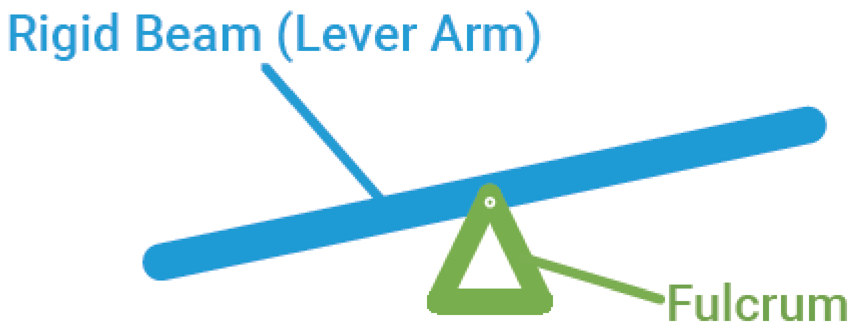
Engineering Discoveries:

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.

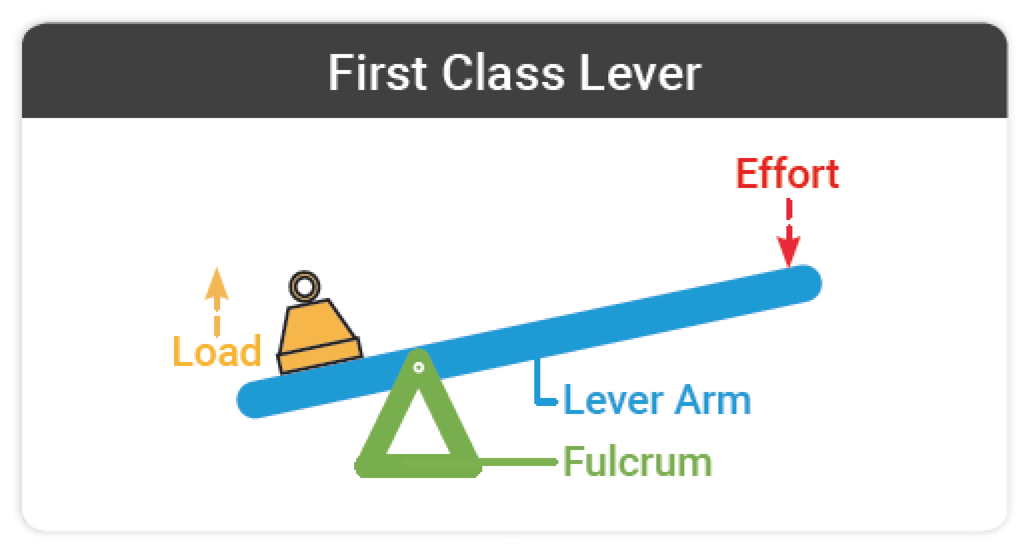


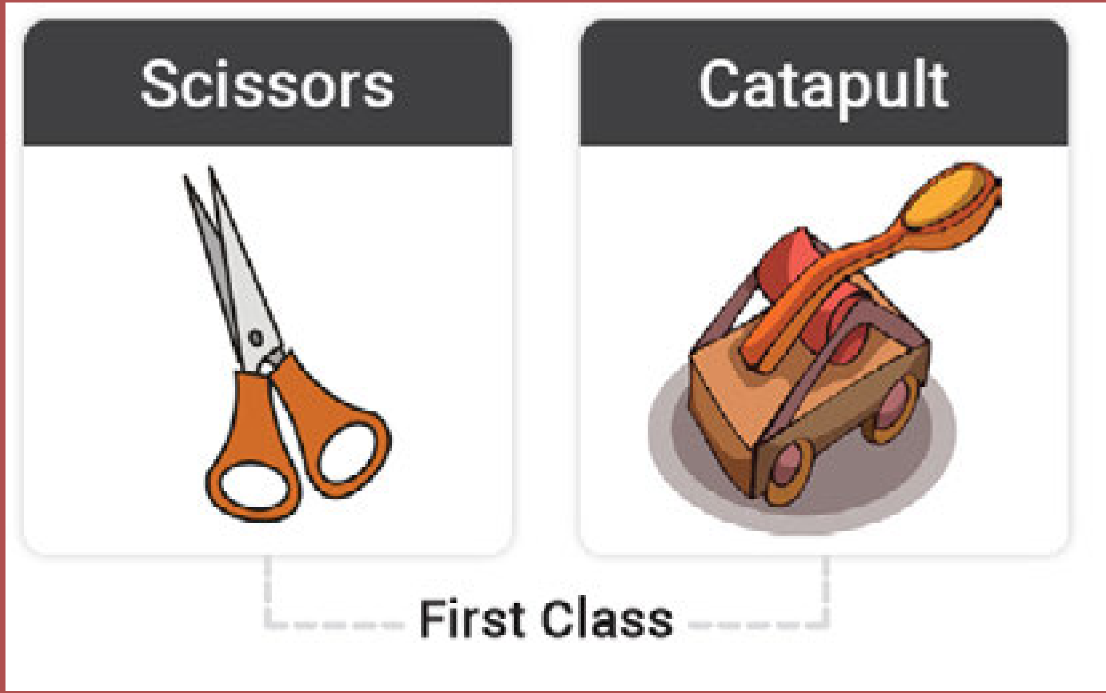
Types of Levers

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

First Class Lever

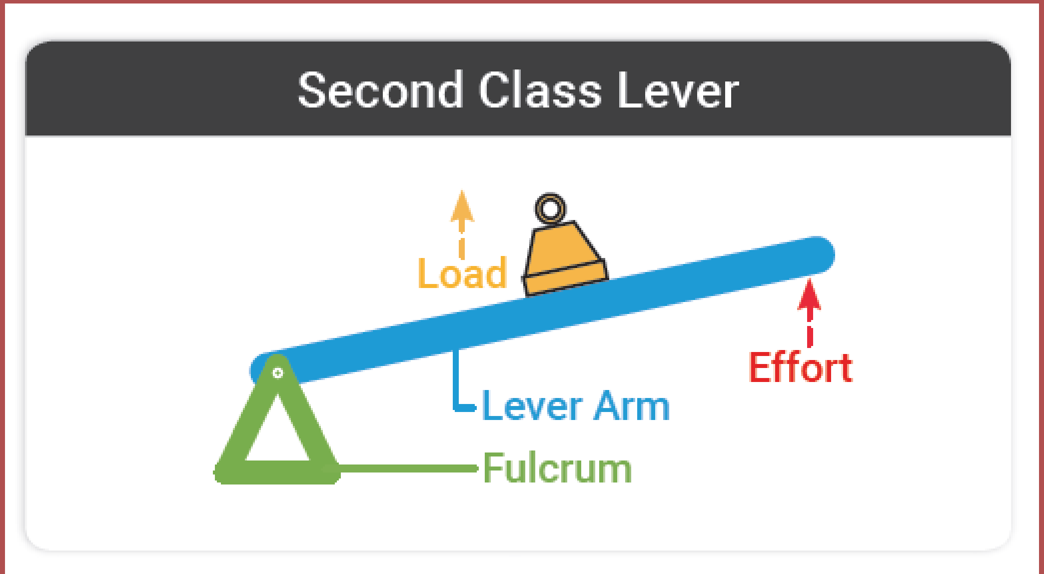
In a first class lever, the **fulcrum** is located between the **effort** and the **load**. A first class lever can be used to reduce the amount of effort needed to raise a load by placing the fulcrum closer to the load, or to increase output speed by placing the fulcrum closer to the effort.





