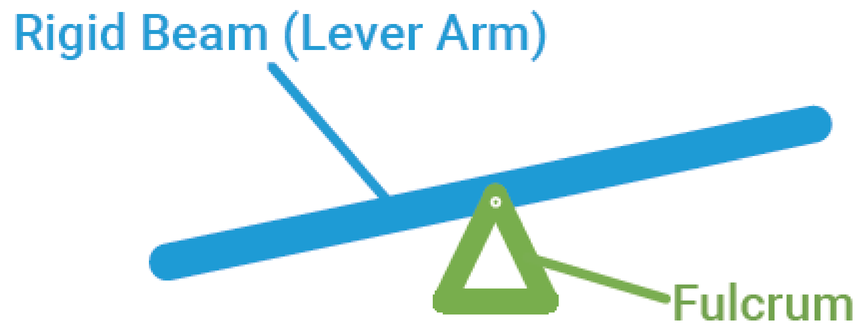
Engineering Discoveries:

Wheels & Levers

The Lever

A lever is a simple machine that consists of a **rigid beam (lever arm)** that pivots on a **fulcrum**. It is used to **redirect motion**, **create mechanical advantage** to make work easier, or **increase output speed** to make a load move faster.

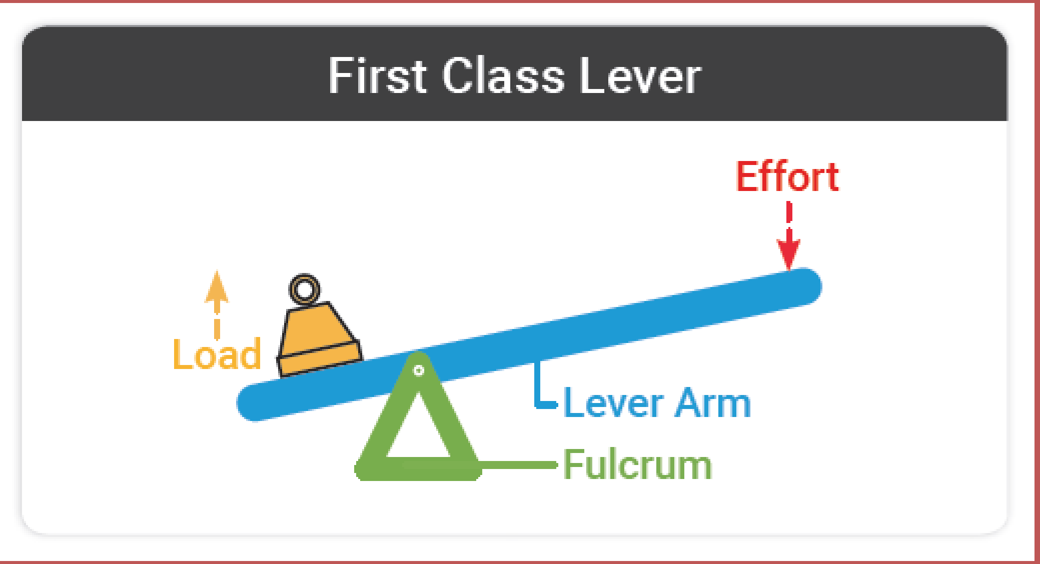


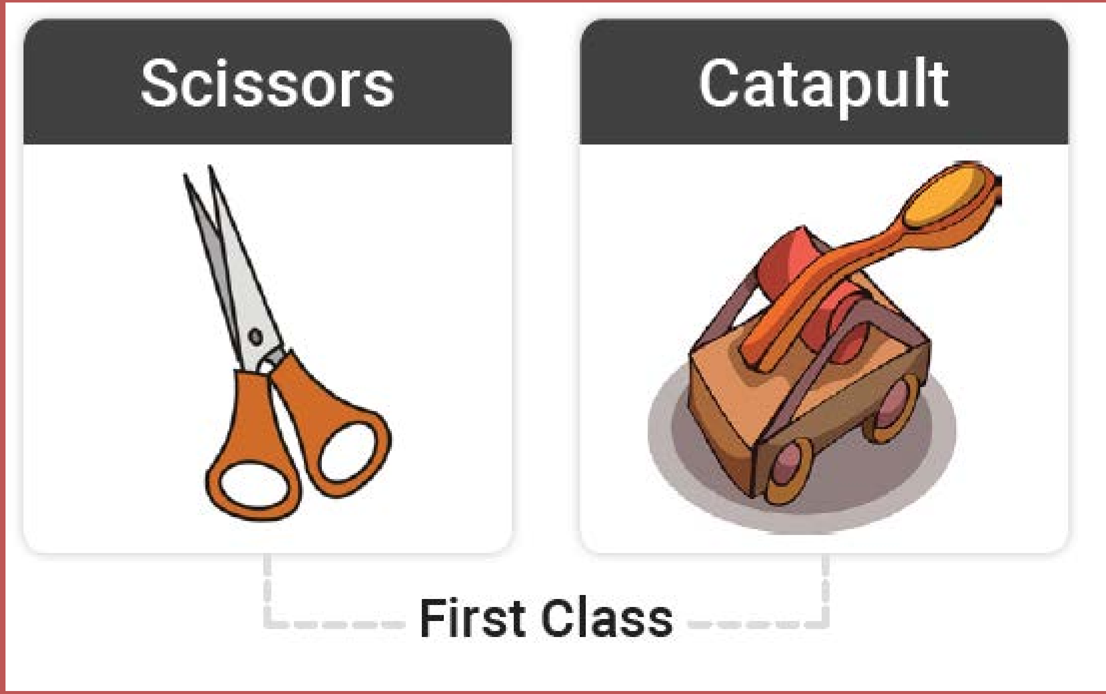
Types of Levers

There are three types of levers, according to where the **load** and **effort** are located in respect to the **fulcrum**.

First Class Lever

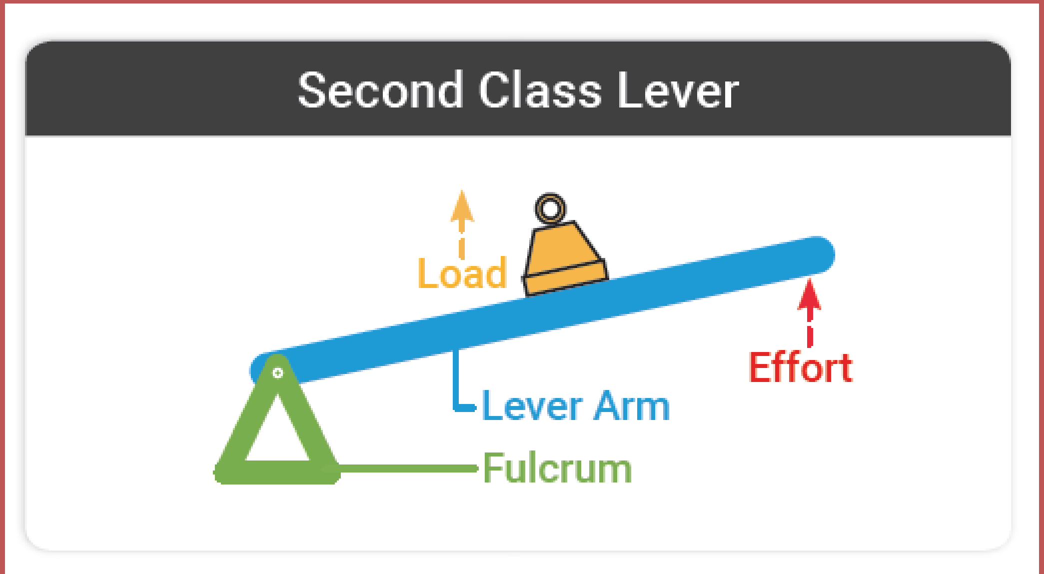
In a first class lever, the **fulcrum** is located between the **effort** and the **load**. A first class lever can be used to reduce the amount of effort needed to raise a load by placing the fulcrum closer to the load, or to increase output speed by placing the fulcrum closer to the effort.





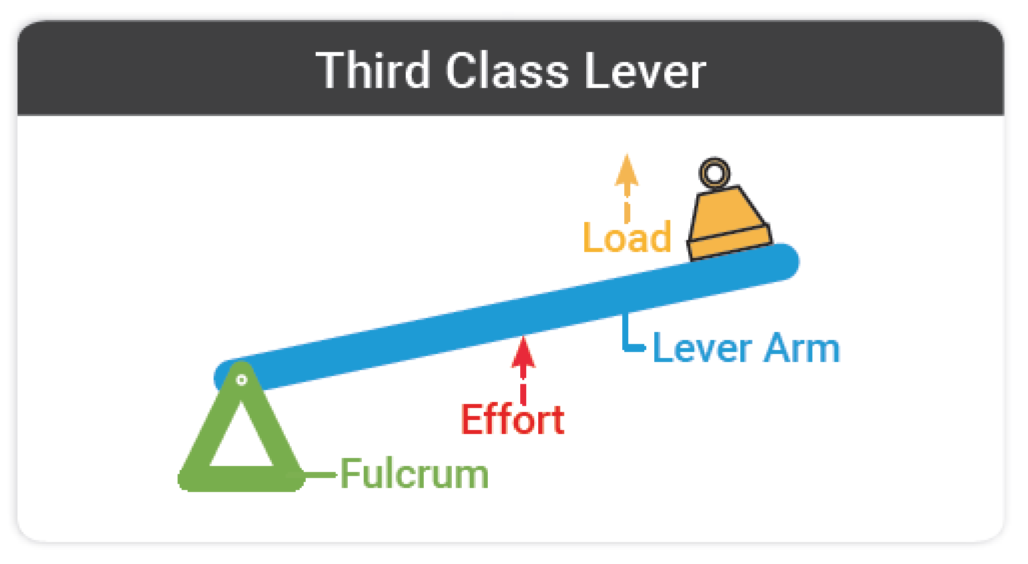
Second Class Lever

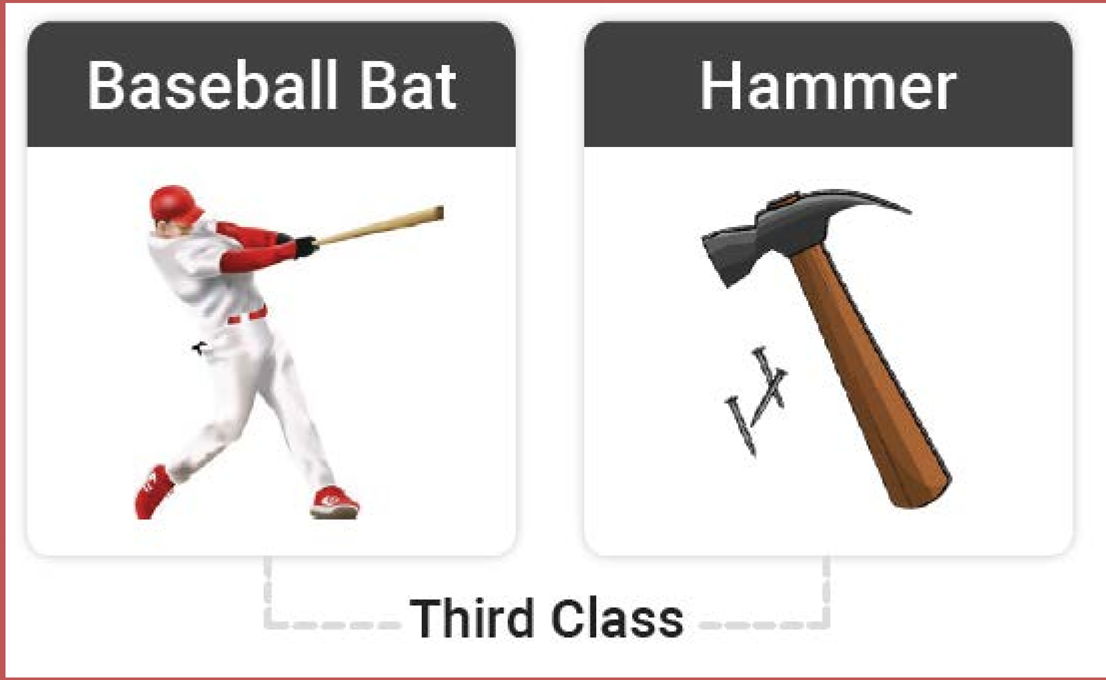
In a second class lever, the load is located between the effort and the fulcrum. The amount of effort needed to raise a load is reduced as the load is placed closer to the fulcrum. A second class lever does not change the direction of motion because the effort and the load move in the same direction.



Third Class Lever

In a third class lever, the **effort** is applied between the **load** and the **fulcrum**. The amount of effort needed to raise the load is reduced as the effort is applied closer to the load. A third class lever is primarily used to increase output speed, which increases as the effort is applied closer to the fulcrum.





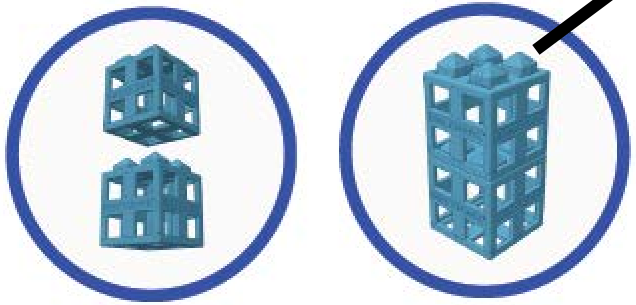
Building Basics

Building Basics with Rokenbok

The following tips will be helpful when using the Rokenbok Student Design and Engineering System.

Connecting/Separating ROK Blocks:

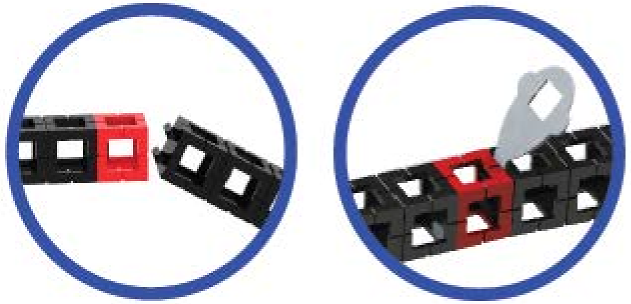
ROK Blocks use a friction-fit, pyramid and opening system to connect. Simply press pyramids into openings to connect.
To separate blocks, pull apart.



Pyramids or connectors

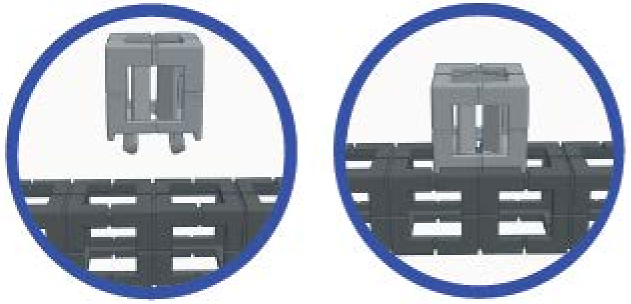
Connecting/Separating Rokenbok Components

Smaller Rokenbok components use a tab and opening system to connect. Angle one tab into the opening, and then snap into place.
To separate, insert key into the engineered slot and twist.



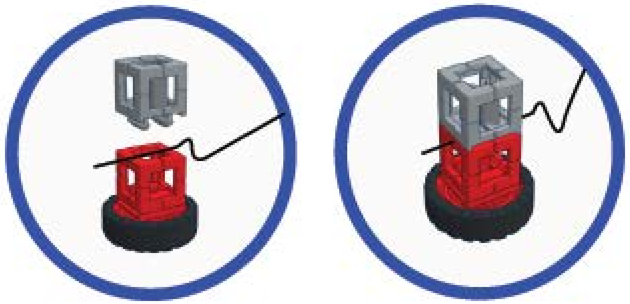
Snapping Across Openings

The tabs on Rokenbok components can also be snapped across openings to provide structural support to a design. This will also allow certain designs to function correctly.



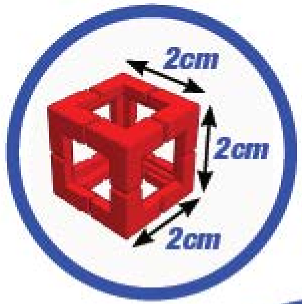
Attaching String:

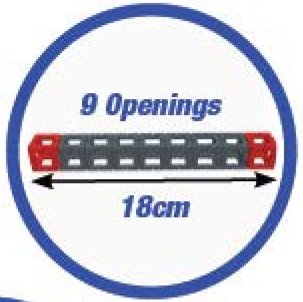
In some instances, string may be needed in a design. Lay string across opening. Snap any Rokenbok component with tabs or pyramids into opening. Make sure tabs run perpendicular to string for a tight hold.



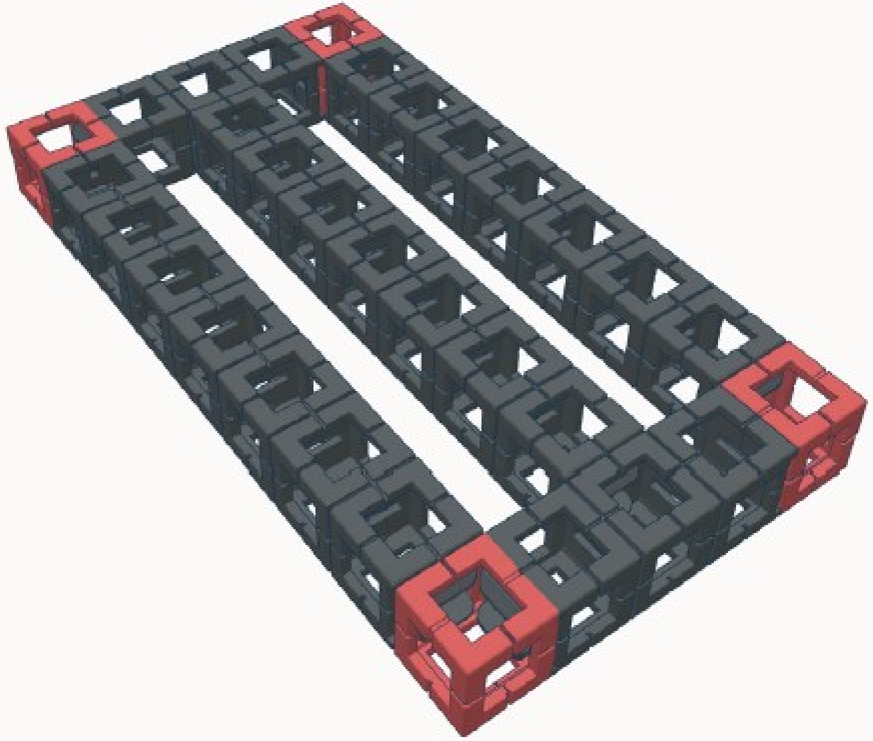
Measuring:

The outside dimensions of each Rokenbok connector block is $2cm^3$. This means the length, depth, and height are all the same.
To determine the size of a Rokenbok build in cm, simply count the number of openings and multiply by two. Repeat this process for length, depth and height.

