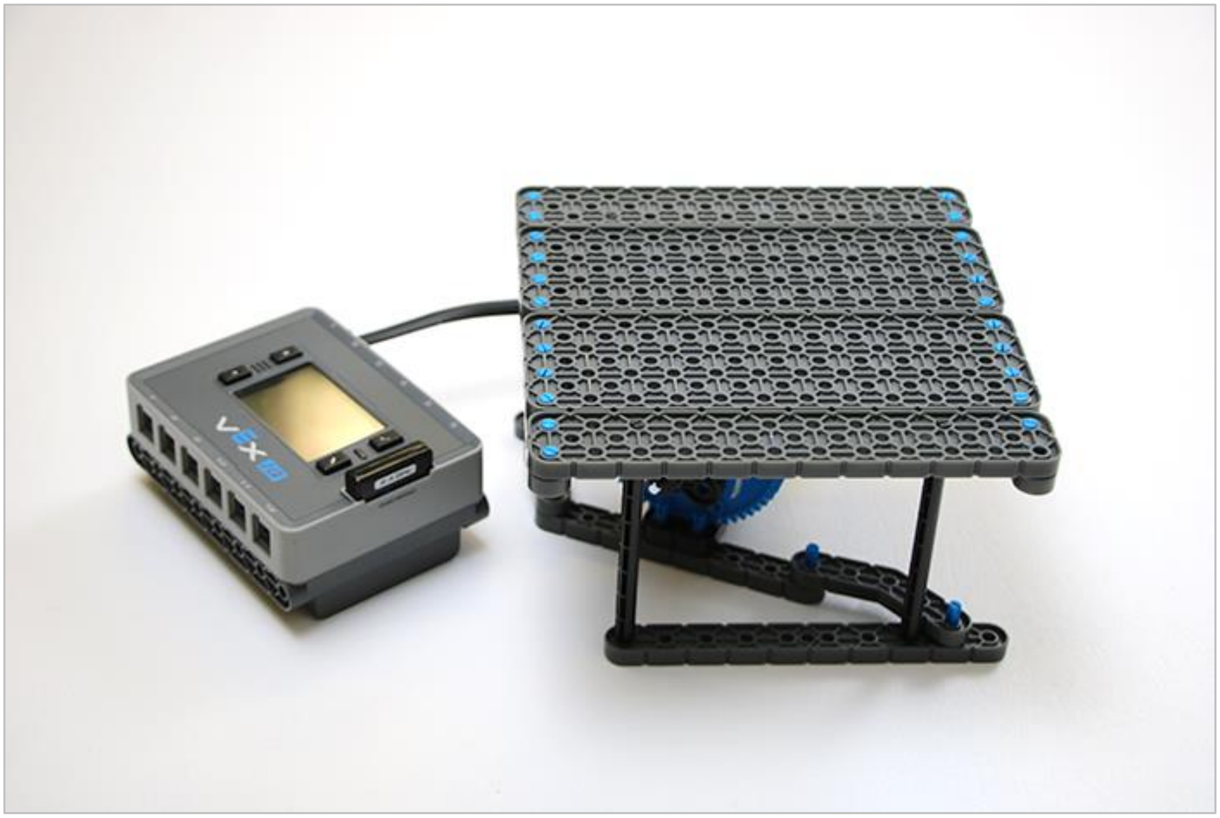
It is good practice to map out a plan and sketch your design in an engineering notebook prior to building your robot as it is likely that many iterations will be needed to find the design that works best.

SPARK

RETHINK

Is there a more efficient way to come to the same conclusion? Take what you've learned and try to improve it.

Prepare for the Tower Strength Challenge



The Earthquake Platform

Running your Earthquake Platform

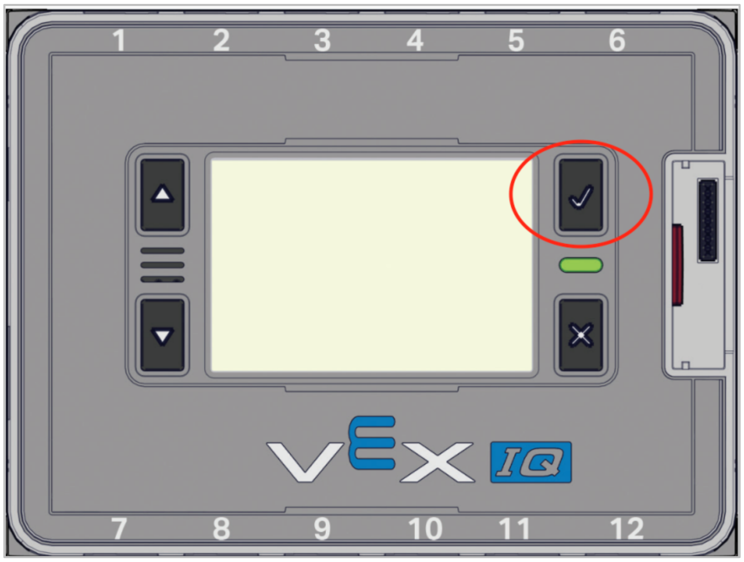
This challenge will require you to run the Earthquake Platform. The Earthquake Platform uses the Device Info feature of your VEX IQ Robot Brain to activate and deactivate the motor. No programming is needed!

Set up the Earthquake Platform

6. Connecting the Earthquake Platform

The Builder should check that the Earthquake Platform is ready with a charged battery and that the Smart Motor is properly connected to Port 1 on the VEX IQ Robot Brain.