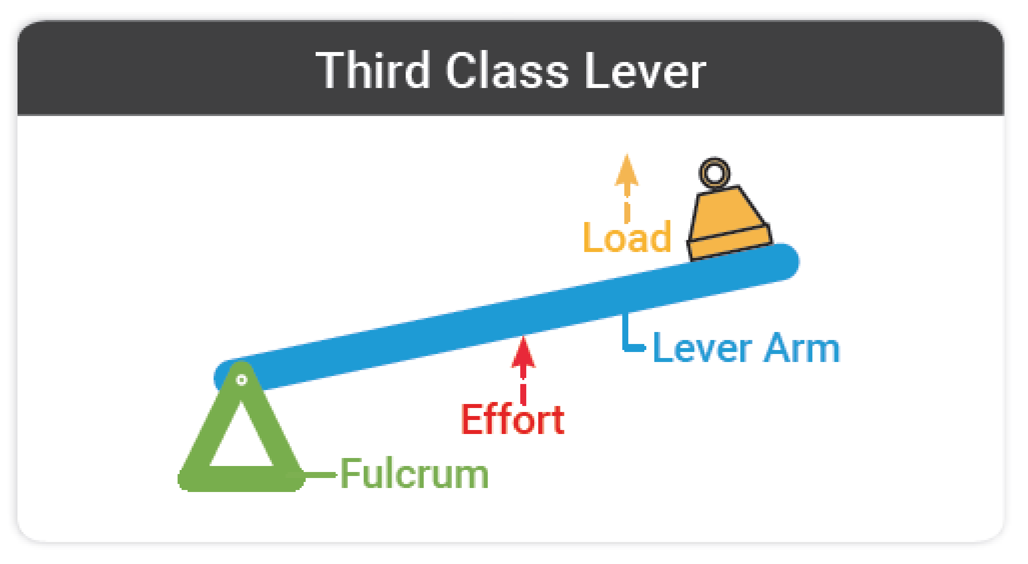
Second Class Lever

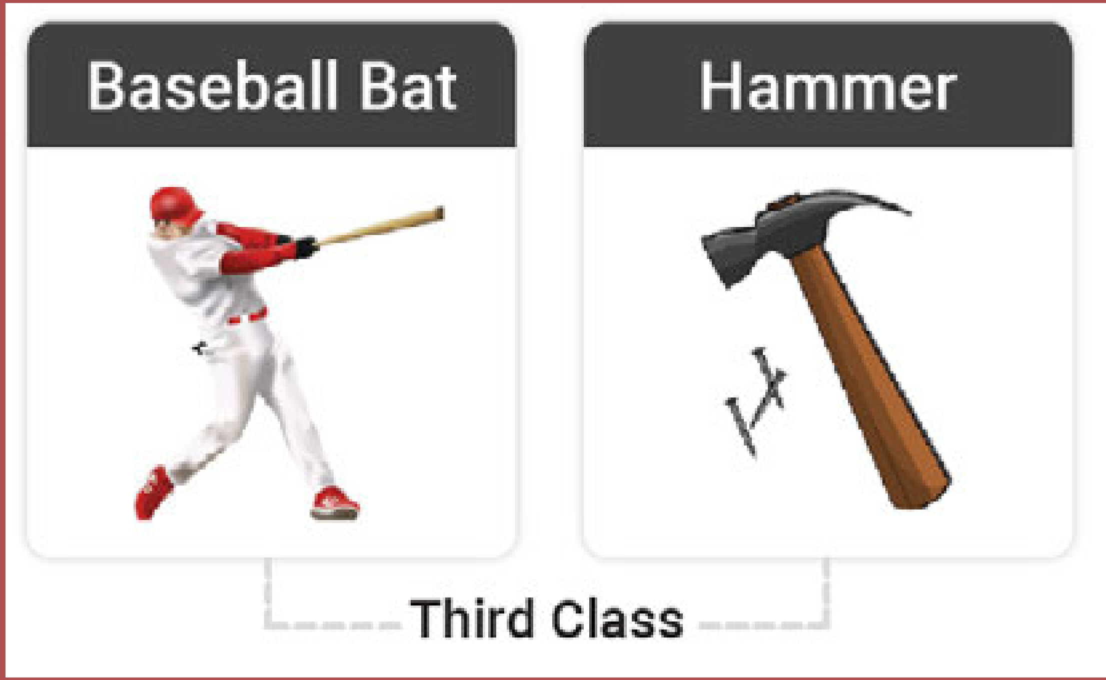
In a second class lever, the load is located between the effort and the fulcrum. The amount of effort needed to raise a load is reduced as the load is placed closer to the fulcrum. A second class lever does not change the direction of motion because the effort and the load move in the same direction.



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.





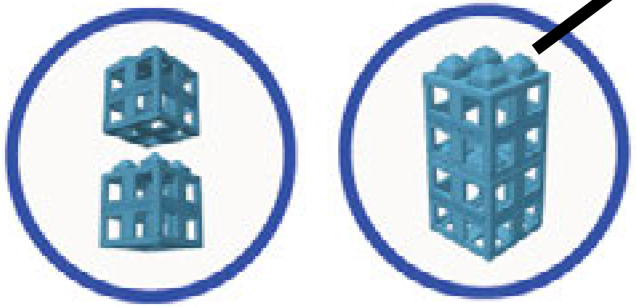
Building Basics

Building Basics with Rokenbok

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

Connecting/Separating ROK Blocks:

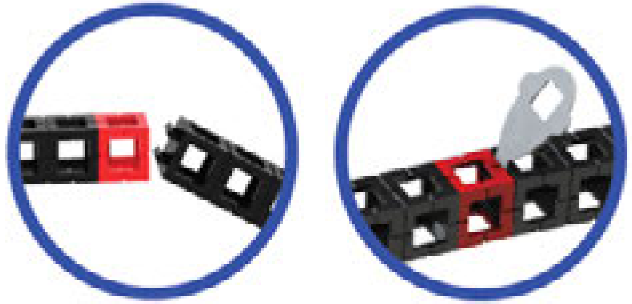
ROK Blocks use a friction-fit, pyramid and opening system to connect. Simply press pyramids into openings to connect.
To separate blocks, pull apart.



Pyramids or connectors

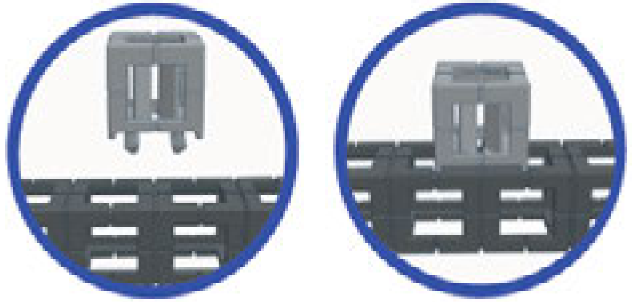
Connecting/Separating Rokenbok Components

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.



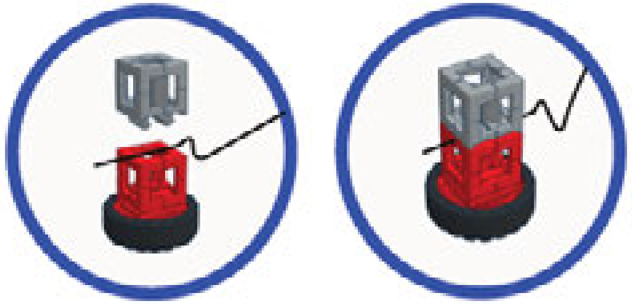
Snapping Across Openings

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:

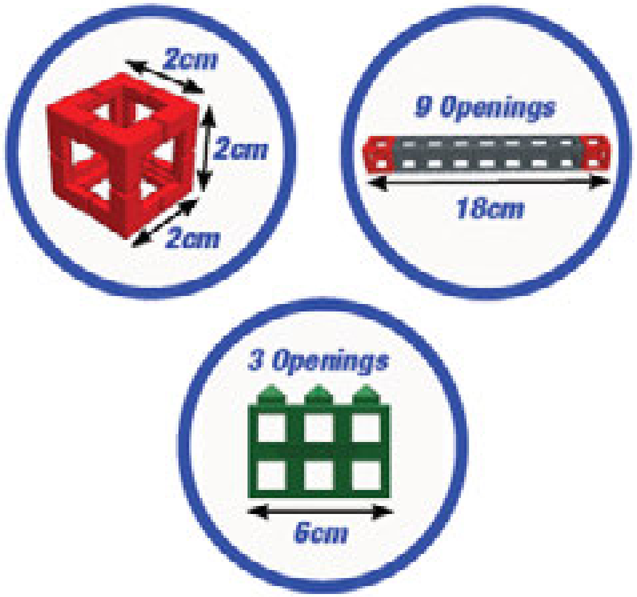
In some instances, string may be needed in a design. Lay string across opening. Snap any Rokenbok component with tabs or pyramids into opening. Make sure tabs run perpendicular to string for a tight hold.