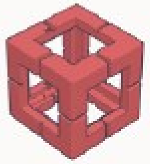




1

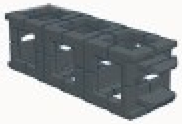


4x
Block

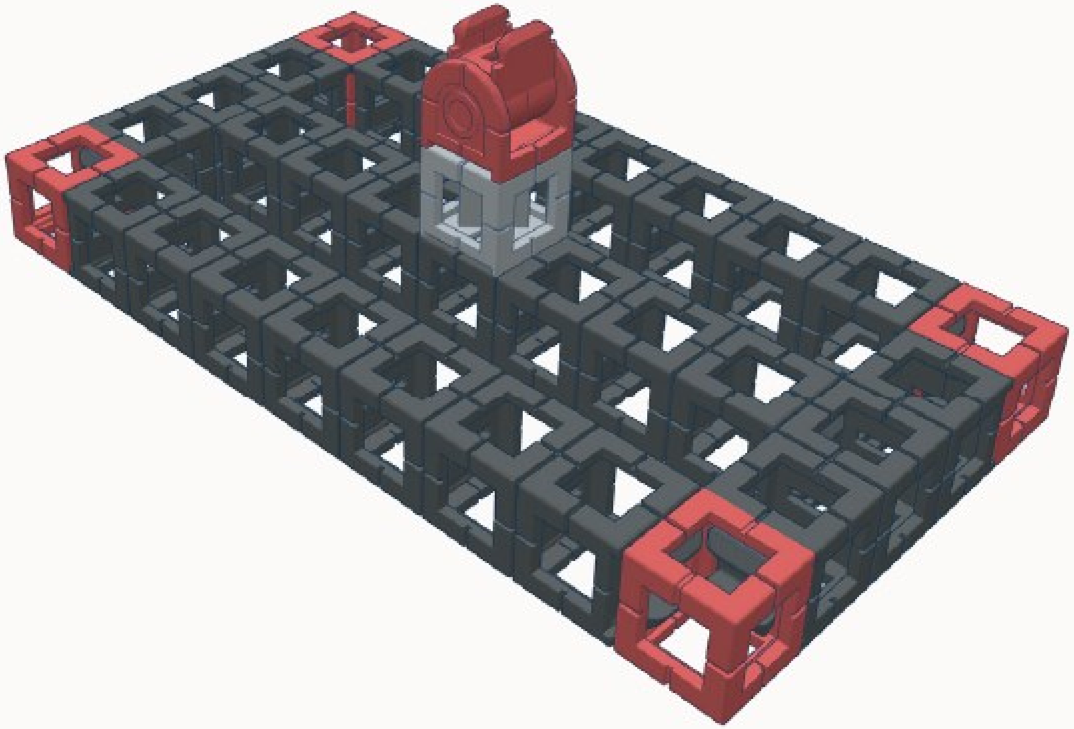


3x
Beam

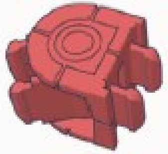
2x
Half Beam



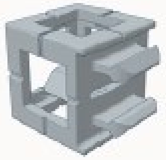
2



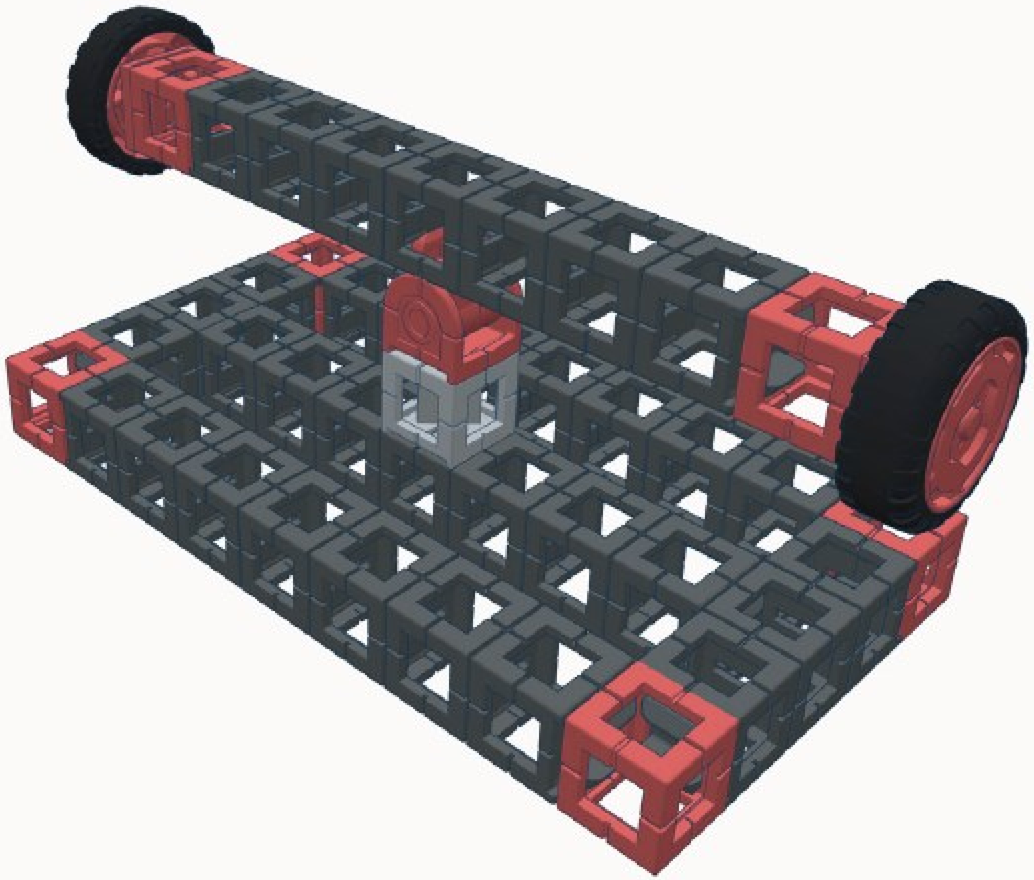
1x
Hinge Block



1x
Single Snap Block

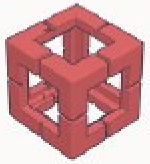


3



2x
Snap-In Wheel

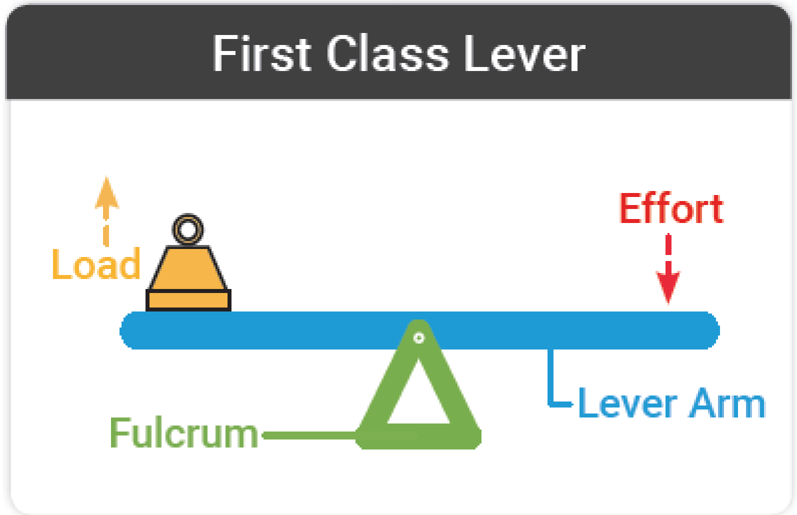
2x
Block

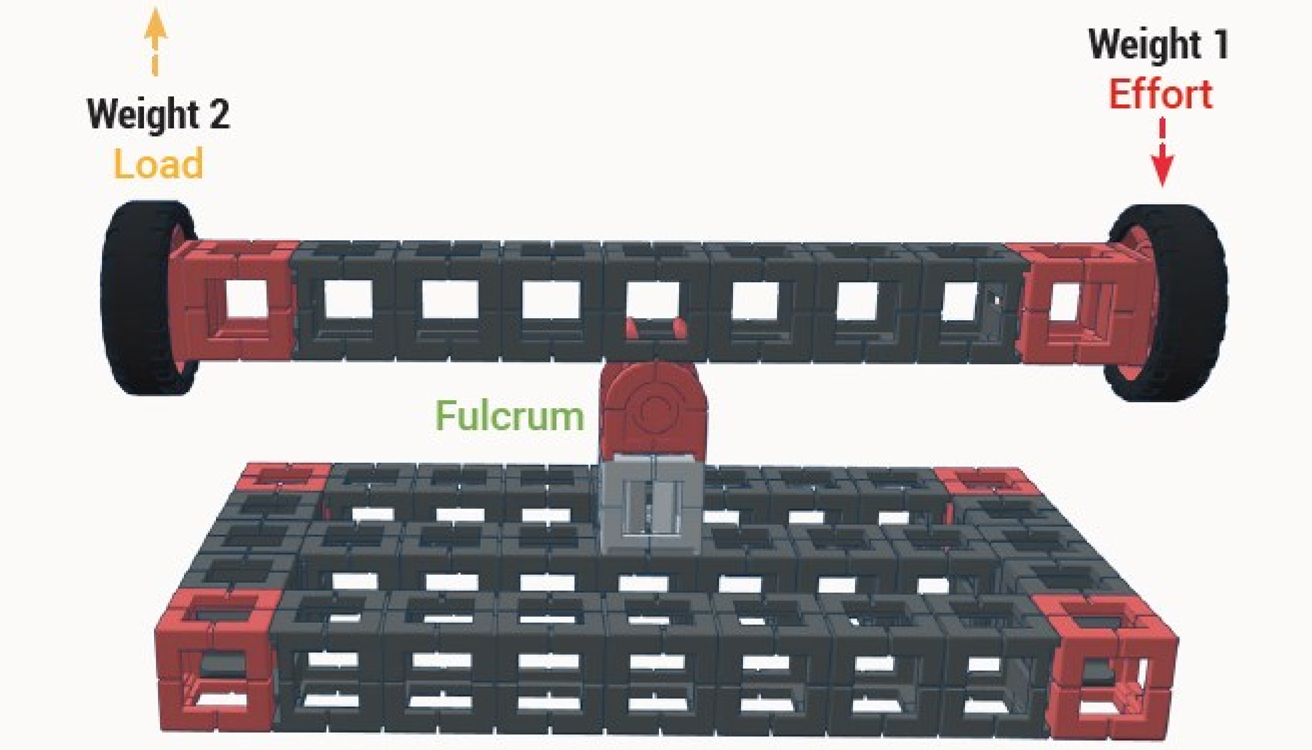


1x
Beam

Testing the First Class Lever

The fulcrum in this example has been centered between **Weight 1** (Effort) and **Weight 2** (Load). Lift **Weight 1** (Effort) as high as possible and let go. Observe how nothing happens. This is because the two weights balance each other equally.

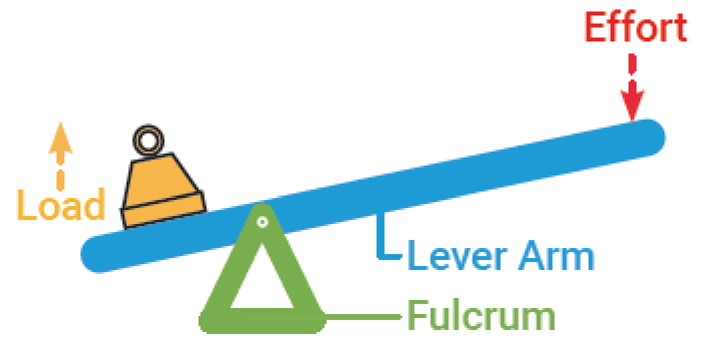


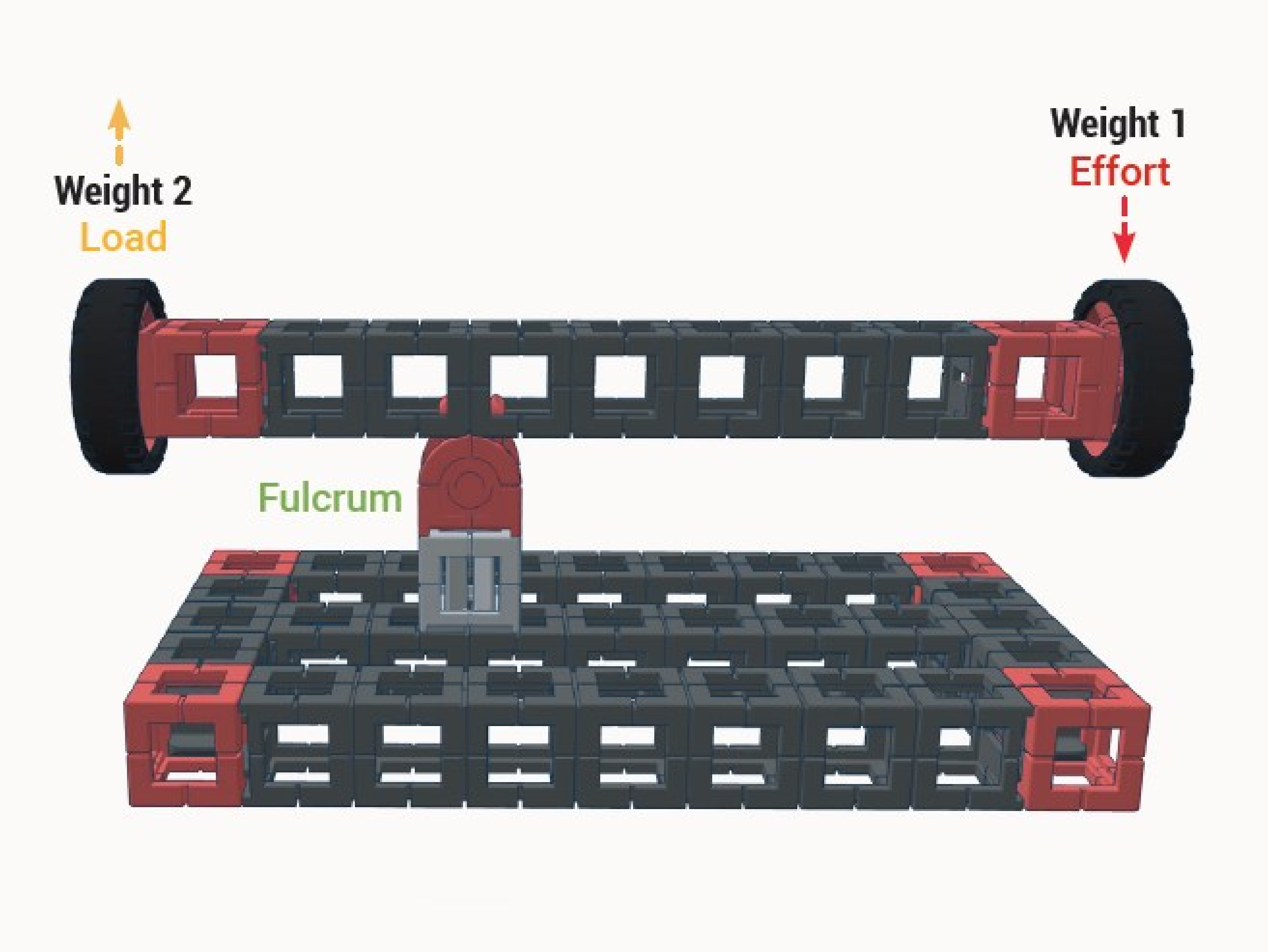


Modifying the First Class Lever

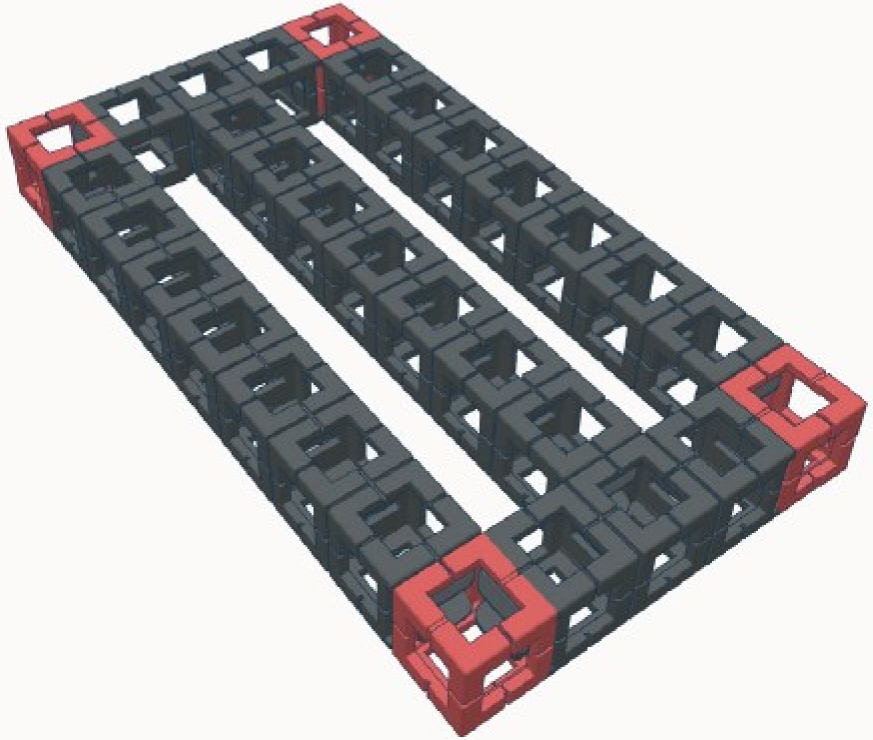
In a first class lever, the amount of effort needed to raise a load is reduced as the fulcrum is moved closer to the load. Move the fulcrum 1.5 openings towards **Weight 2** (Load) as shown in the figure to the right. Now, lift **Weight 1** (Effort) as high as possible and let go. Observe how **Weight 1** (Effort) drops to the base, and **Weight 2** (Load) is raised to its highest position. In this example, the fulcrum is closer to the load than it is to the effort. This modification allows **Weight 1** (Effort) to travel a further distance and raise **Weight 2** (Load). Observe how far **wheel 1** (Effort) travels in relation to **wheel 2** (Load).