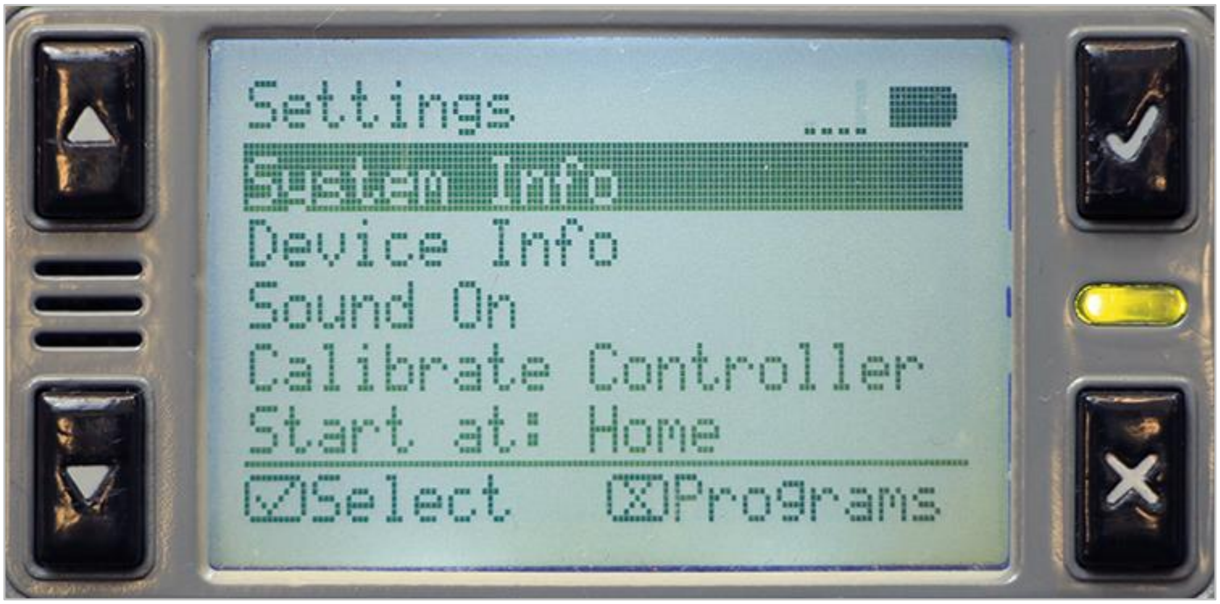
7. Powering on your Robot Brain



A powered off Robot Brain screen

The Tester can now operate the Robot Brain and press the Check button to power on the Robot Brain.

8. Opening the Settings menu



The top-level Settings menu

Press the X button until you arrive at the Settings menu.

9. Opening the Device Info menu

The Device Info option

Use the arrow buttons to navigate down to the 'Device Info' selection on the Settings menu and press the Check button.

10. Viewing a Connected Smart Device

The Device Menu for Port 1 with a Smart Motor connected

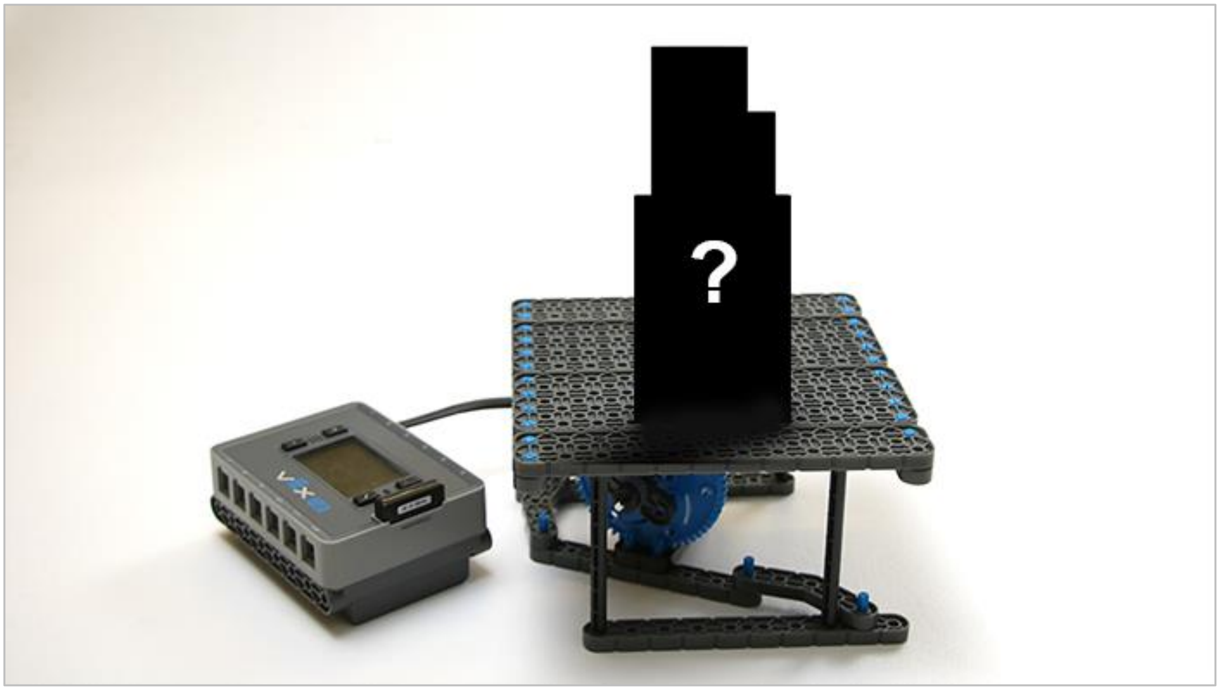
You can use the up and down arrows to navigate through the Smart Devices that you have connected.

11. Activating the Motor

The Device Menu for Port 1 with a Smart Motor connected

The Tester should press the Check button again to activate the motor. Press X to stop it at any time, and press the Check button again to restart it.

Tower Strength Challenge



An example of a tower on top of the Earthquake Platform

Test Your Strength!

The Tower Strength Challenge will have you test the stability of your tower to see if it can withstand the shaking while placed on top of the Earthquake Platform.

All group members should check that the tower meets these standards:

- Must be able to withstand a simulated earthquake that lasts 30 seconds.
- Should use parts from your kit only (no glue, paper, etc.).
- Should stand on its own (no hands!).
- Should be as tall is possible!

The Tower Strength Challenge:

- The Builder should check that the Earthquake Platform is ready.
- The Tester should place the tower on the platform and make the platform shake.

- The Recorder should time how long the tower remains standing and intact and record the time and other observations in the engineering notebook.

Additional Challenge: Create a tower that can hold four wheels with tires at the top while withstanding a simulated earthquake for 30 seconds.

Improve and Tinker with Your Build

Now that you have completed the Tower Strength Challenge, answer the following questions in your engineering notebook. If you are working in groups, have the Recorder document your group's answers.

- What part of the tower seemed to be the strongest during the challenge? What part failed or seemed weak? Why do you think those parts were strong/weak?
- Now that you have considered the tower's strengths and weaknesses, rebuild and improve the tower so that it would perform better if you were to repeat the Tower Strength Challenge. What steps will you follow to change the build? Explain with details and/or sketches.
- Run the Tower Challenge again with the new build. Did your changes make the build more structurally sound? Explain the results.

Understand the core concepts and how to apply them to different situations. This review process will fuel motivation to learn.

Review

1. **Structures were only able to be so tall until the invention of...**
    - ○ Rubber
    - ○ Steel
    - ○ Glue
    - ○ Brackets

2. **Due to the number of earthquakes that happen in San Francisco, many of the buildings use the following to reduce damage:**
    - ○ Rubber-Coated Steel
    - ○ Seismic Windows
    - ○ Minimalist Design
    - ○ Seismic Isolators

3. **Reinforcing your structure...**
    - ○ Creates stronger connections.
    - ○ Increases stability of a structure.
    - ○ Creates additional connections in case of one failing.
    - ○ All of the answers are correct.