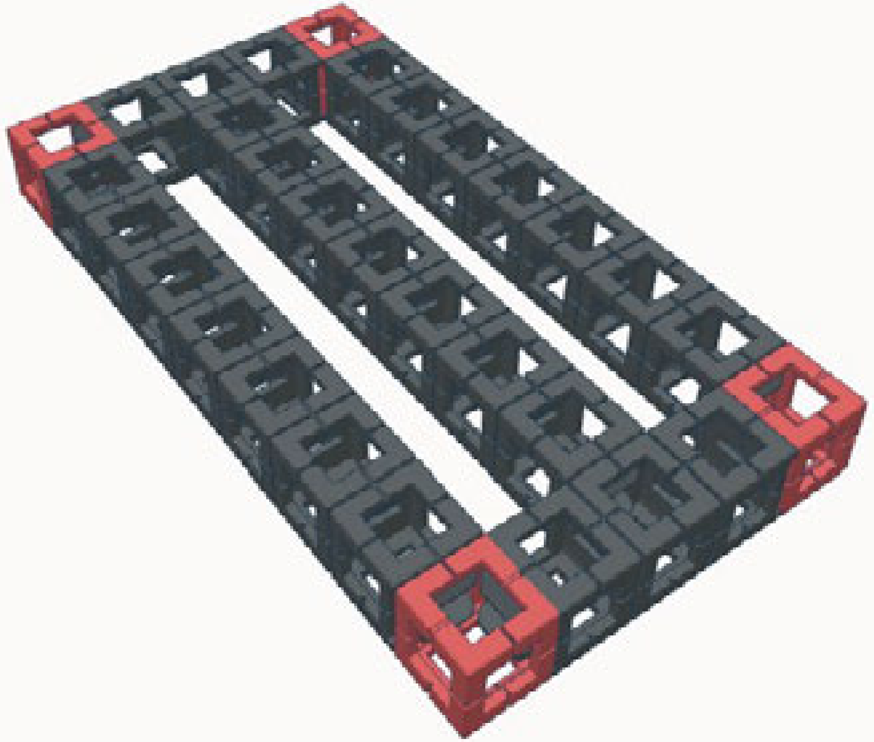
Measuring:

The outside dimensions of each Rokenbok connector block is $2cm^3$. This means the length, depth, and height are all the same.

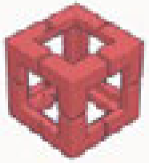
To determine the size of a Rokenbok build in cm, simply count the number of openings and multiply by two. Repeat this process for length, depth and height.