First Class Lever

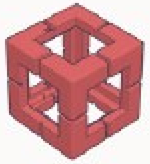




1

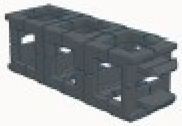


4x
Block

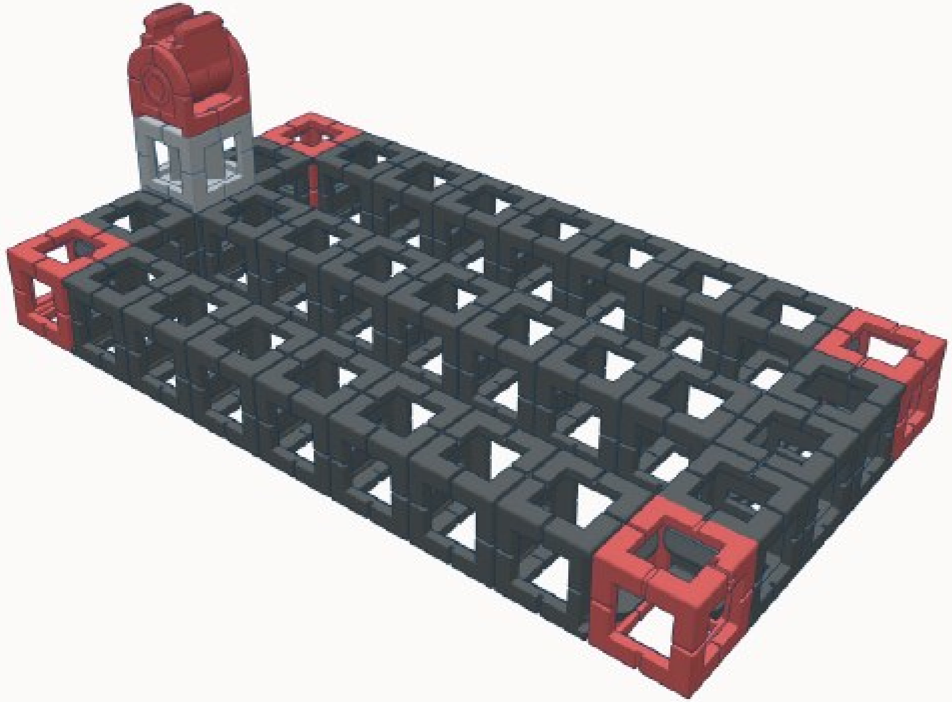


3x
Beam

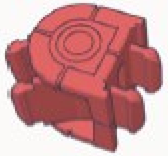
2x
Half Beam



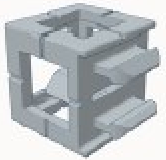
2



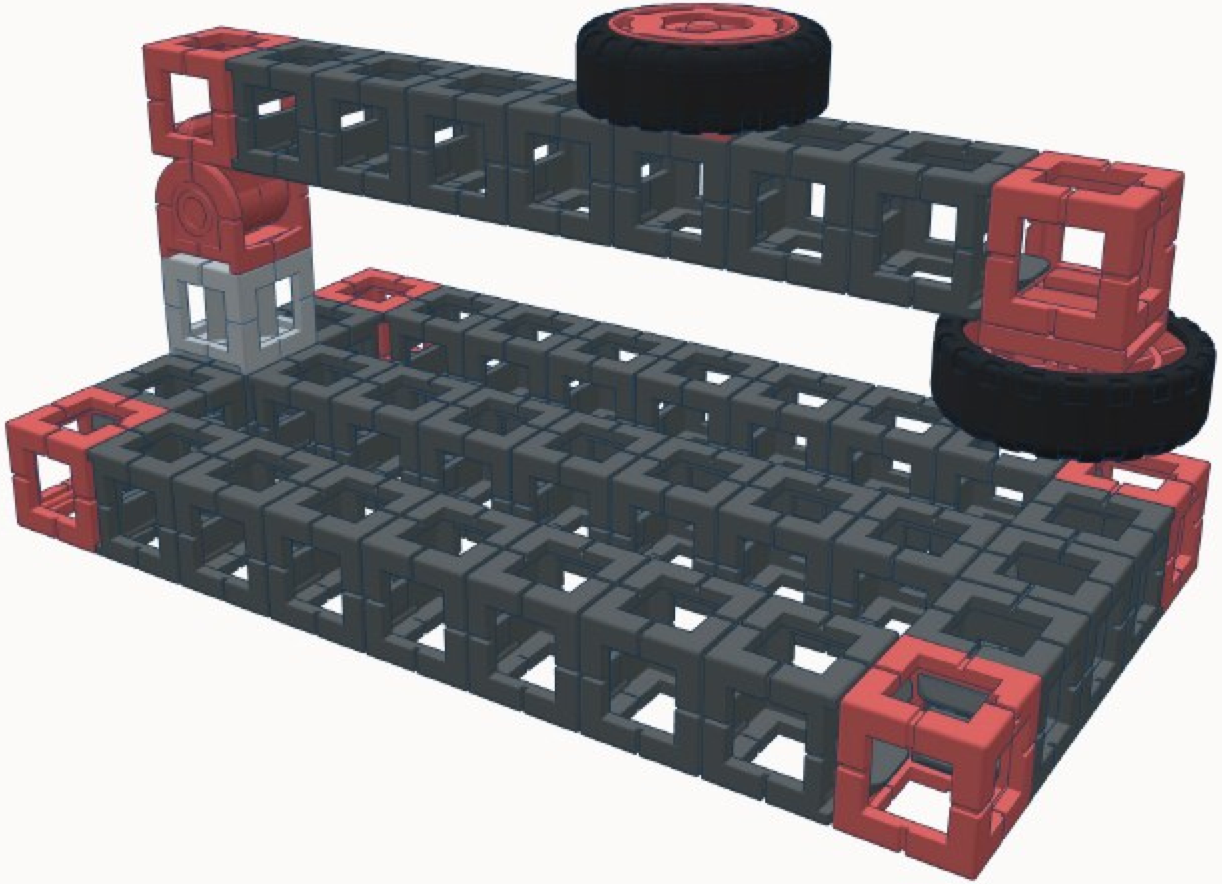
1x
Hinge Block



1x
Single Snap Block

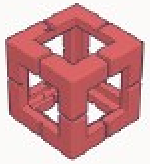


3

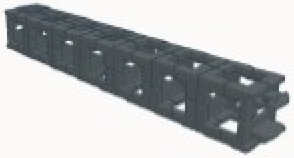


2x
Snap-In Wheel

2x
Block

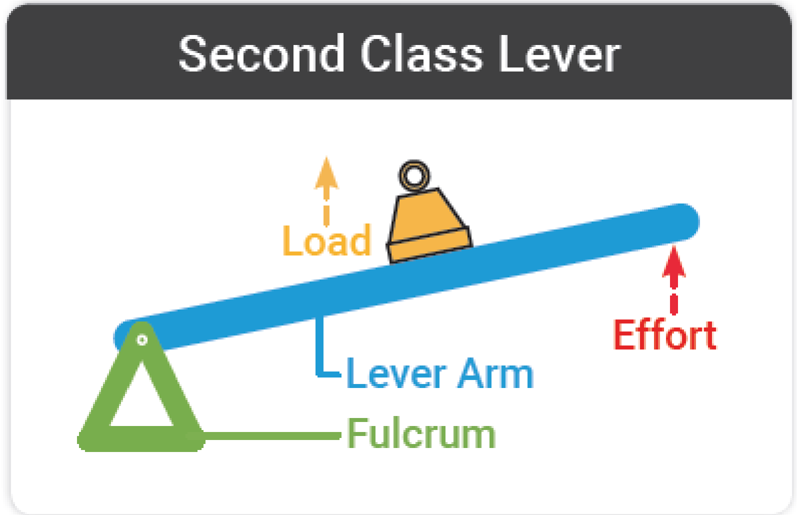


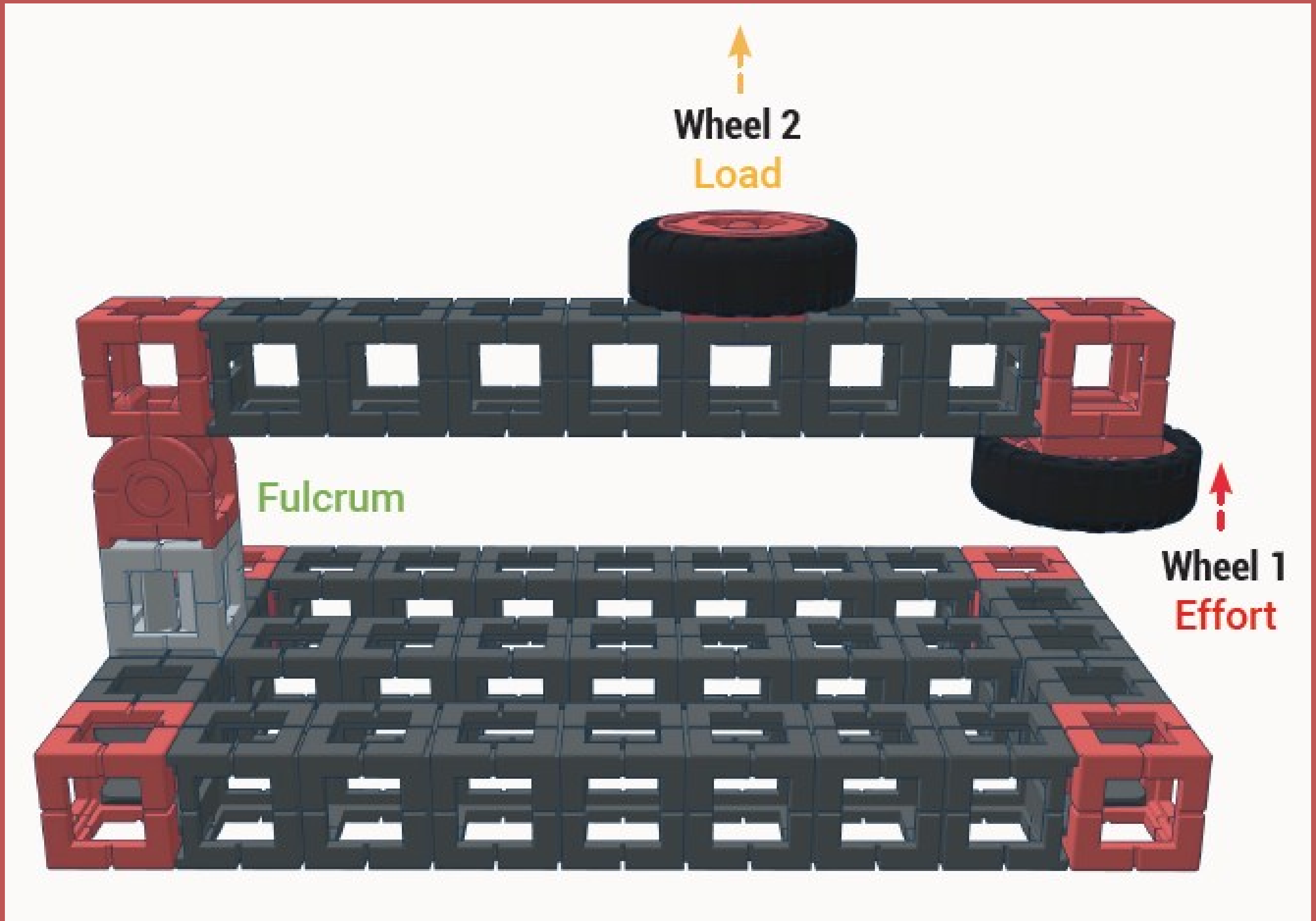
1x
Beam



Testing the Second Class Lever

In a second class lever, the load is placed between the fulcrum and the effort. In this example, when **Wheel 1** (Effort) is raised, **Wheel 2** (Load) is raised in the same direction.

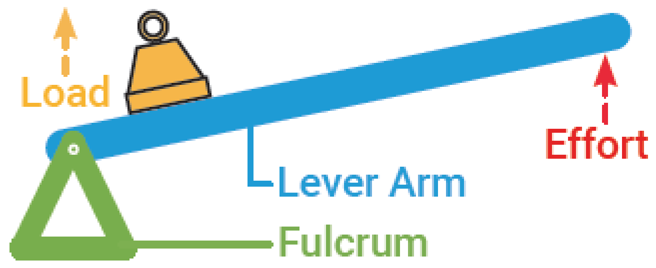


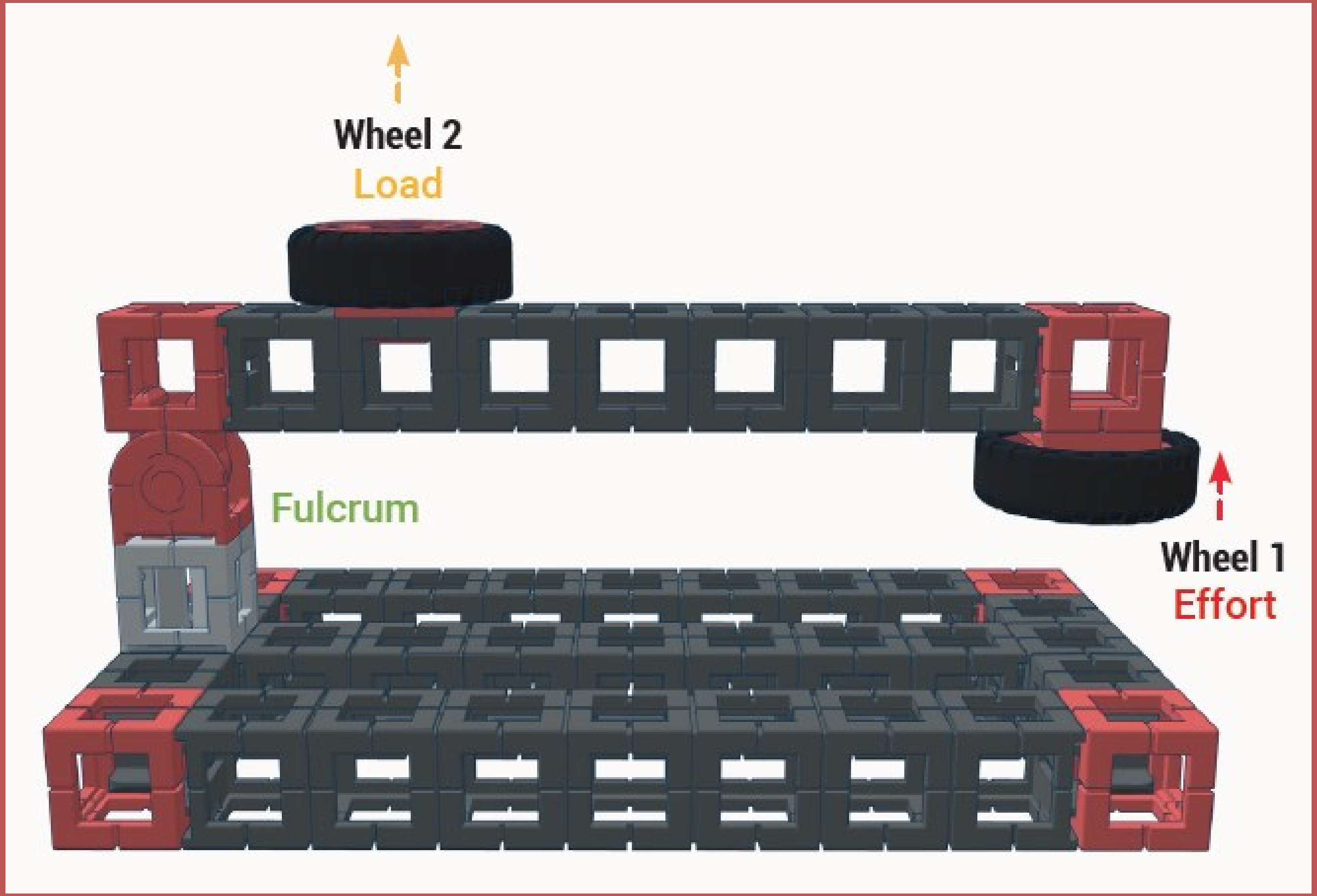


Modifying the Second Class Lever

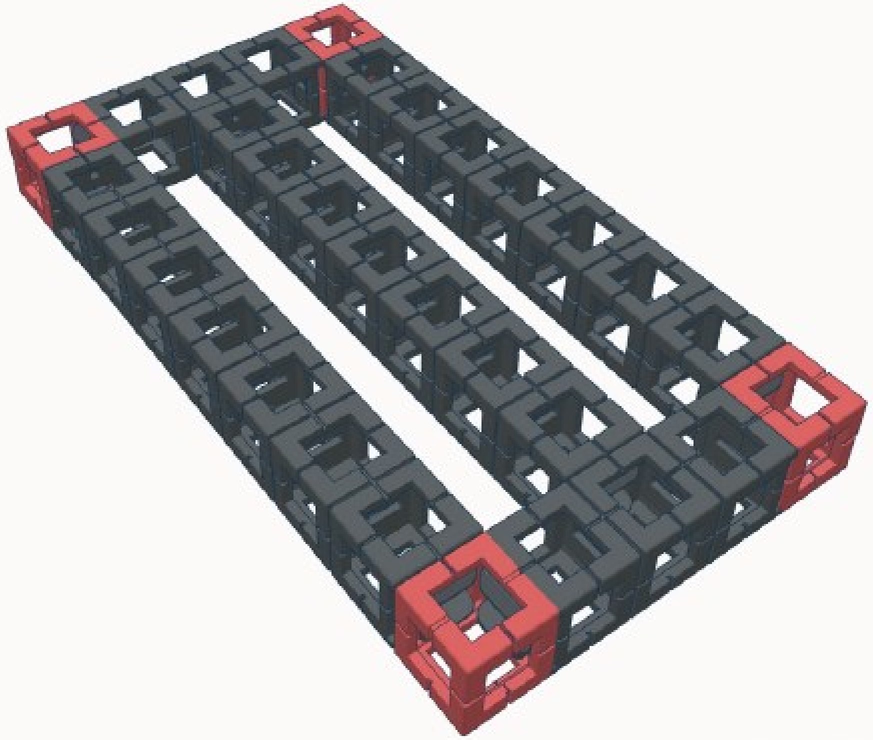
In a second class lever, the amount of effort needed to raise a load is reduced as the load is moved closer to the fulcrum. Move **Wheel 2** (Load) 3 openings towards the **fulcrum** as shown in the figure to the right. Lift **Wheel 1** (Effort) to raise **Wheel 2** (Load). There should be a noticeable difference in the amount of effort needed to raise the load. As the load is moved closer to the fulcrum, the effort will travel a further distance to raise the load. Observe how far **Wheel 1** (Effort) travels in relation to **Wheel 2** (Load).