4. **Iterative Design is when...**
    - ○ You try to make a design once.
    - ○ You plan the different versions you are going to create.
    - ○ You create, test, and revise your design several times.
    - ○ None of these answers is correct.

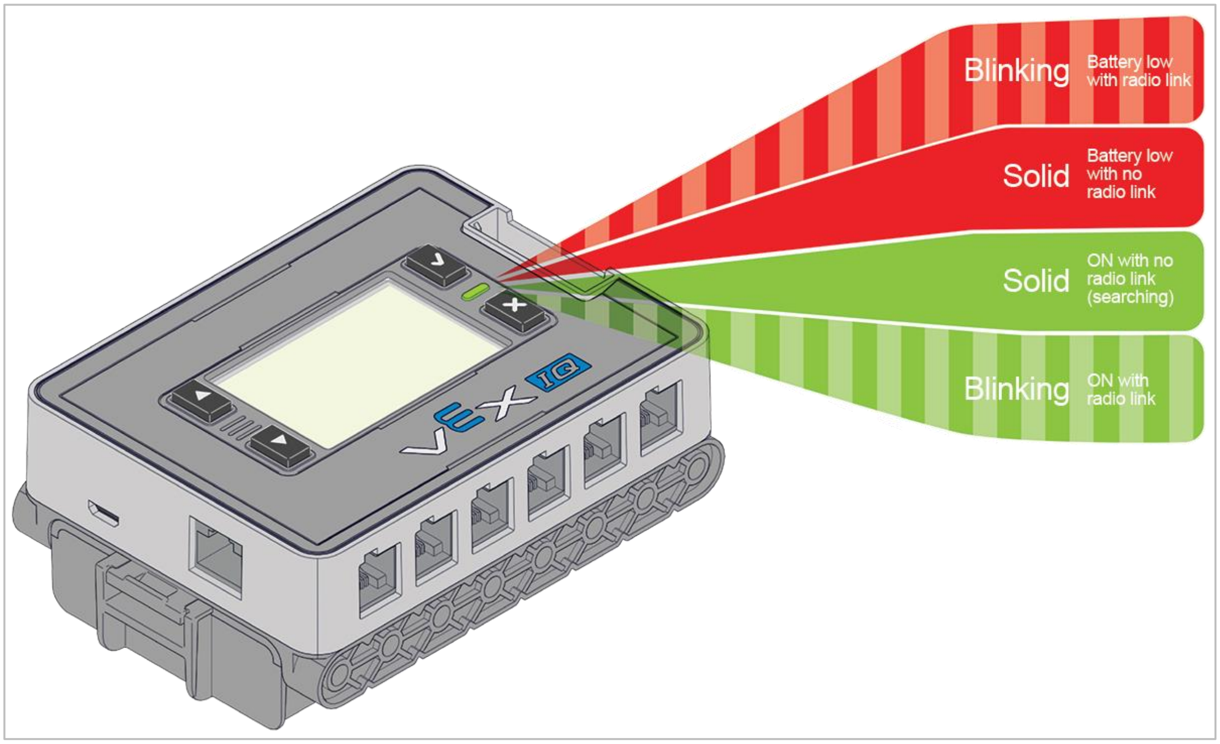
5. **True or False: Skyscrapers typically are made so that the top is wider than the base to ensure stability.**

- False
- True

APPENDIX

Additional information, resources, and materials.

Brain LED Status

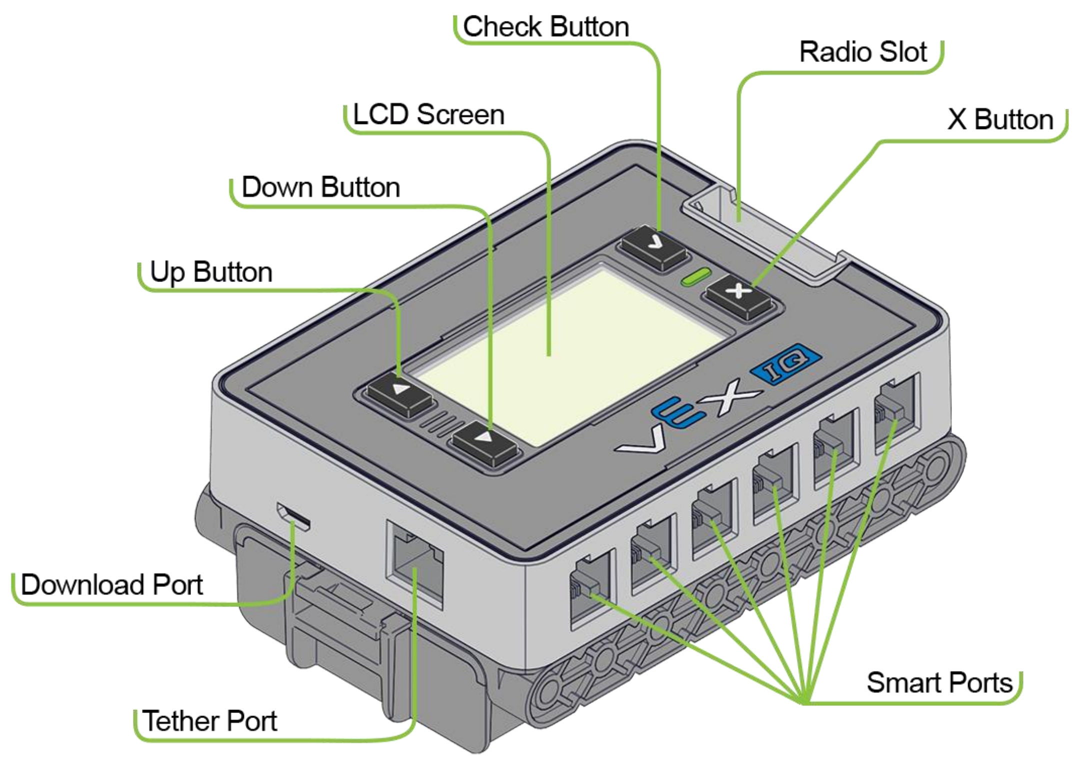


Robot Brain LED states

The Robot Brain LED can appear in four different states:

- Blinking Red — The battery is low but the Robot Brain has a connection to a radio link.
- Solid Red — The battery is low and the Robot Brain does not have a connection to a radio link.
- Solid Green — The Robot Brain is ON, the battery has a charge, but the Robot Brain does not have a connection to a radio link. It is currently searching for one.
- Blinking Green — The Robot Brain is ON, the battery has a charge, and the Robot Brain has a connection to a radio link.

Brain Overview



Overview of the Robot Brain and its buttons and ports

How to use the Robot Brain

Power

- To turn ON the Robot Brain, press the Check button.
- To turn OFF the Robot Brain, press and hold the X Button until the Robot Brain powers down.

Navigation

After the Robot Brain is ON, you can navigate through the interface using the following buttons:

- **Up Button** - Moves your menu selection up
- **Down Button** - Moves your menu selection down
- **Check Button** - Enters or selects the highlighted item
- **X Button** - Returns to the previous screen or cancels current operation

Radio Slot
The Radio Slot is used to hold a Radio to enable wireless communication between the Robot Brain and the VEX Controller.

Smart Ports
The Smart Ports act as inputs or outputs and can be used with VEX IQ Smart Devices to control motors, or get readings from sensors.

Tether Port
The Tether Port allows you to connect your VEX Controller directly to the Robot Brain.

Download Port
The Download Port allows you to connect the Robot Brain to your computer.

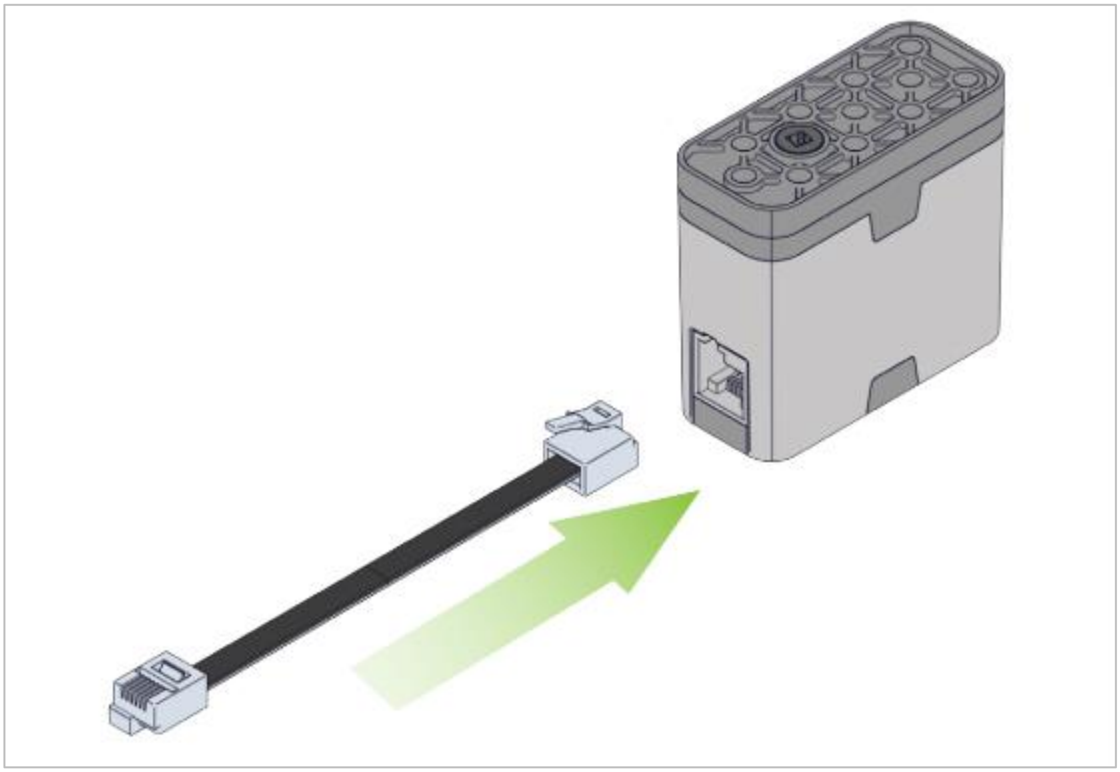
Disconnecting a Smart Device

In this section you will learn how to disconnect a Smart Device.

Hardware/Software Required:

Amount	Hardware/Software
1	Smart Motor 228-2560
1	Smart Cable 228-2780

1. Disconnecting a Smart Device



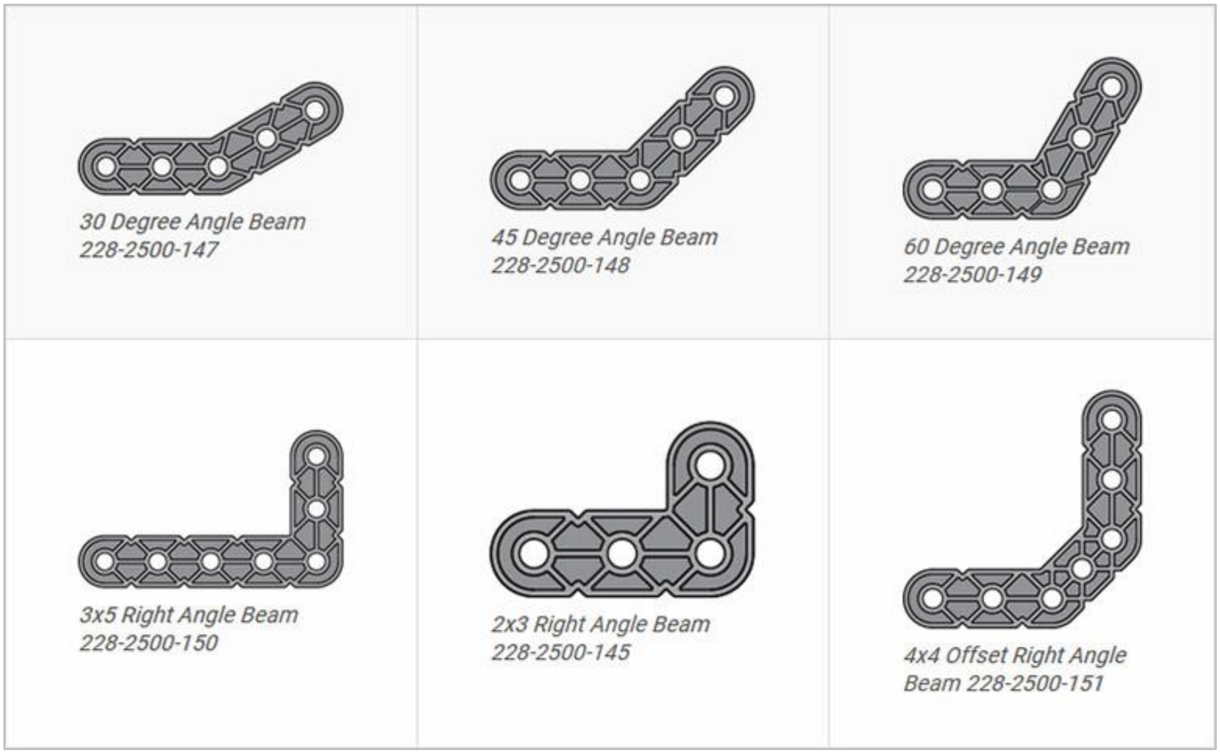
Connecting a Smart Cable to a Smart Motor

To disconnect a Smart Device, push down on the Smart Cable tab while gently pulling out on the Smart Cable.