Second Class Lever

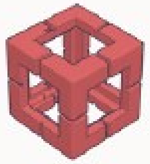




1

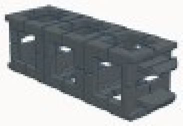


4x
Block

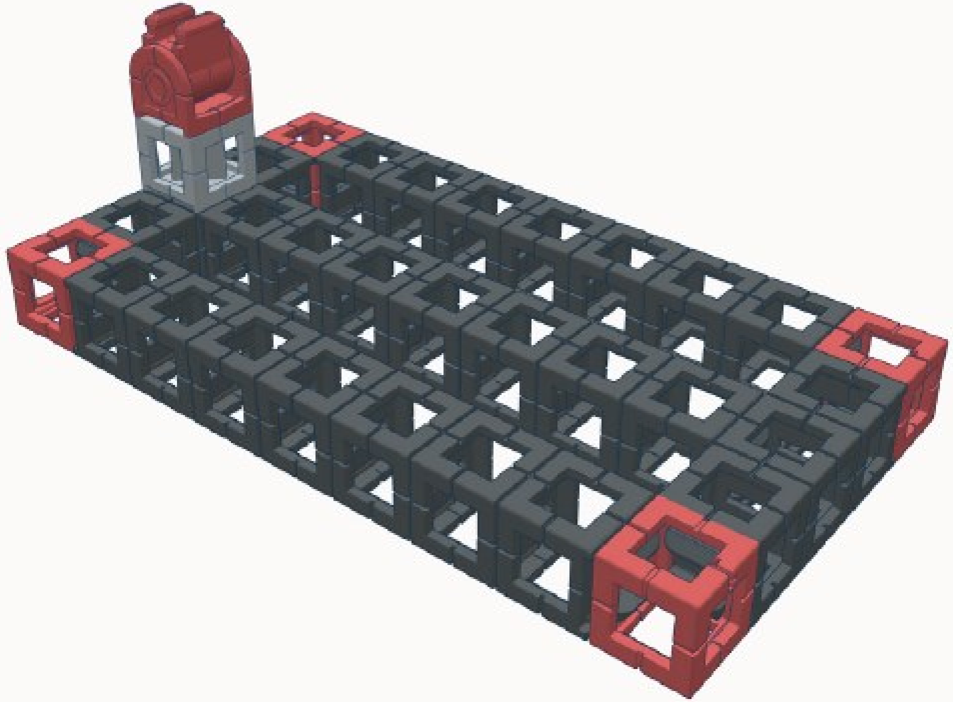


3x
Beam

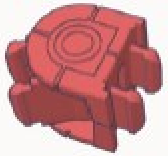
2x
Half Beam



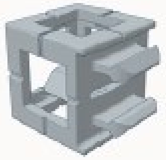
2



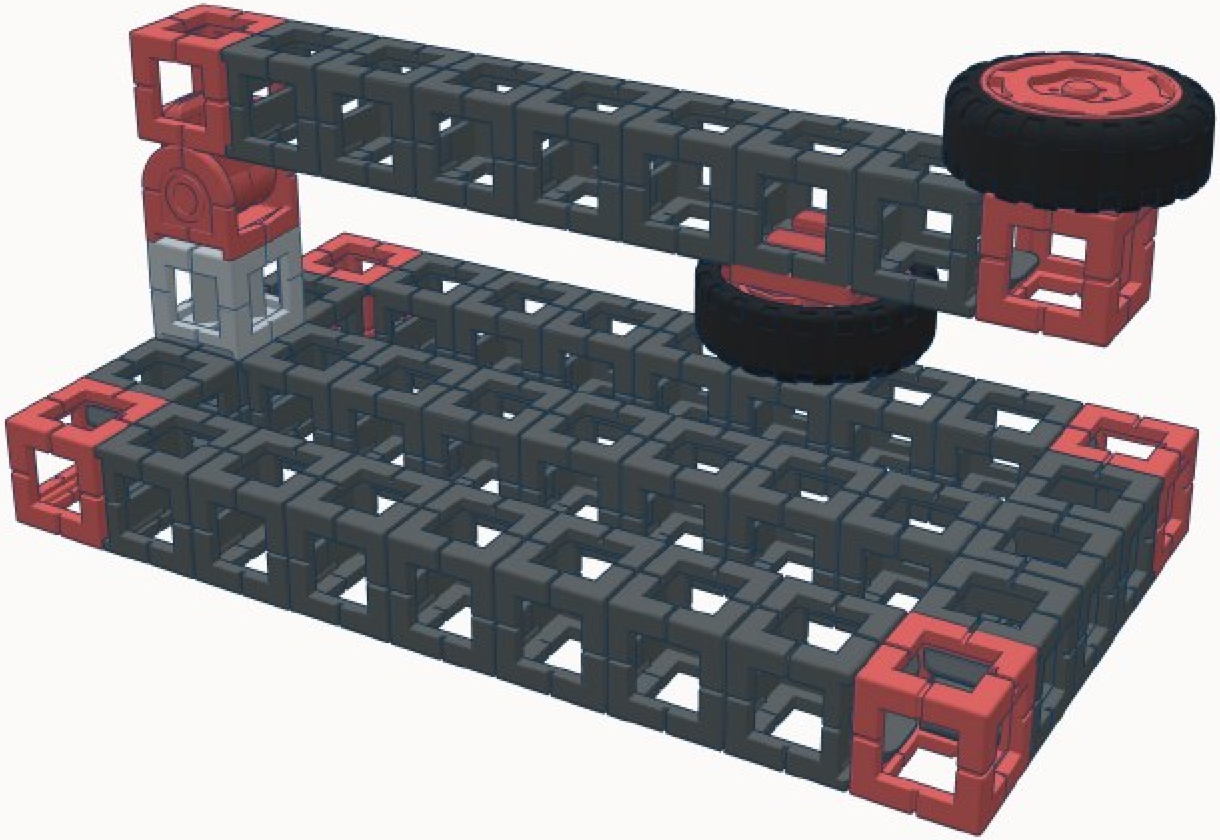
1x
Hinge Block



1x
Single Snap Block

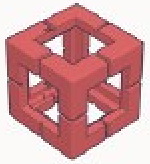


3



2x
Snap-In Wheel

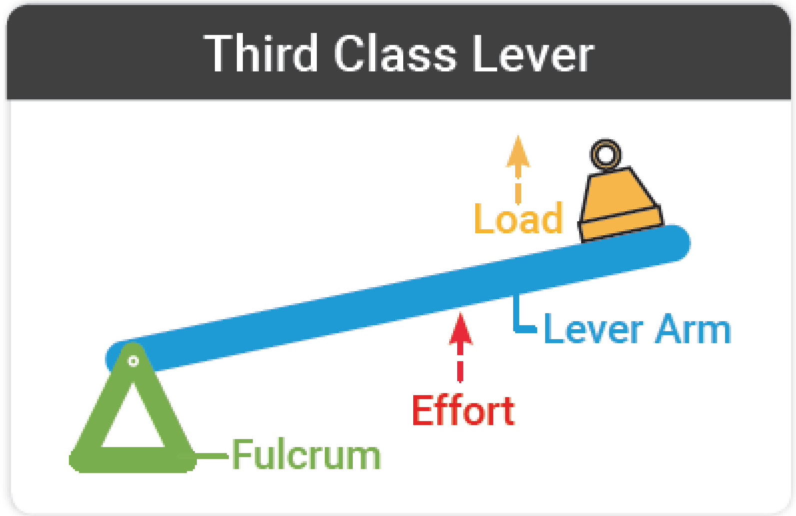
2x
Block

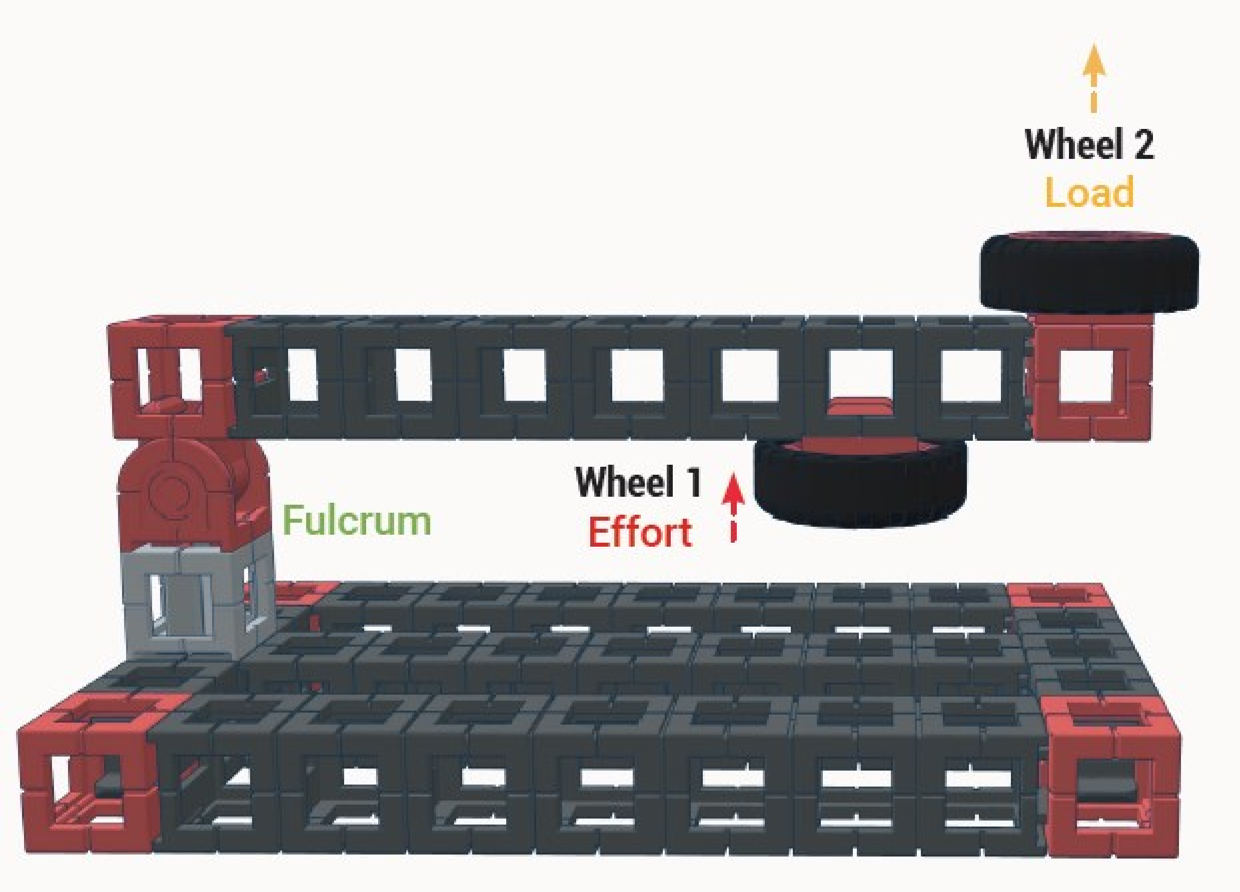


1x
Beam

Testing the Third Class Lever

In a third class lever, the effort is applied between the fulcrum and the load. In this example, when **Wheel 1** (Effort) is raised, **Wheel 2** (Load) is raised in the same direction. The amount of effort needed to raise a load is reduced as the effort is applied closer to the load.

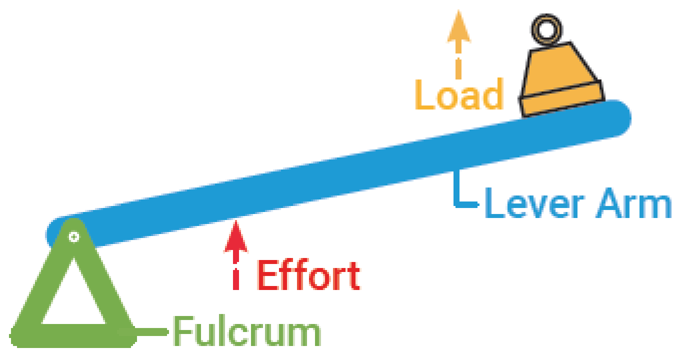


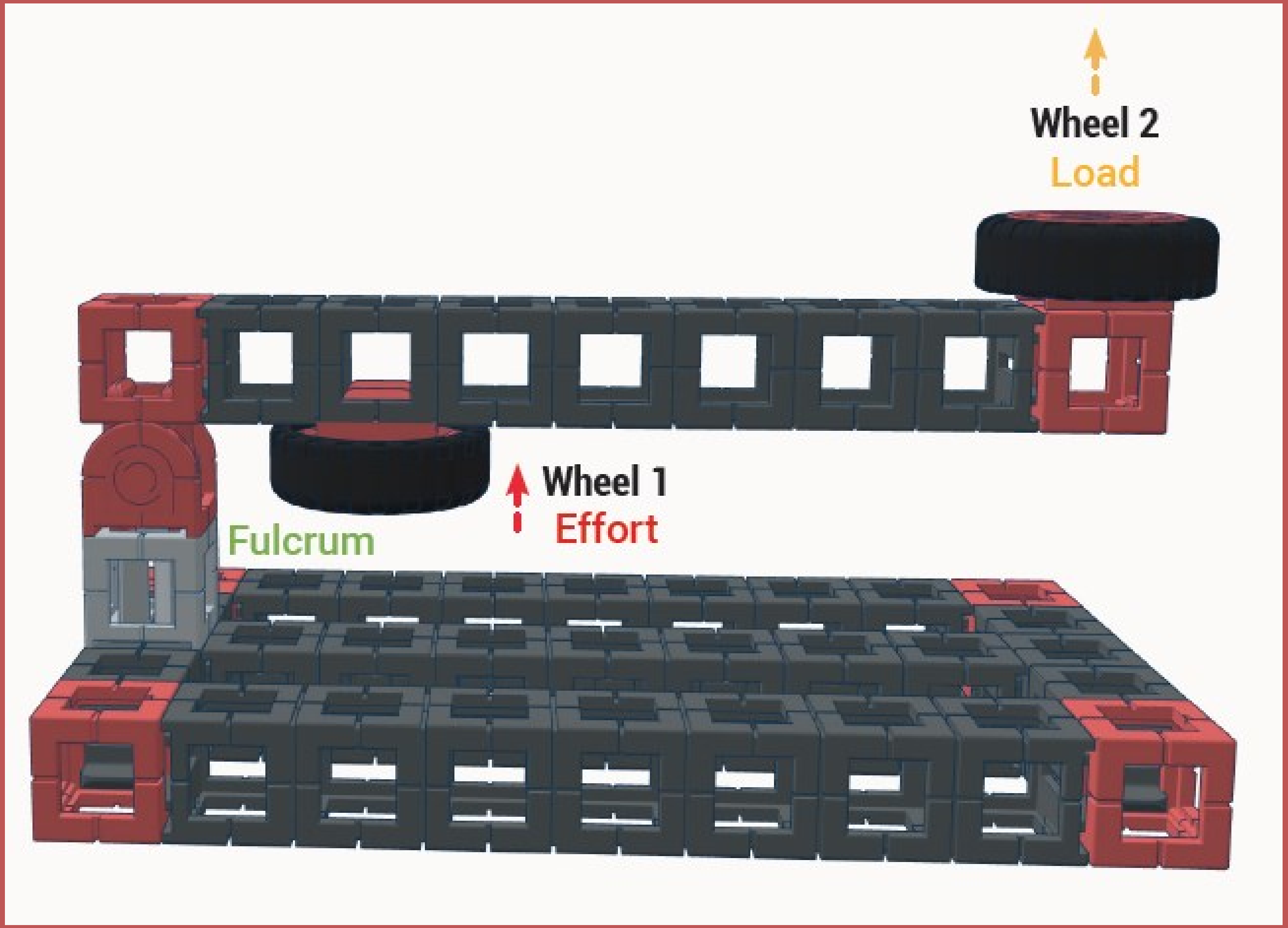


Modifying the Third Class Lever

The primary purpose of a third class lever is to increase output speed. Move **Wheel 1 (Effort)** 4 spaces towards the fulcrum as shown in the image to the right. In this example, when **Wheel 1 (Effort)** is raised, **Wheel 2 (Load)** is raised in the same direction. As the effort is applied closer to the fulcrum, the load will travel a further distance than the effort in the same amount of time. Observe how far **Wheel 2 (Load)** travels in relation to **Wheel 1 (Effort).**

Third Class Lever



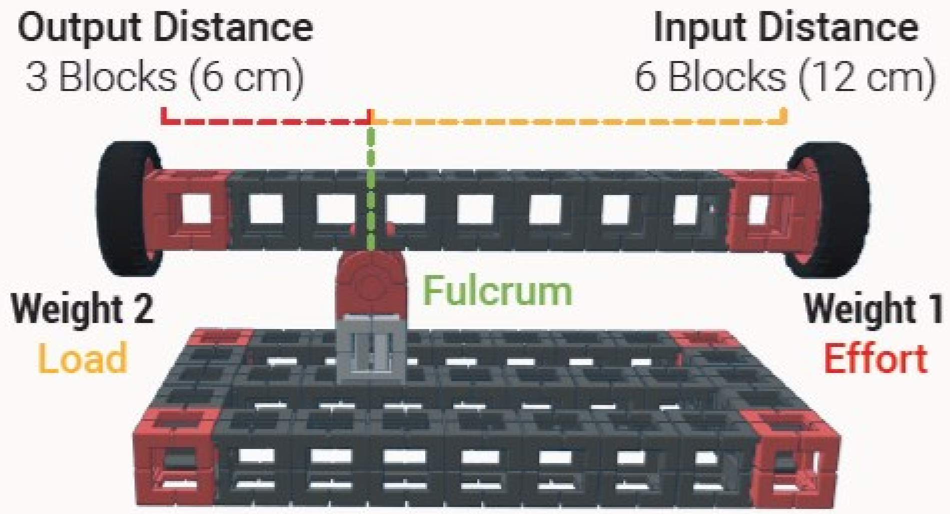


First Class Lever

A first class lever can be used create mechanical advantage by placing the fulcrum closer to the load.