Conclusion:

Now you know how to disconnect your Smart Devices from any of the 12 ports on the Robot Brain.

Identifying Angle Beams



How to Identify the Different Angles of the Angled Beams

There are four different types of beams that have a bend at an angle: 30^o Angle Beams, 45^o Angle Beams, 60^o Angle Beams, and Right Angle (90^o) Beams. There are also three types of Right Angle Beams: 3x5, 2x3, and Offset. The best way to tell which angles are which is to stack the beams on top of each other. Then you can compare how they look. You can also use a protractor to measure the angle of the beam.

Installing a Robot Battery

In this section you will insert the Robot Battery into the Robot Brain.

Hardware/Software Required:

Amount	Hardware/Software
1	Robot Battery 228-2604
1	Robot Brain 228-2540

1. Inserting the Battery

The Robot Battery is inserted into the Robot Brain

Orient the battery as shown in the figure and insert the Robot Battery into the Robot Brain.

2. Ensuring Proper Battery Placement

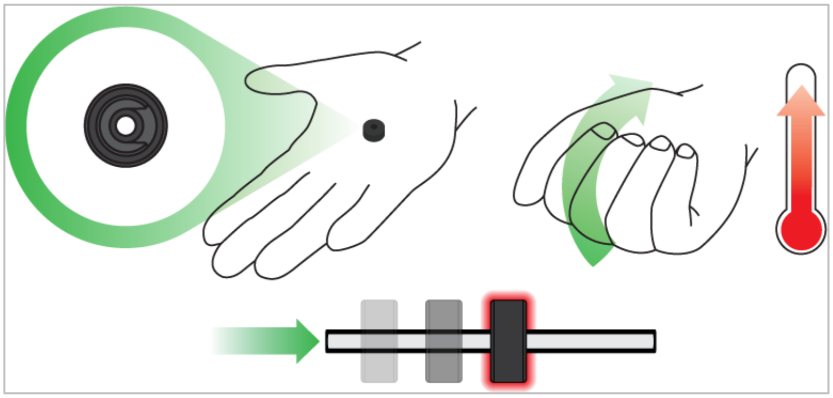
The Robot Battery is securely placed into the Robot Brain

The Robot Battery should make a click to ensure that it has been inserted correctly into the Robot Brain.

Conclusion:

In this section you inserted the Robot Battery into the Robot Brain.

Installing Rubber Shaft Collars



Using your hand to warm a Rubber Shaft Collar

Rubber Softens as it gets Warm

Hold the Rubber Shaft Collars in your hand for 15-30 seconds before you slide them onto a shaft. Holding the Rubber Shaft Collar in your hand will warm and soften the rubber to make it easier to slide onto a shaft.

Navigating the Device Information Menu

You can use the VEX IQ menu to view the Smart Motors and sensors connected to the Robot Brain. From here, you can make sure that the devices are working properly.

Hardware/Software Required:

Amount	Hardware/Software
1	VEX IQ Robot Brain with connected Smart Devices

1. Powering on your Robot Brain

A powered off Robot Brain screen

Press the Check button to power on your Robot Brain.

2. Opening the Settings menu

The top-level Settings menu

Press the X button until you arrive at the Settings menu.

3. Opening the Device Info menu

The Device Info option

Use the arrow buttons to navigate down to the 'Device Info' selection on the Settings menu and press the Check button.

4. Viewing a Connected Smart Device

The Device Menu for Port 1 with a Smart Motor connected

You can use the up and down arrows to navigate through the Smart Devices that you have connected.

Conclusion:

Use this menu to check the status of your devices. Notice how the sensor values change when you interact with them, and think of how they might be used in robotic applications.

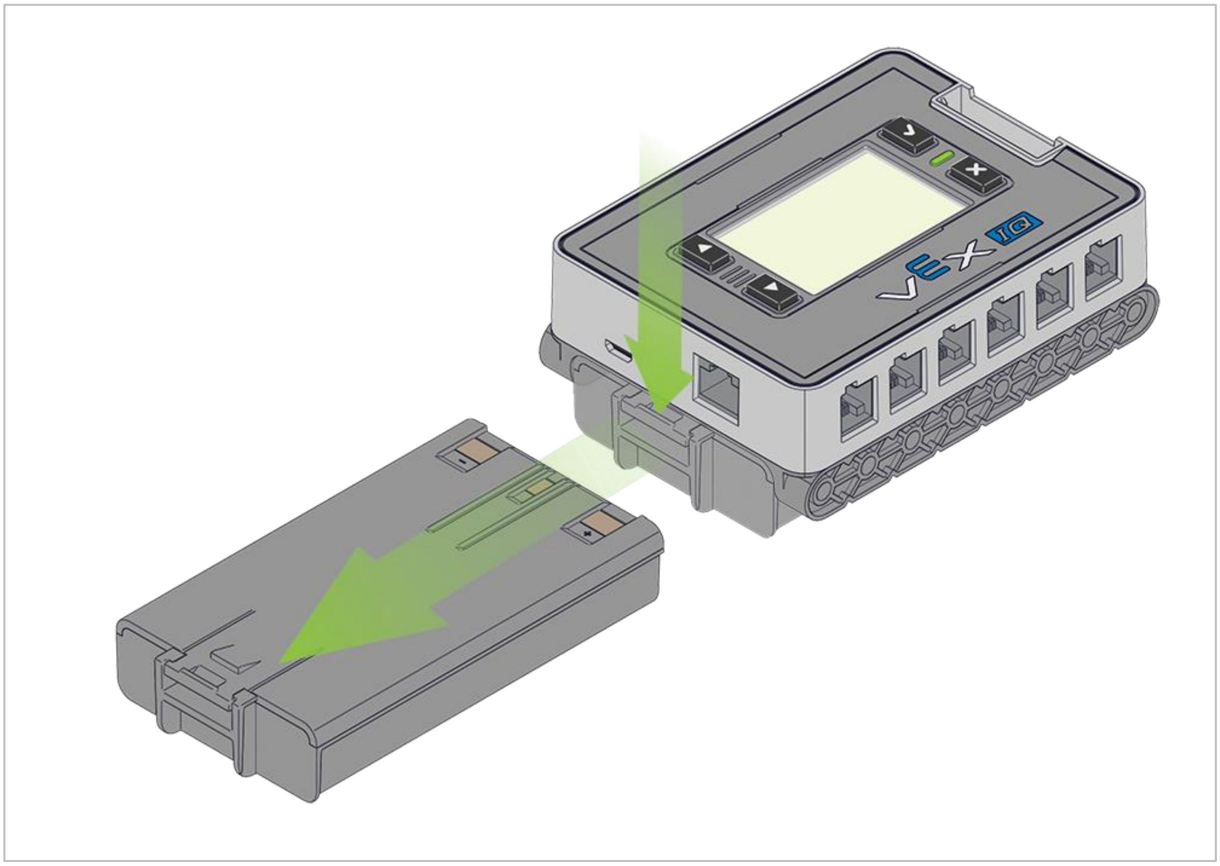
Removing a Robot Battery

In this section you will remove the Robot Battery from the Robot Brain.

Hardware/Software Required:

Amount	Hardware/Software
1	Robot Battery
1	Robot Brain

1. Removing the Battery



Removing the battery from the Robot Brain

To remove the Robot Battery from the Robot Brain, you must press the latch down while pulling the Robot Battery out.

Conclusion:

In this section you removed the Robot Battery from the Robot Brain. It is recommended that you do not leave the battery inside the Robot Brain for an extended period of time. Click here for best practices for preserving the battery's life.

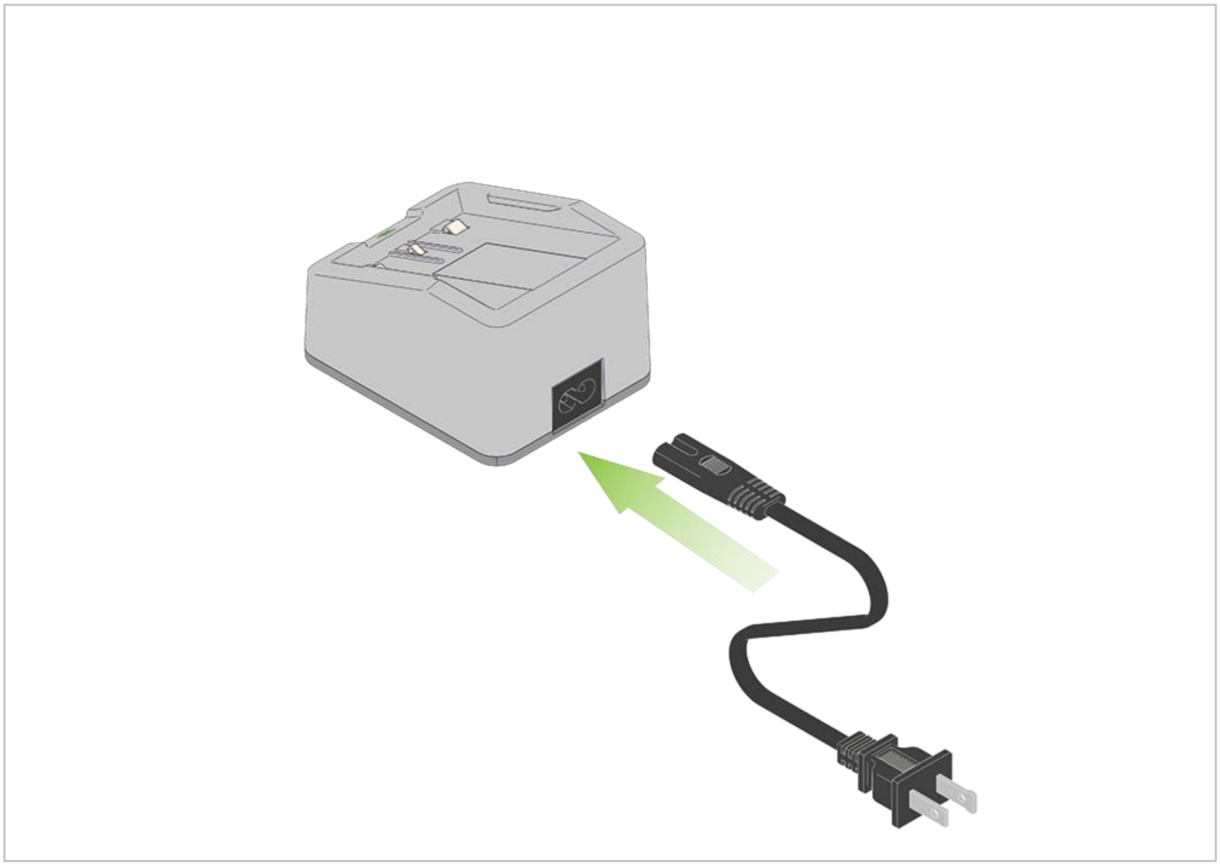
Robot Battery Charging and Usage

In this section you will learn about assembling the Robot Battery Charger and charging the Robot Battery.

Hardware/Software Required:

Amount	Hardware/Software
1	Robot Battery Charger 228-2743
1	Robot Battery Charger Power Cord appropriate for your region
1	Robot Battery 228-2604