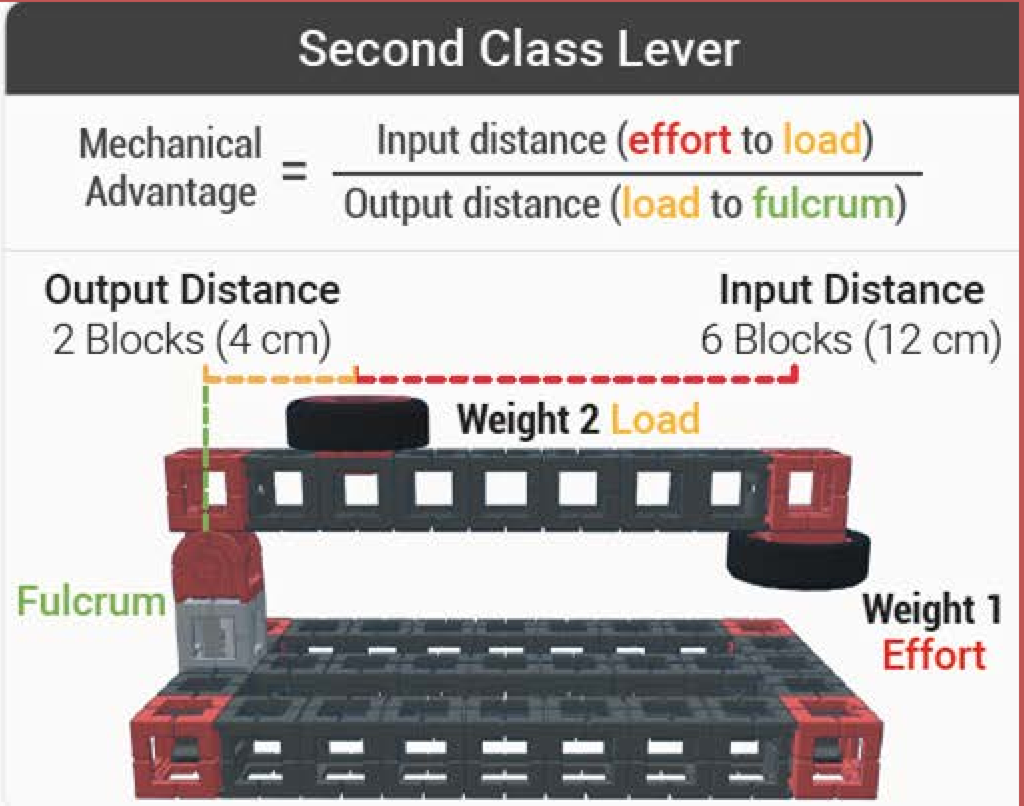
First Class Lever

$$\text{Mechanical Advantage} = \frac{\text{Input distance (effort to fulcrum)}}{\text{Output distance (load to fulcrum)}}$$



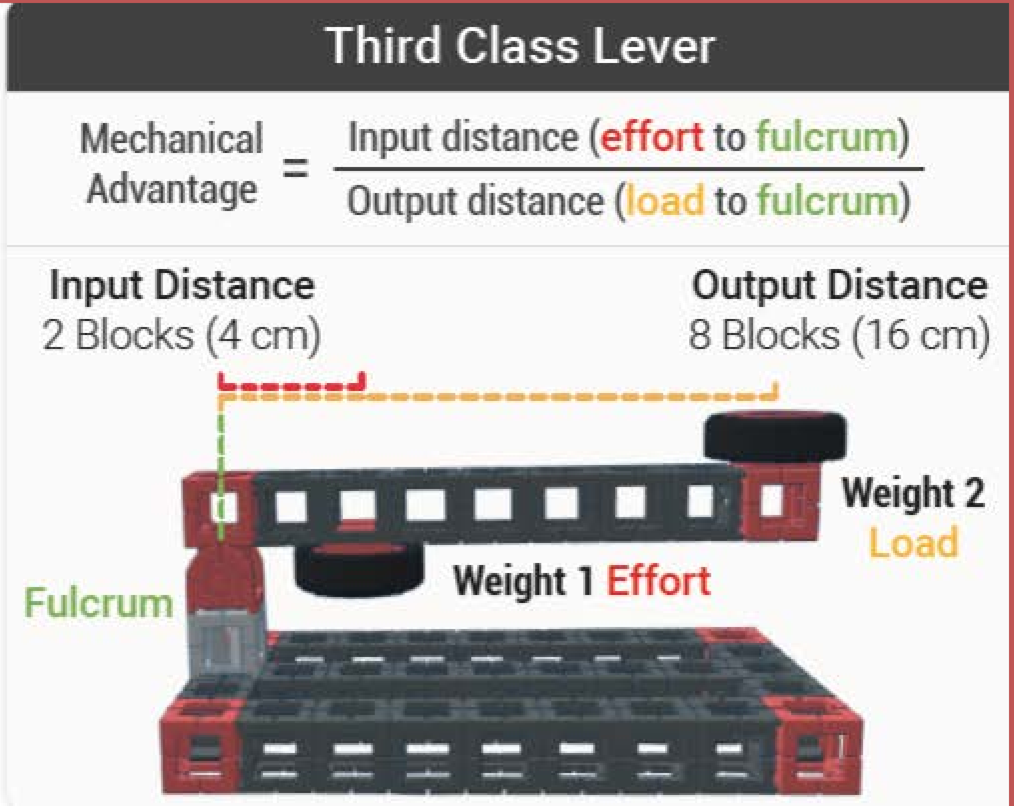
Second Class Lever

A second class lever can be used create mechanical advantage by placing the load closer to the fulcrum.



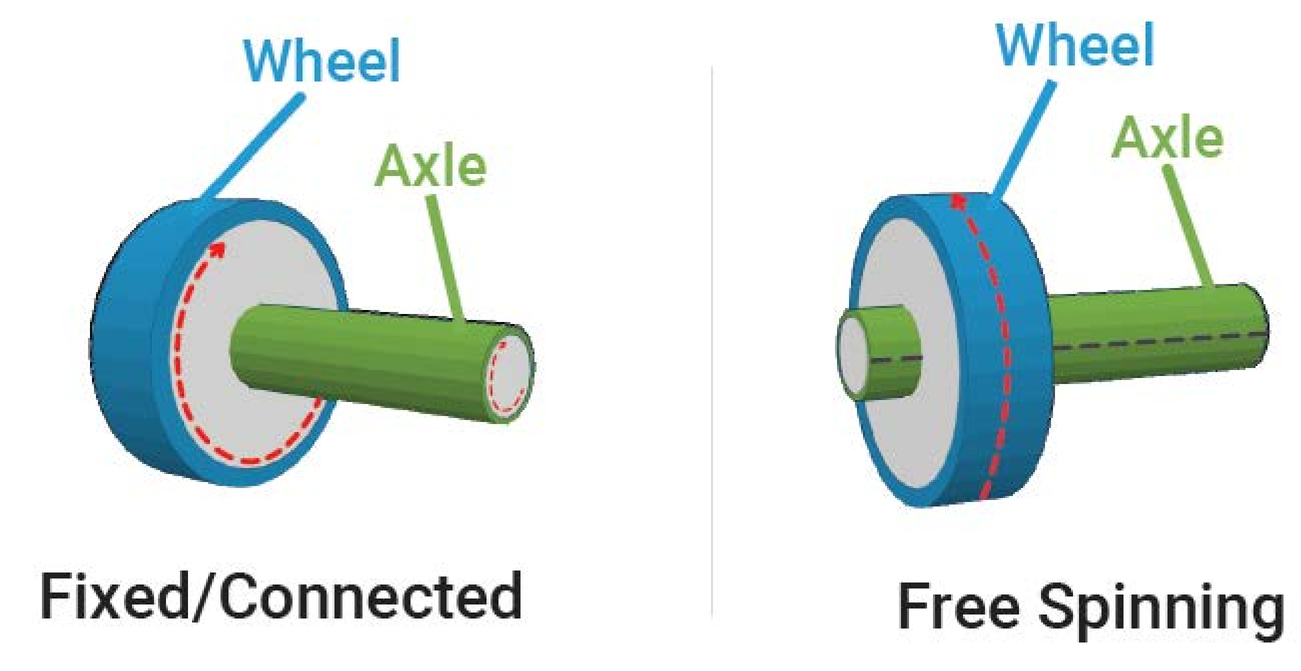
Third Class Lever

To calculate how much mechanical advantage is in a third class lever, divide the **Input distance** (distance from the effort to the fulcrum) by the **Output distance** (distance from the load to the fulcrum).



The Wheel & Axle

A wheel & axle is a simple machine that consists of a **wheel** that is connected to a smaller wheel, which is referred to as an **axle**. The axle can be fixed to the center of a wheel, or it can be placed through the center of a wheel, allowing the wheel to rotate freely around the axle.



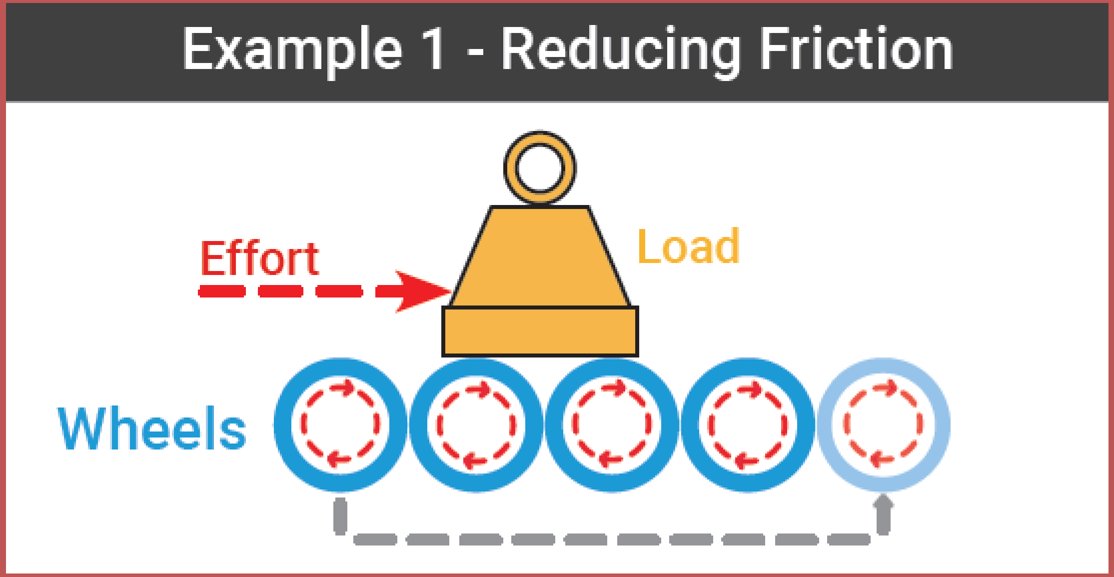
Purpose

A wheel & axle can be used to make work easier by **reducing friction** or by **creating mechanical advantage.**

Reducing Friction

A **wheel** reduces the amount of effort needed to move a load by reducing the amount of friction between the load and the ground or surface. The wheel allows contacting surfaces to roll rather than dragging or sliding over each other. In **example 1**, a load is being rolled over a series of wheels instead of just being pushed or pulled across the surface or ground. As the load moves forward, wheels are taken from the back and placed in the front to keep the load moving forward.

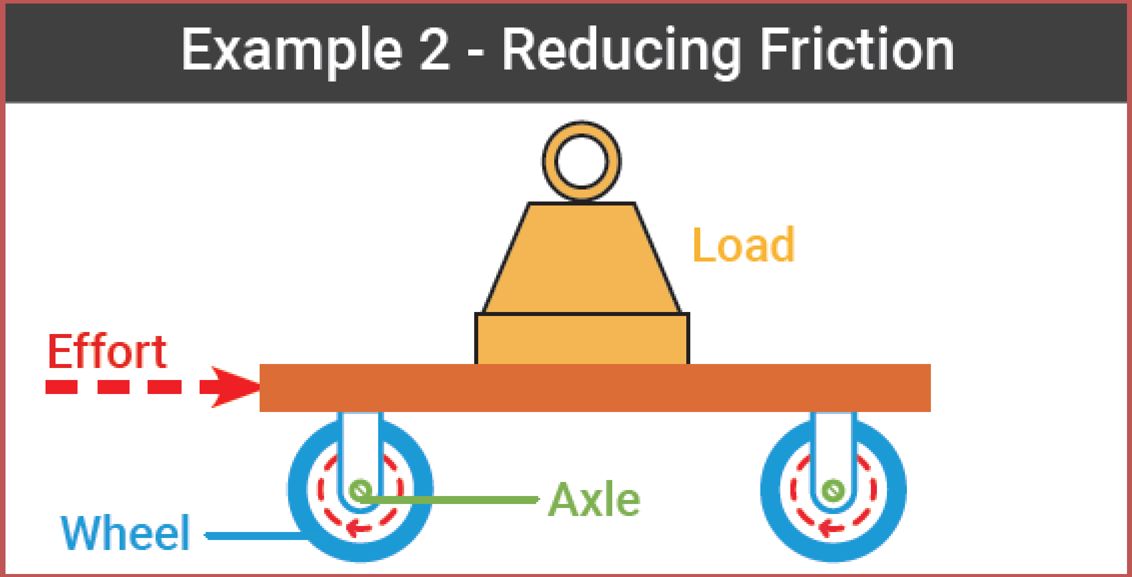
To eliminate the need to constantly place wheels in front of a load to keep it moving forward, an **axle** can be placed through the center of a wheel, which allows the wheel to rotate freely around the axle. In **example 2**, a load has been placed on a platform that is attached to two axles. The wheels rotate freely around the axles, allowing the load to easily move forward.



Airport security

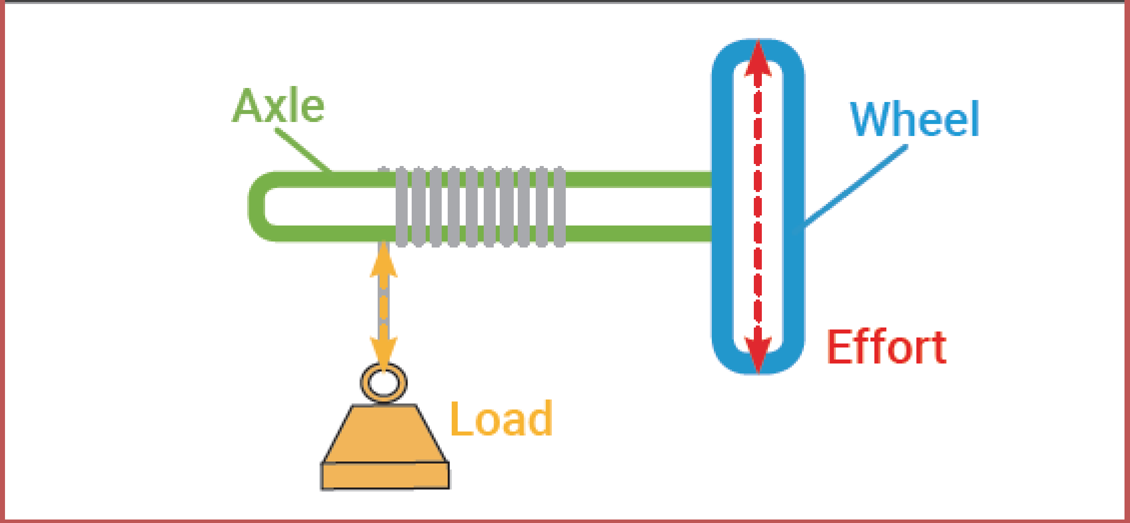
Conveyor belt

Roller slide



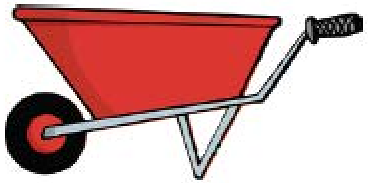
Example 2 - Reducing Friction
Load
Effort
Axle
Wheel

Example 3 - Mechanical Advantage



Bicycle Wheel

Wheelbarrow



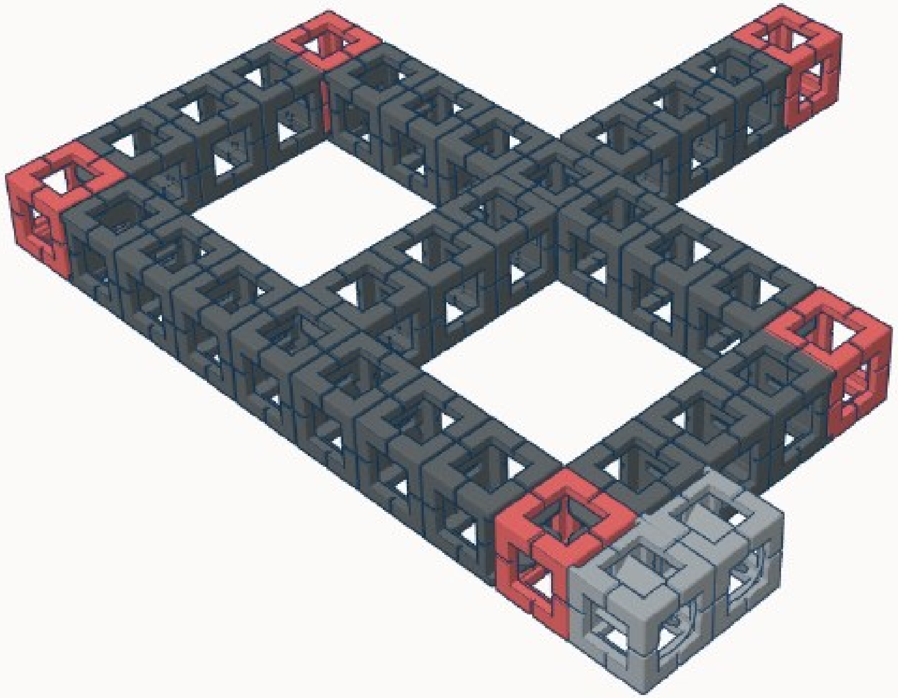
Steering Wheel

Screwdriver

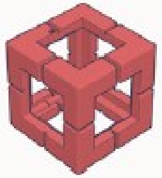
Well

Gears

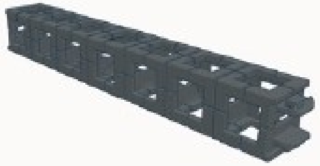
1



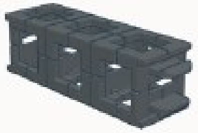
5x
Block



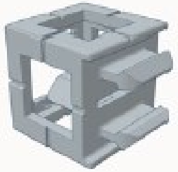
2x
Beam



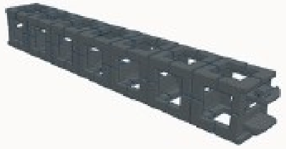
4x
Half Beam



2x
Single Snap Block

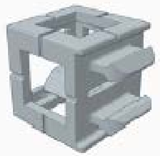


3x
Beam



2x
Half Beam

3x
Single Snap Block



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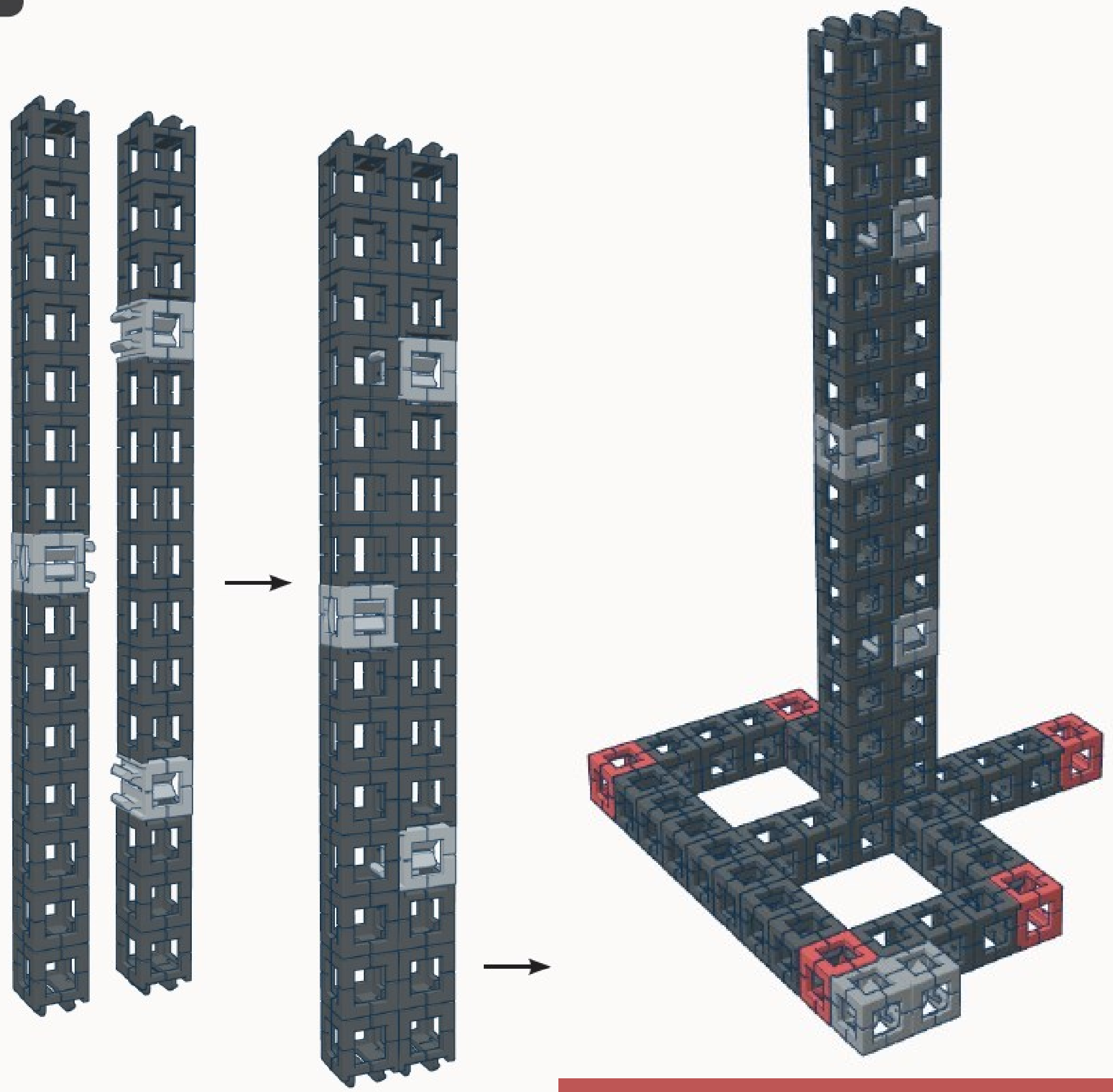

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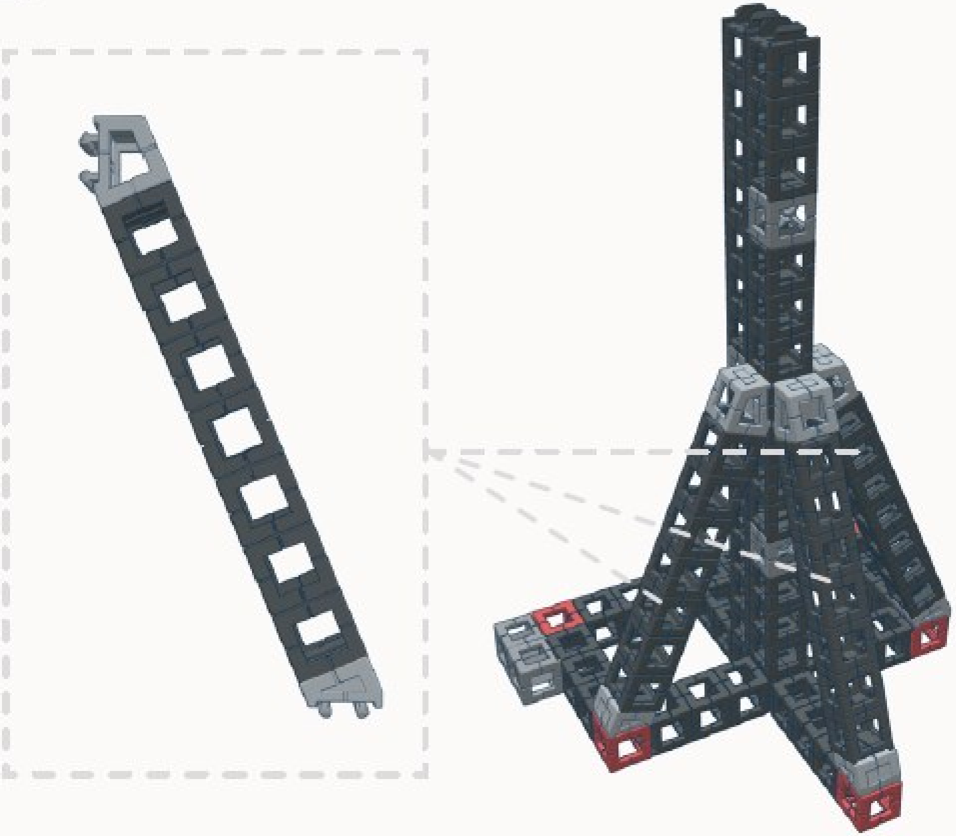
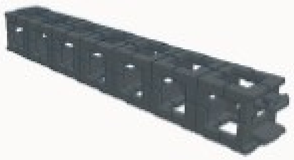
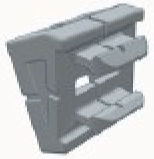