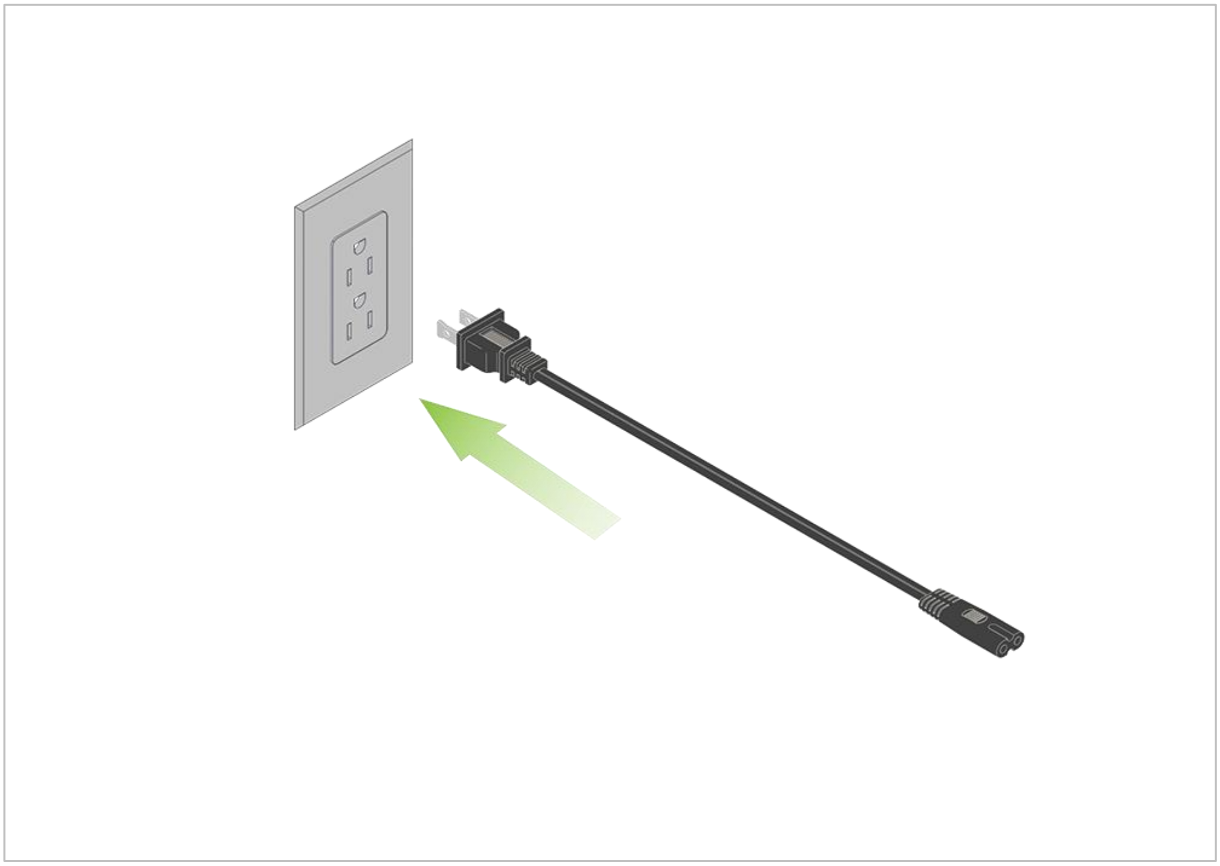
1. Connecting the Cord



The Robot Battery Charger Power Cord connects to the Robot Battery Charger

Connect the Robot Battery Charger Power Cord to the Robot Battery Charger.

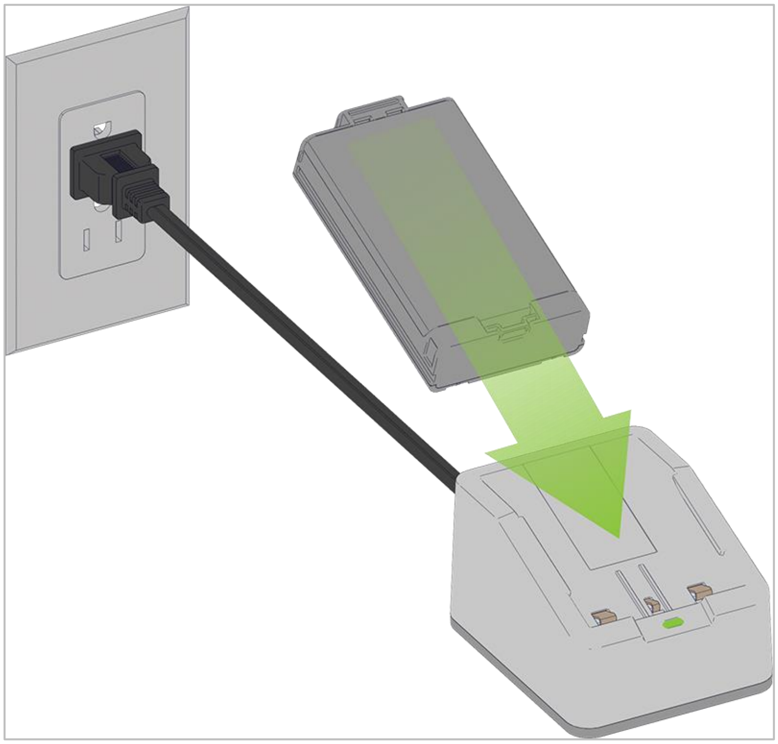
2. Plugging in to an Outlet



The Robot Battery Charger Power Cord connects to a wall power outlet

Plug the other end of the Robot Battery Charger Power Cord to a power outlet.

3. Charging the Robot Battery



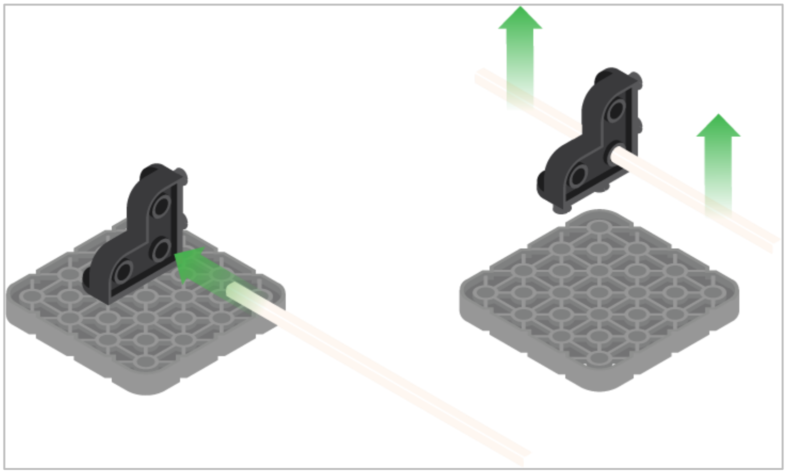
The Robot Battery sliding into the Robot Battery Charger

Slide the Robot Battery into the cradle of the Robot Battery Charger. You should see the light change to red to indicate that it is charging.

Conclusion:

Once the Robot Battery Charger is connected to a power outlet, the Robot Battery can be charged. It may take a few hours to fully charge.

Removing Connectors from Beams and Plates

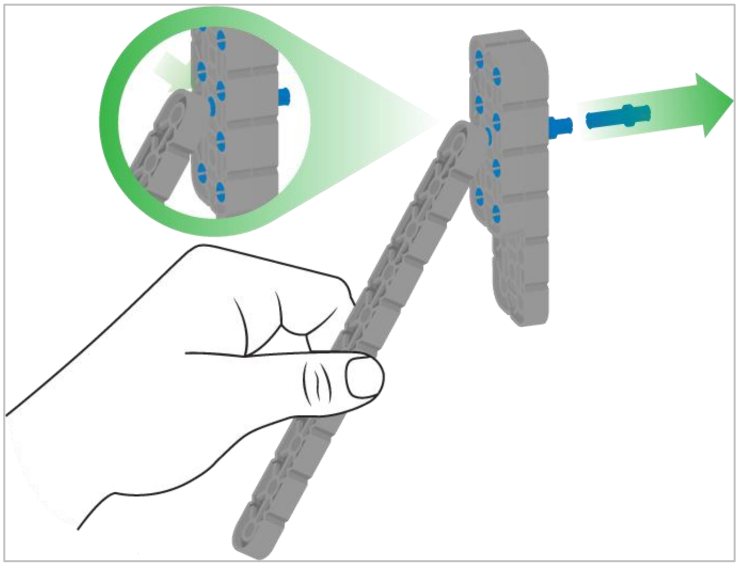


Using a pitch shaft to remove a corner connector

How to Easily Remove Connectors

You can easily remove corner connectors from beams or plates by placing a metal shaft through one of the holes of the corner connector and pulling outward while holding down the beam or plate.

Removing Pins from VEX IQ Beams and Plates


Removing a pin from a plate assembly using a beam

How to Easily Remove Pins from Beams and Plates

You can quickly remove connector pins from beams or plates by pressing a beam against the back of the pin, which partially pushes the pin out, so you can remove it with your fingers. You can use this technique to more easily remove pins from individual plates and beams, or from built structures.

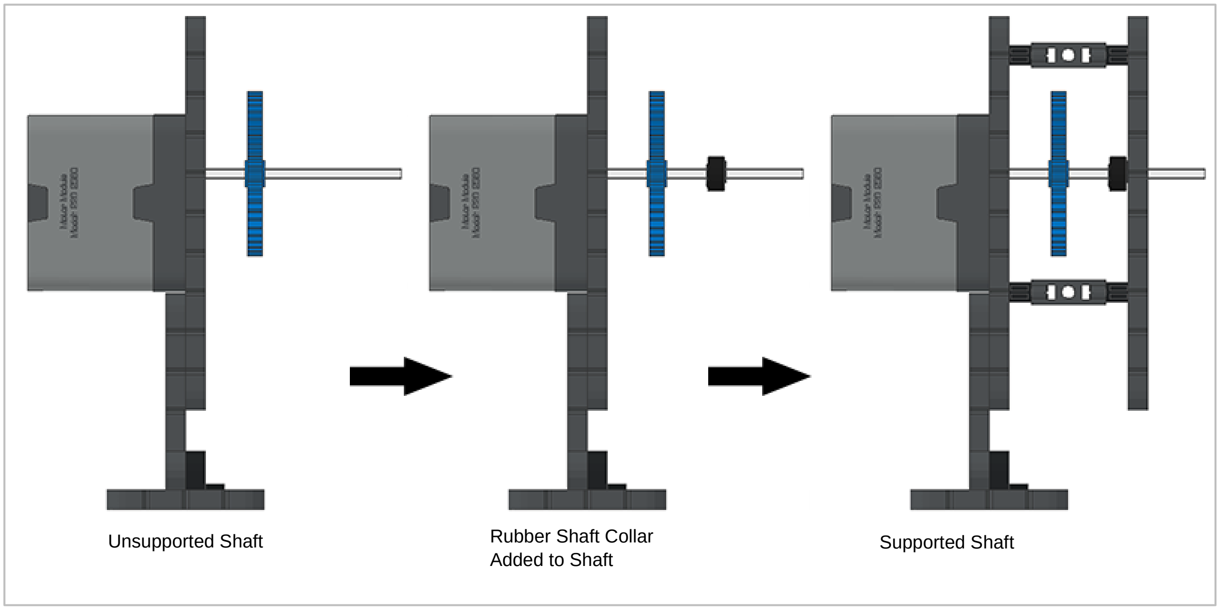
Removing Standoffs from Mini Standoff Connectors

Removal of a standoff from a Mini Standoff Connector

How to Easily Remove Parts from Mini Standoff Connectors

Standoffs and Mini Standoff Connectors can be separated by pushing a shaft through the Mini Standoff Connector. The same technique can be used for parts with similar ends in Mini Standoff Connectors, such as pins.

Supporting Shafts using Rubber Shaft Collars

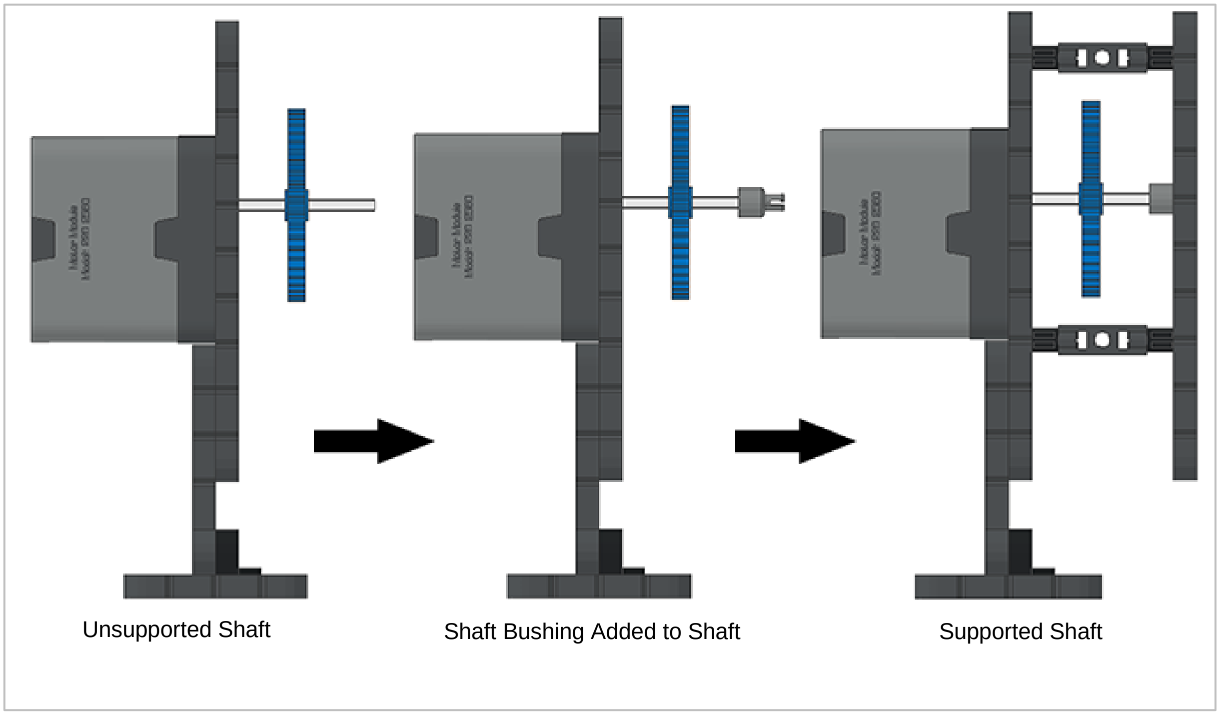


Supporting a shaft with a Rubber Shaft Collar

How to Support Shafts with Rubber Shaft Collars

Shafts can fall out of place or alignment very easily if they aren't supported properly. You can make a shaft more secure and prevent it from falling out of place by putting a Rubber Shaft Collar before the end of it. You can then connect the shaft to a support structure with the shaft collar positioned against it. That will allow the shaft to turn but will prevent it from wobbling or falling out.

Supporting Shafts using Shaft Bushings



Supporting a shaft with a Shaft Bushing

How to Support Shafts Using Shaft Bushings

Shafts can fall out of place or alignment very easily if they aren't supported properly. You can make a shaft more secure and prevent it from falling out of place by putting a bushing at the end of it. You can then connect that bushing into another beam or additional part. That will allow the shaft to turn but will prevent it from wobbling or falling out.