3x
Beam

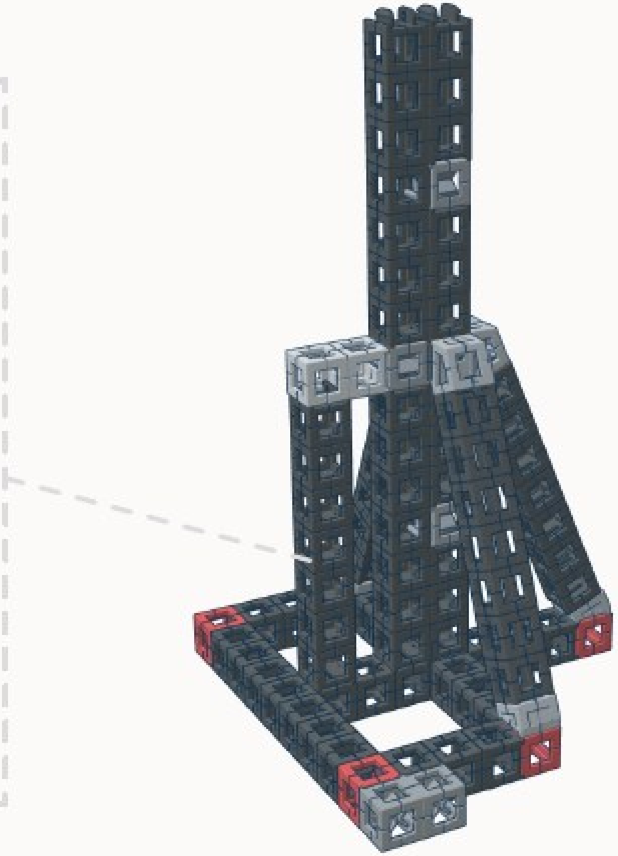


3x
60° Block

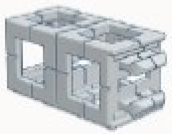
3x
30° Block



4

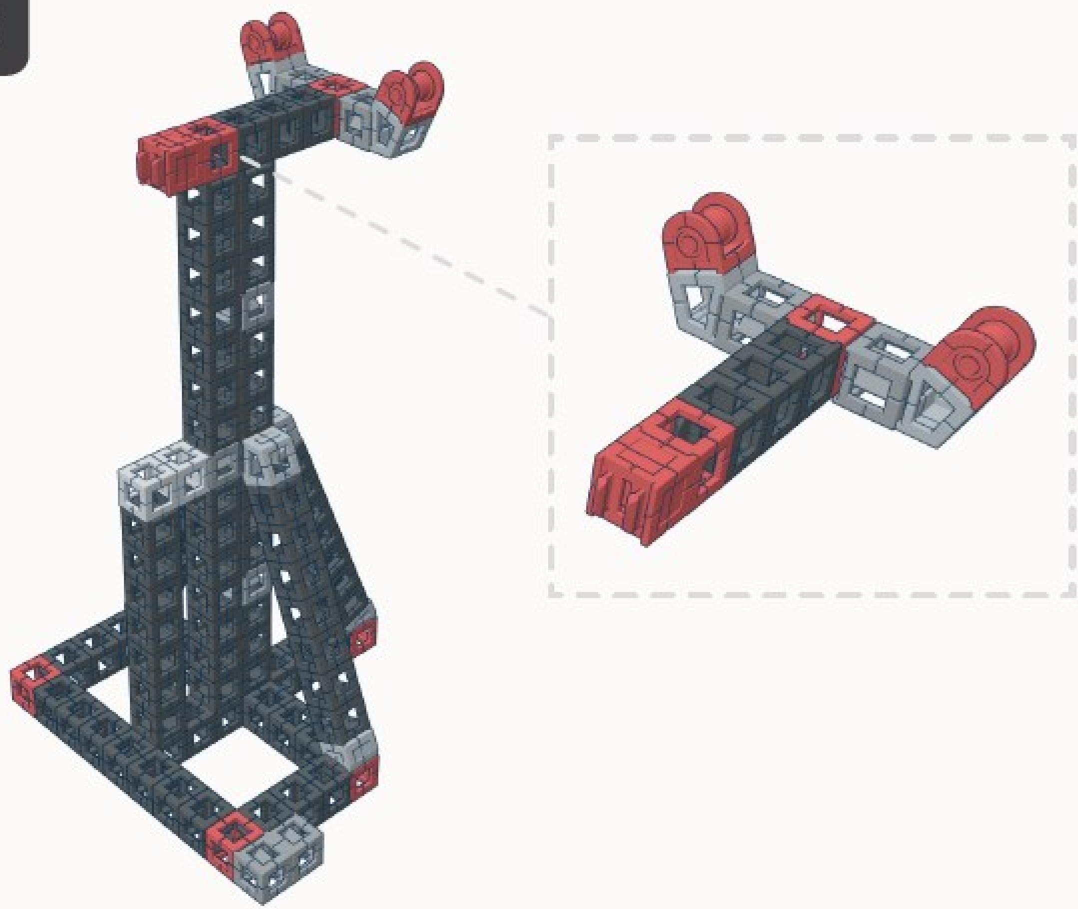


1x
Riser

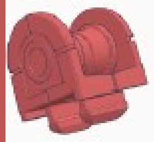


1x
Beam

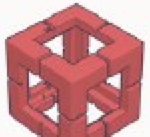
5



2x
Pulley



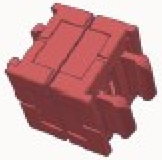
2x
Block



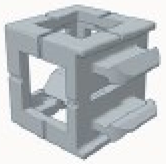
1x
Half Beam

2x
60° Block

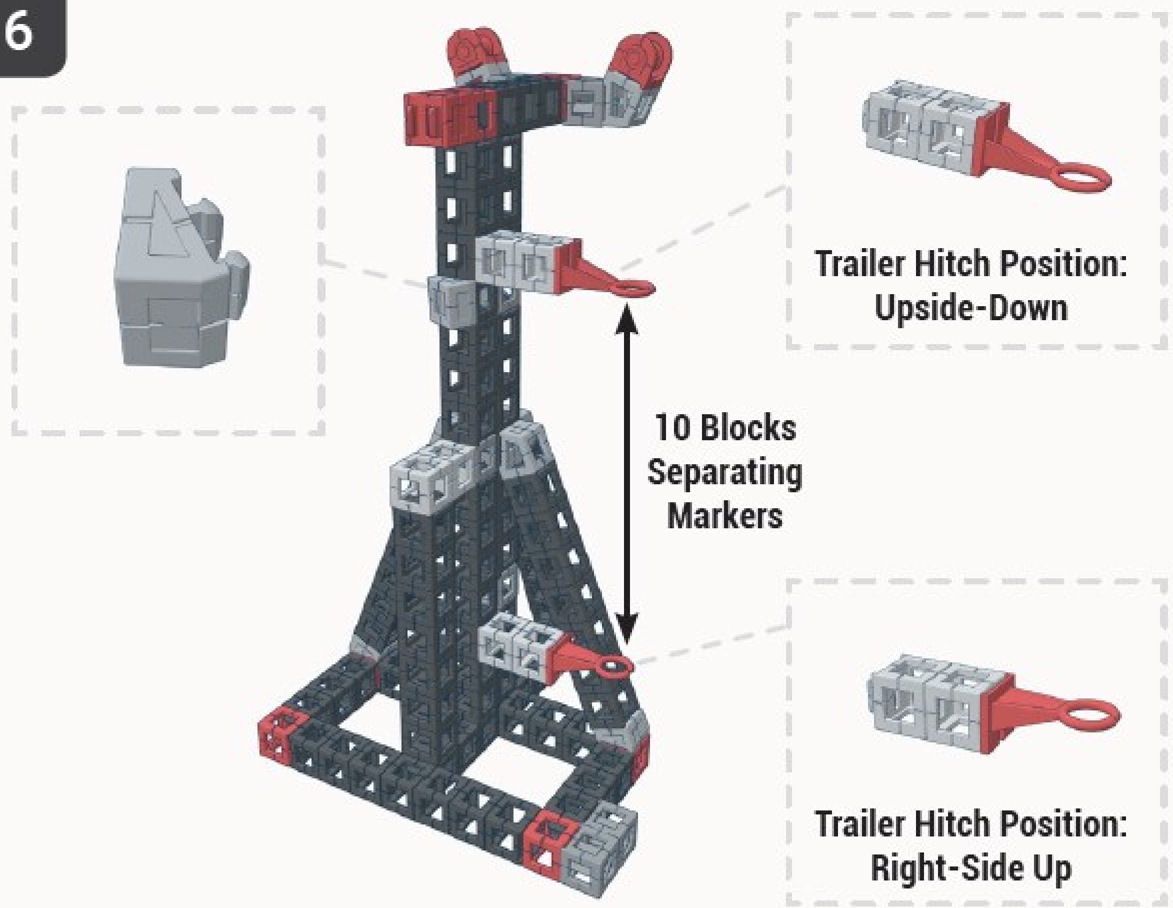
1x
Axle Block



2x
Single Snap Block

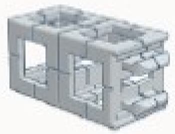


6

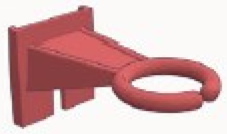


1x
30° Block

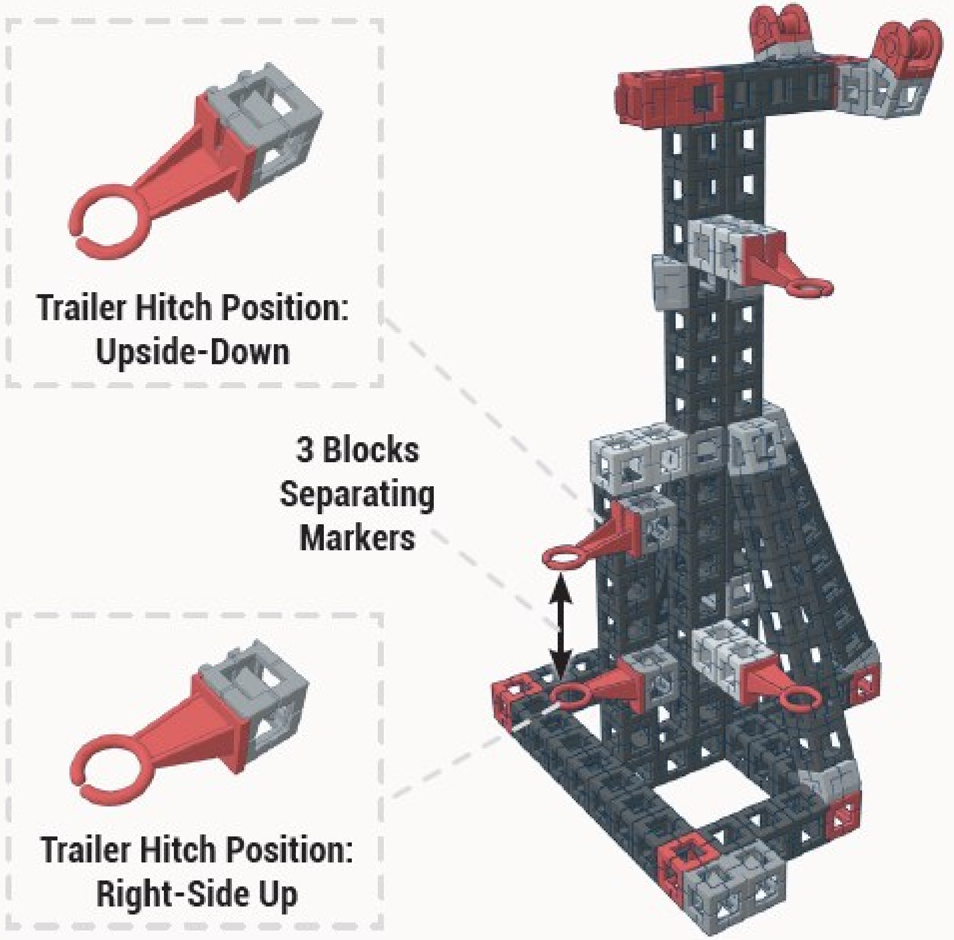
2x
Riser



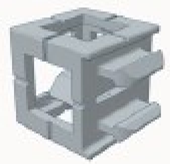
2x
Trailer Hitch



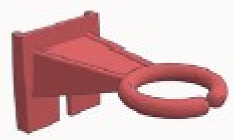
7



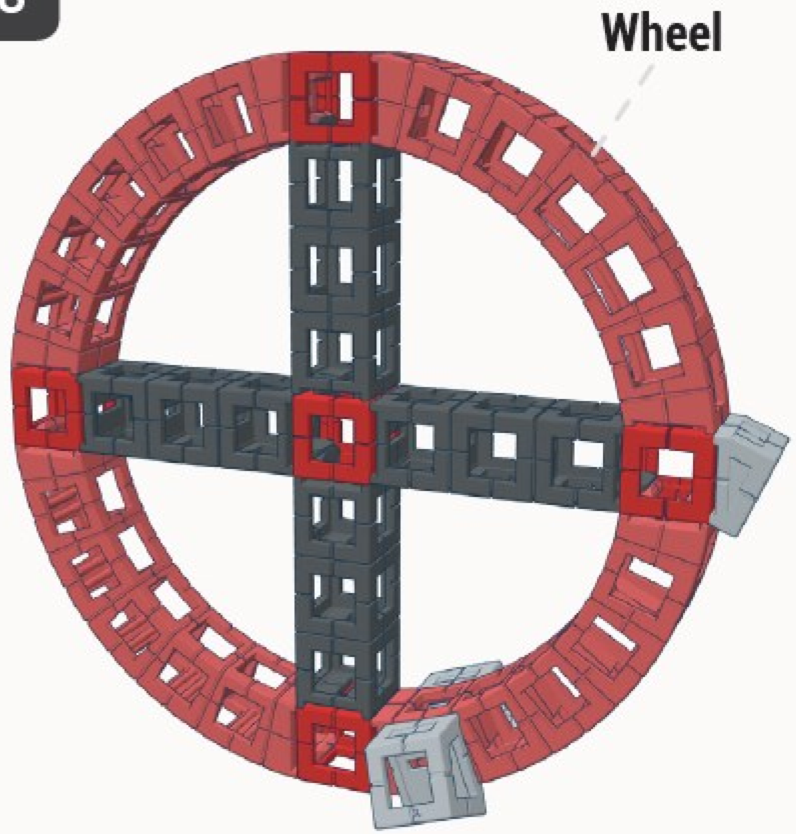
2x
Single Snap Block

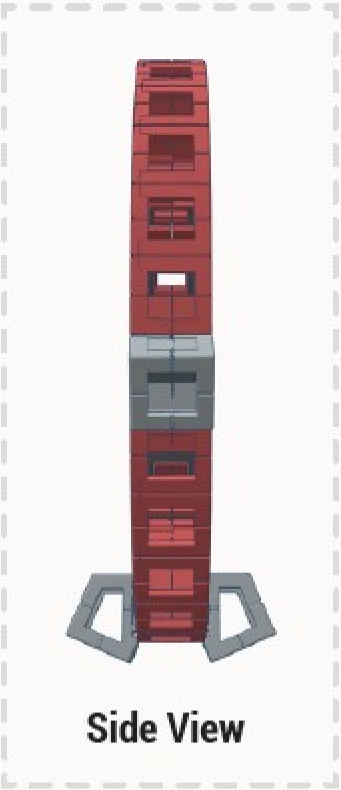


2x
Trailer Hitch

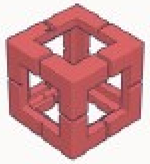


8





5x Block

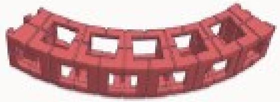


4x Half Beam

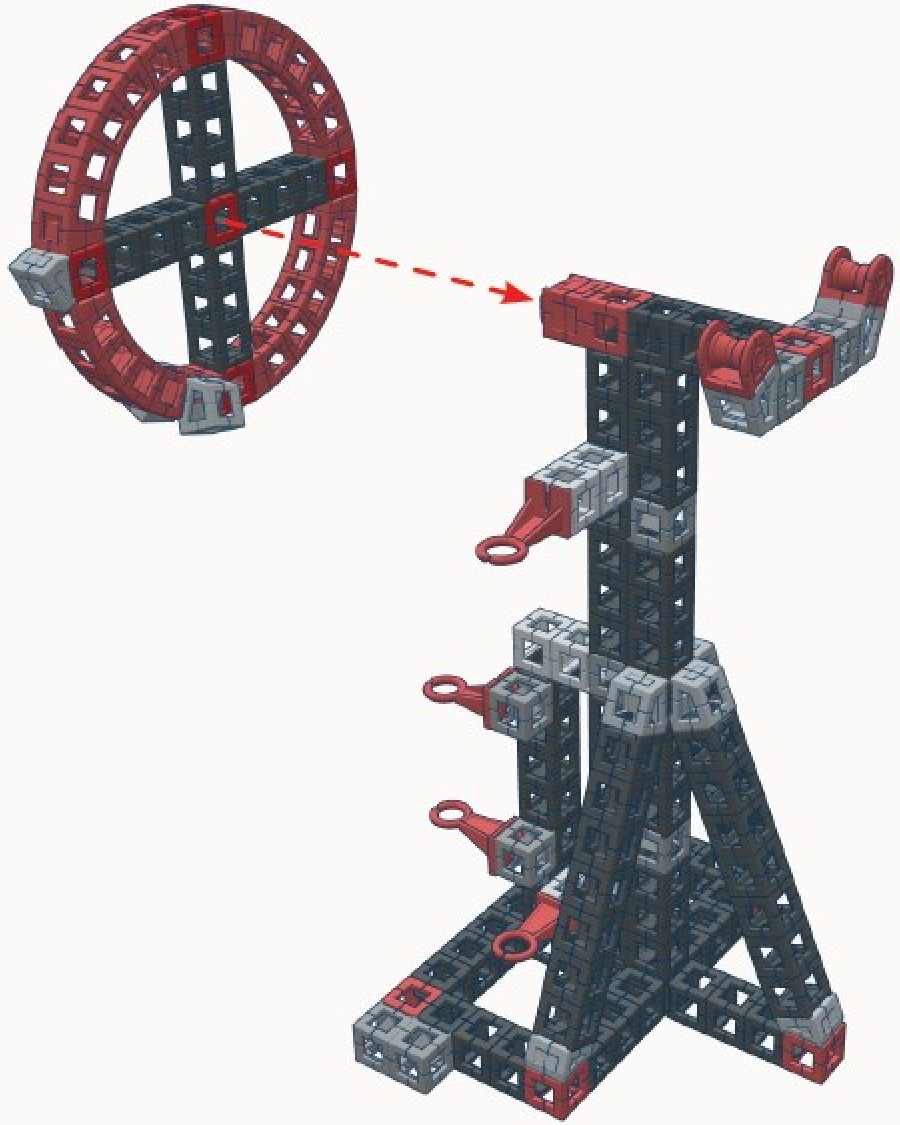
1x 30° Block

2x 60° Block

4x Small Curved Beam



9



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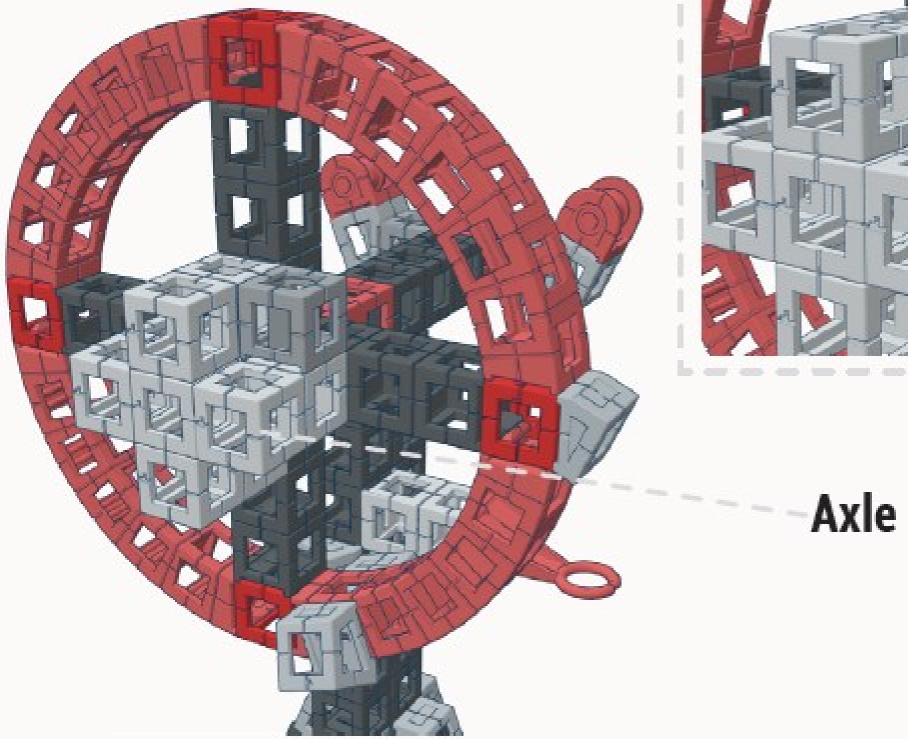
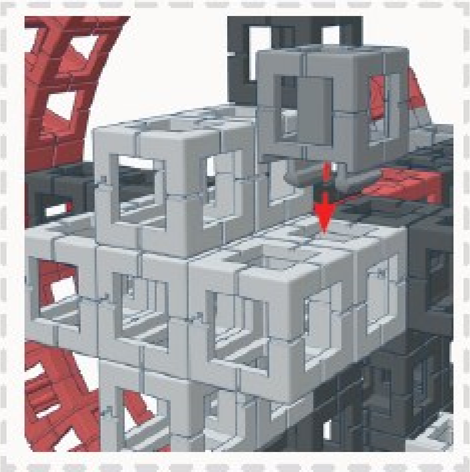
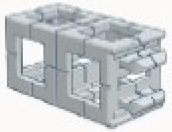
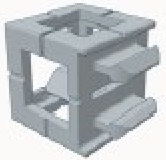




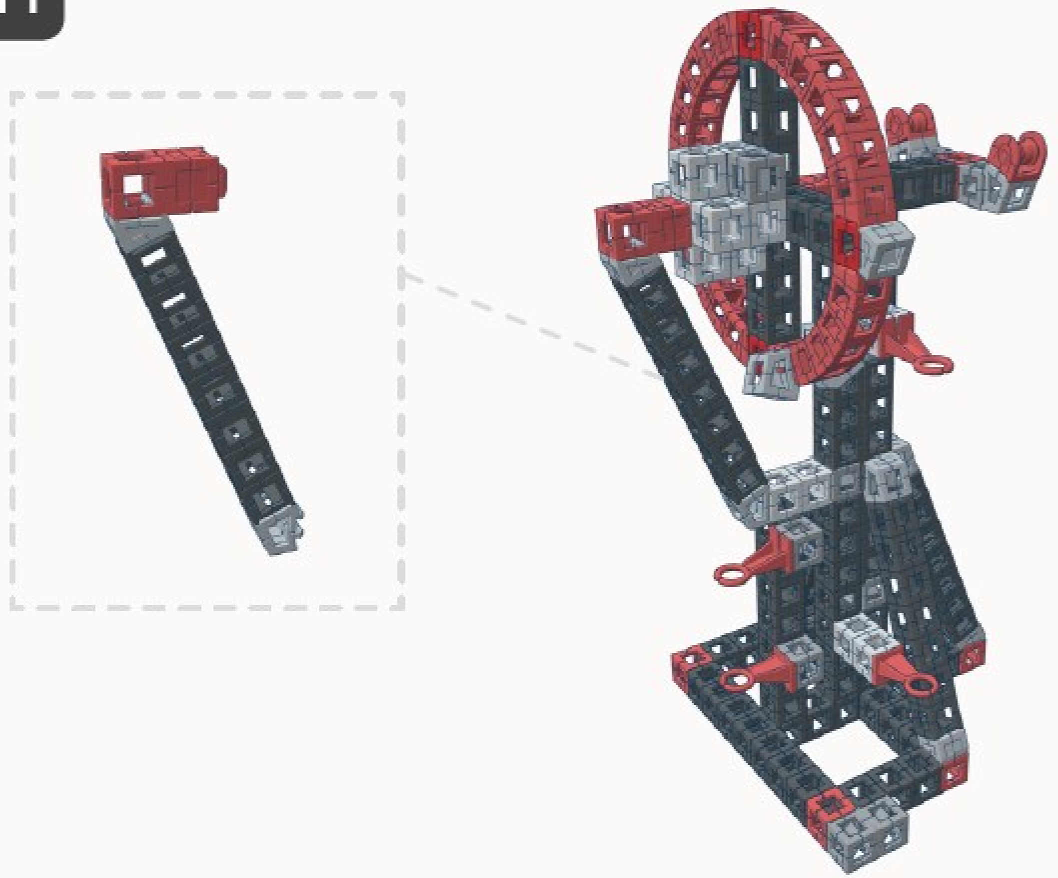
5x
Riser



1x
Single Snap Block



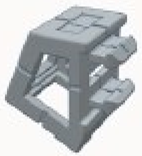
11



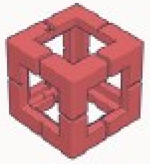
1x
30° Block

1x
Beam

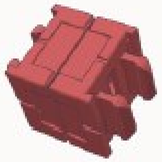
1x
60° Block



1x
Block

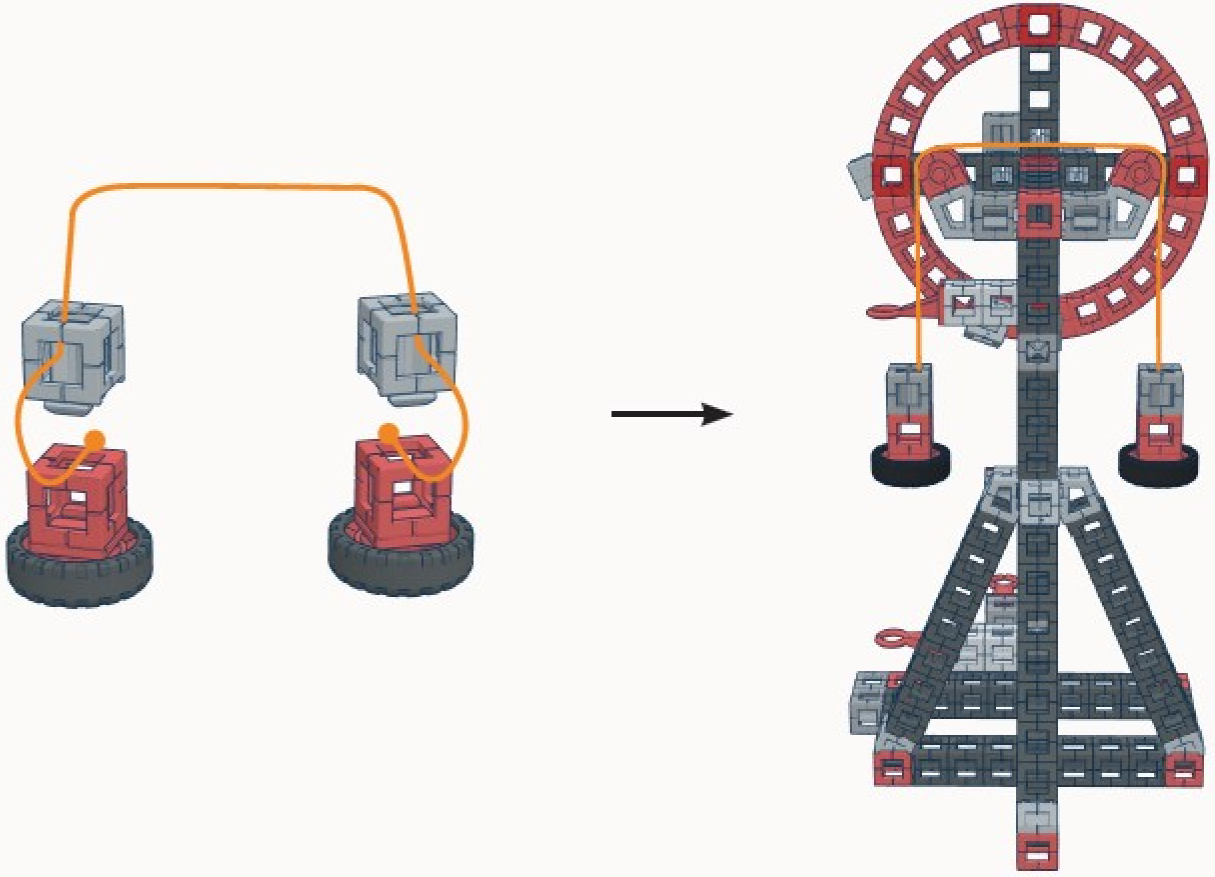


1x
Axle Block

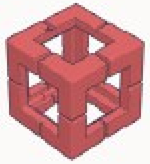


12

Cut a piece of string that is 48cm long. Feed each end of the string through the single snap blocks as shown. Lay string on top of the red connector blocks and snap into place. Once connected, place string of weights over fixed pulleys.

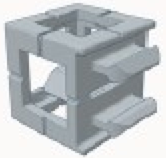


2x
Block



2x
Snap-In Wheel

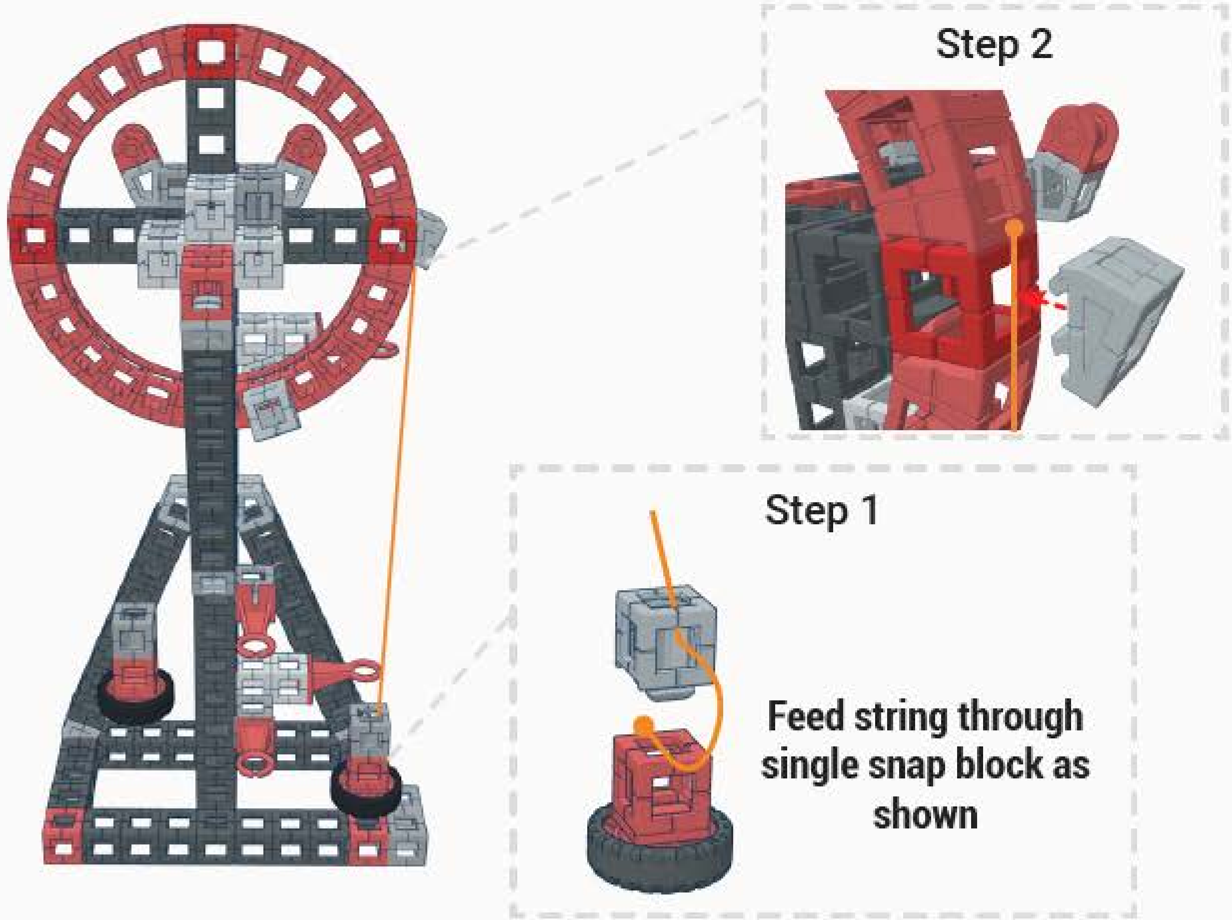
2x
Single Snap Block



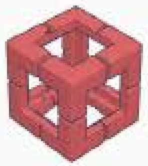
Step 1: Connecting Weight 1
Cut a piece of string that is 40cm long. To connect weight 1, feed one end of the string through the single snap block as shown. Lay string on top of the red connector block. Then snap connector block and single snap block together to secure string in place.

Step 2:
Disconnect 30° block from large wheel. Place the other end of string across opening and snap 30° block back into place, to secure string.

Note: *Adjust string if necessary to make sure Weight 1 is resting on the base frame. Make sure string is taut.*



1x
Block



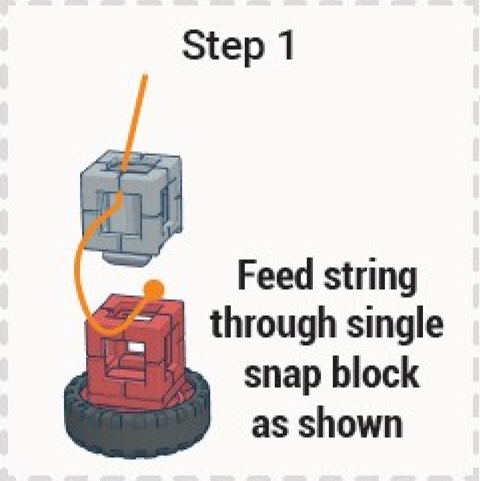
1x
Snap-In Wheel

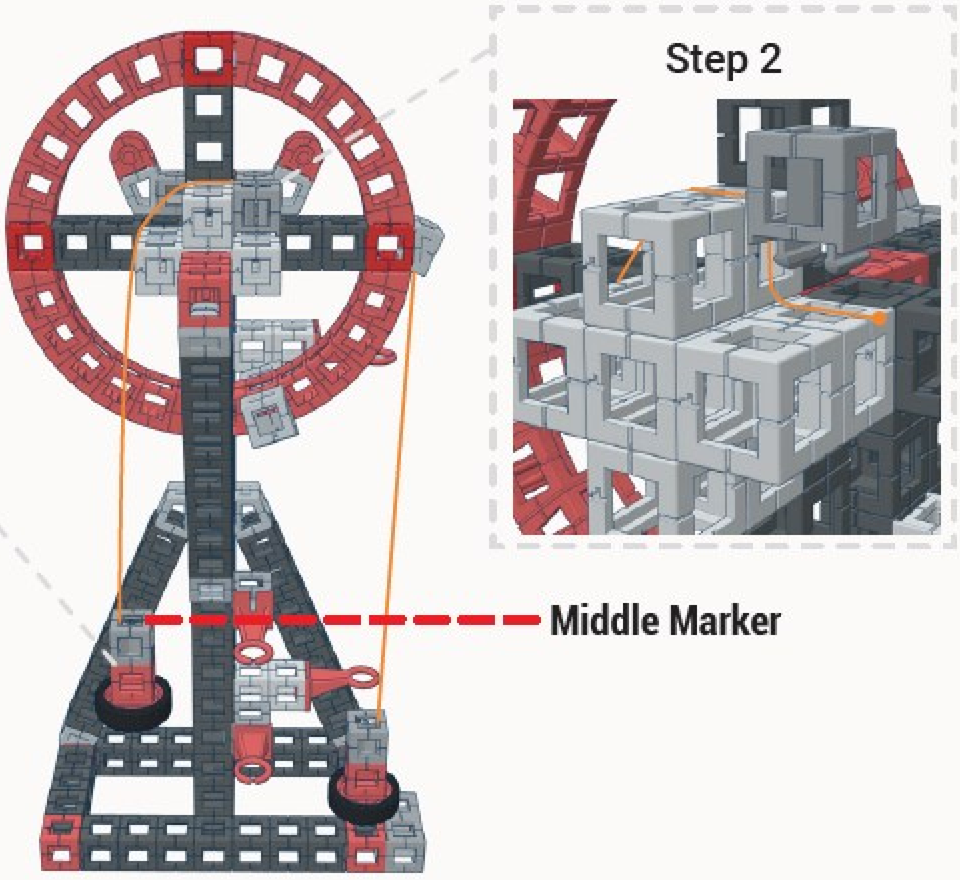
1x
Single Snap Block

Step 1: Connecting Weight 2
Cut a piece of string that is 40cm long. To connect weight 2, feed one end of the string through the single snap block as shown. Lay string on top of the red connector block. Snap connector block and single snap block together to secure string in place.

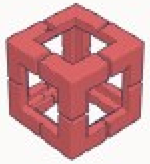
Step 2:
Disconnect single snap block from the axle. Place the other end of string across opening and snap single snap block back into place, to secure string.

Note: *Make sure that tabs on single snap block are perpendicular to the string, as shown. Adjust string if necessary to make sure the top of Weight 2 is even with the middle marker.*



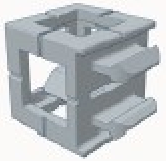


1x
Block



1x
Snap-In Wheel

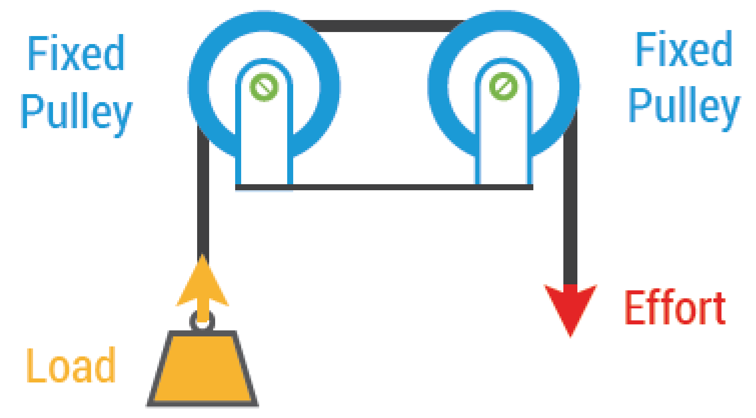
1x
Single Snap Block

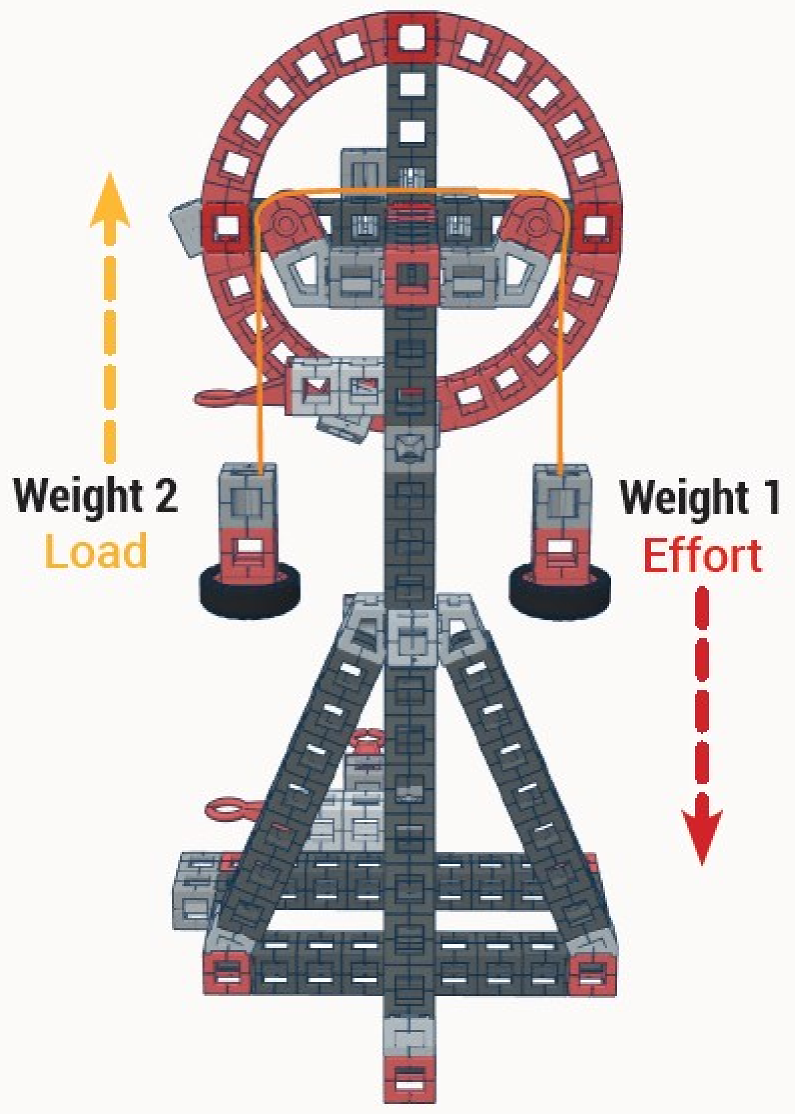


Testing Fixed Pulley System

Turn the model so that the string of weights can be tested on the fixed pulley system. Place the string of weights over the fixed pulleys. Observe how the weights balance each other out. Pull down on **Weight 1 (Effort)** and observe how **Weight 2 (Load)** moves in the opposite direction. You will notice that the mass of weight 1 isn't enough to overcome the mass of weight 2 on its own, because this system creates no mechanical advantage.

Fixed Pulley System



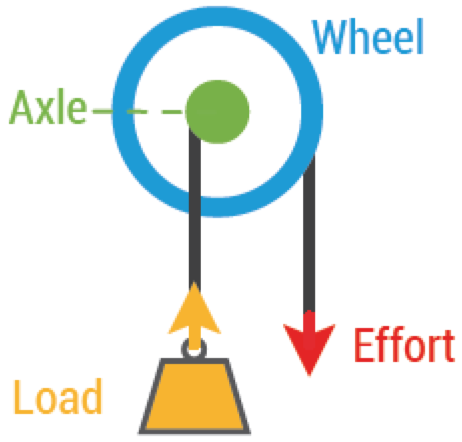


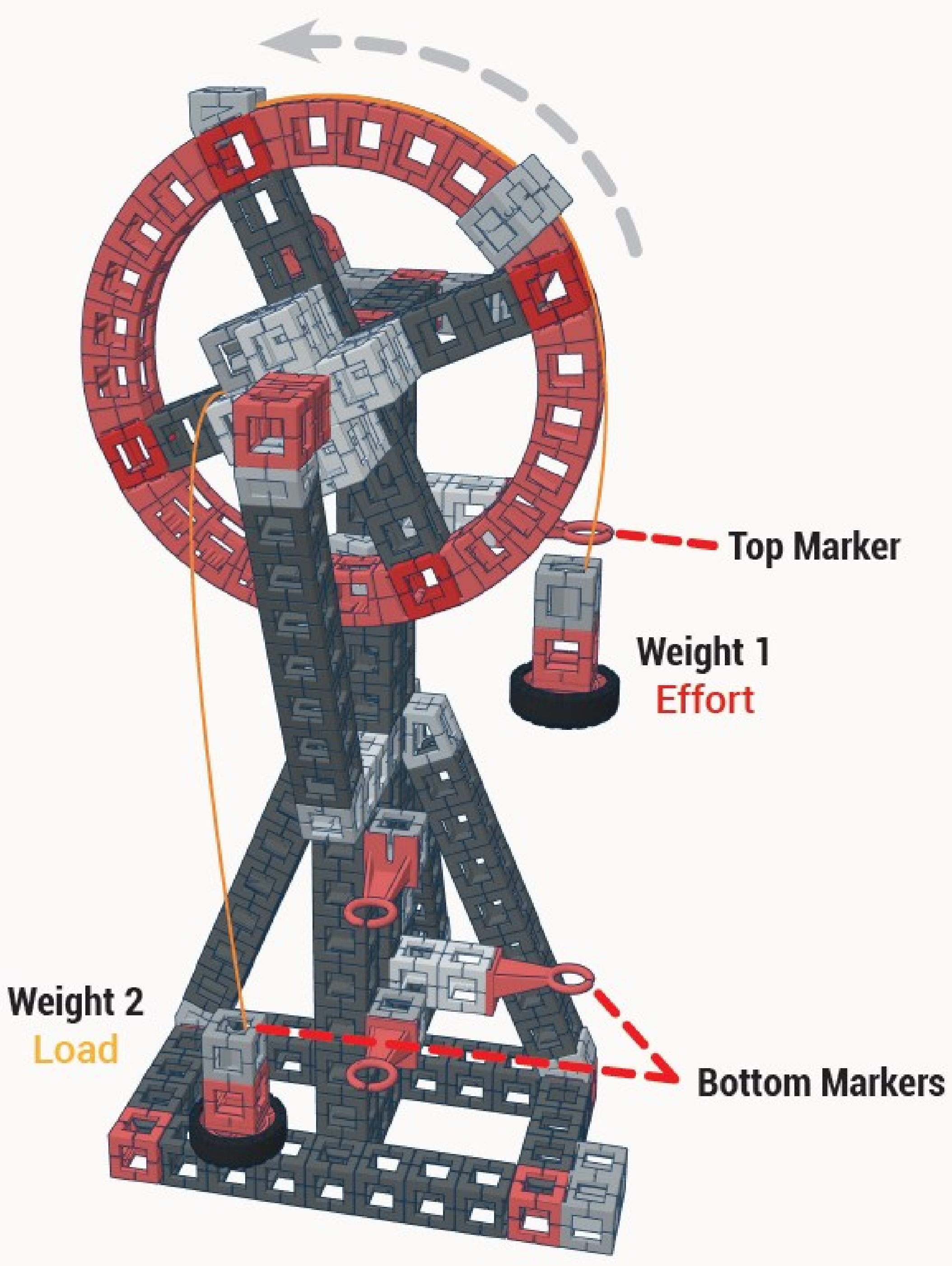
Testing Wheel & Axle

Step 1:
Turn the large wheel so that the top of **Weight 1 (Effort)** is even with the top marker and the top of **Weight 2 (Load)** is even with the bottom markers.

Step 2:
Release the wheel and observe what happens.

Wheel & Axle



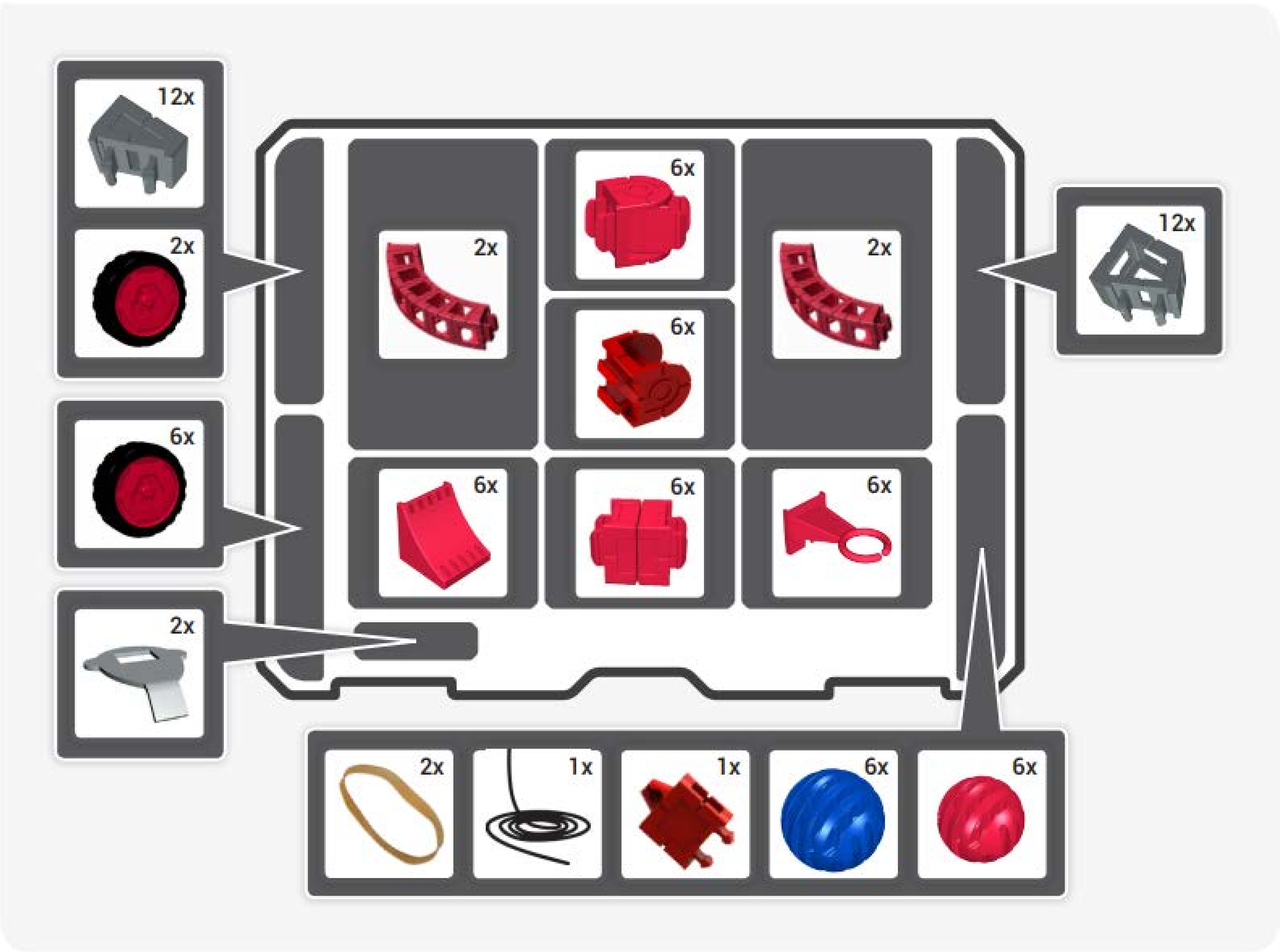


Understanding Mechanical Advantage

The main purpose of a simple machine is to make work easier. This is done by either redirecting motion or creating mechanical advantage. **Mechanical Advantage** exists when the output force of a machine is greater than the input force that was applied to it. To accomplish this, the machine must trade increased time or distance for reduced effort.

Clean Up

BOTTOM OF
MODULE



REMOVABLE BINS