1



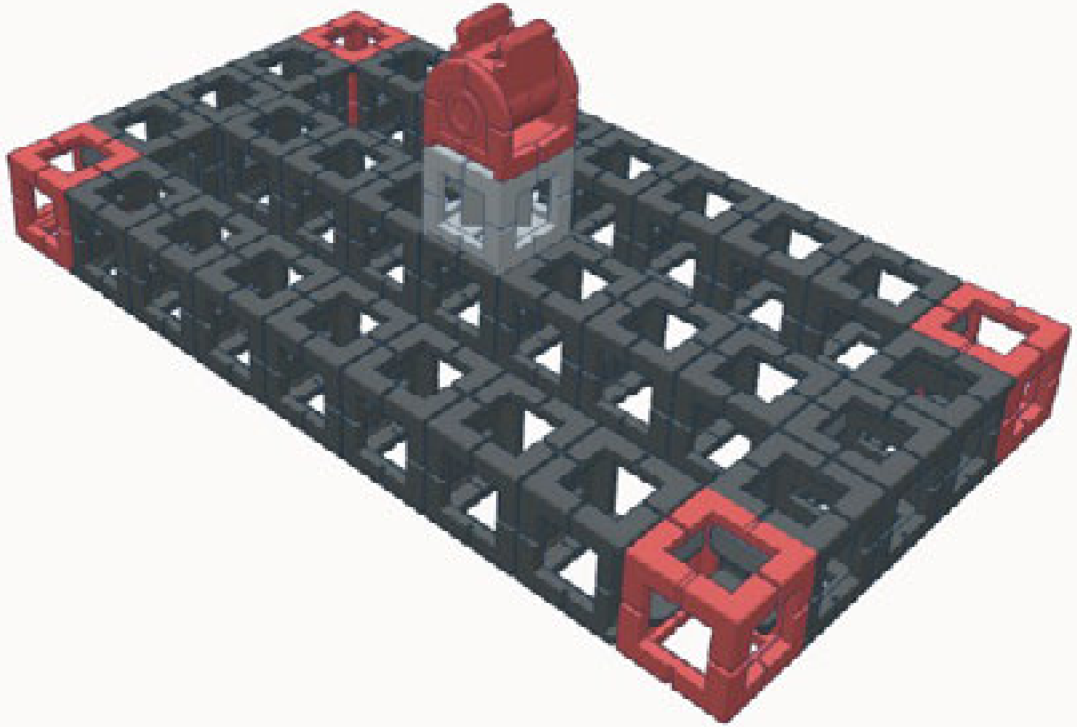
4x
Block



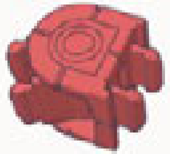
3x
Beam

2x
Half Beam

2

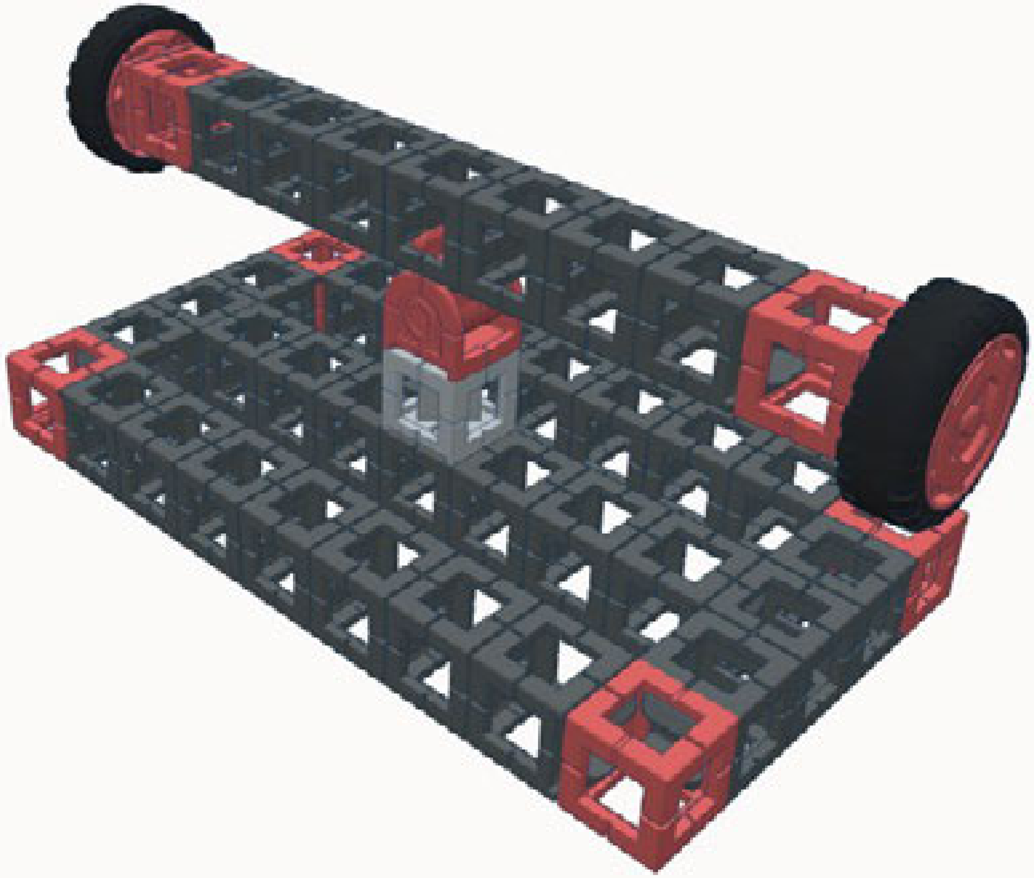


1x
Hinge Block



1x
Single Snap Block

3



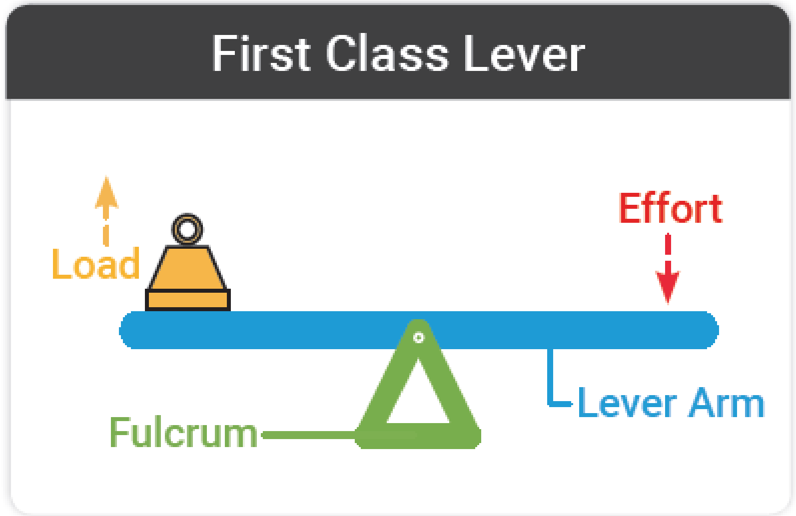
2x
Snap-In Wheel

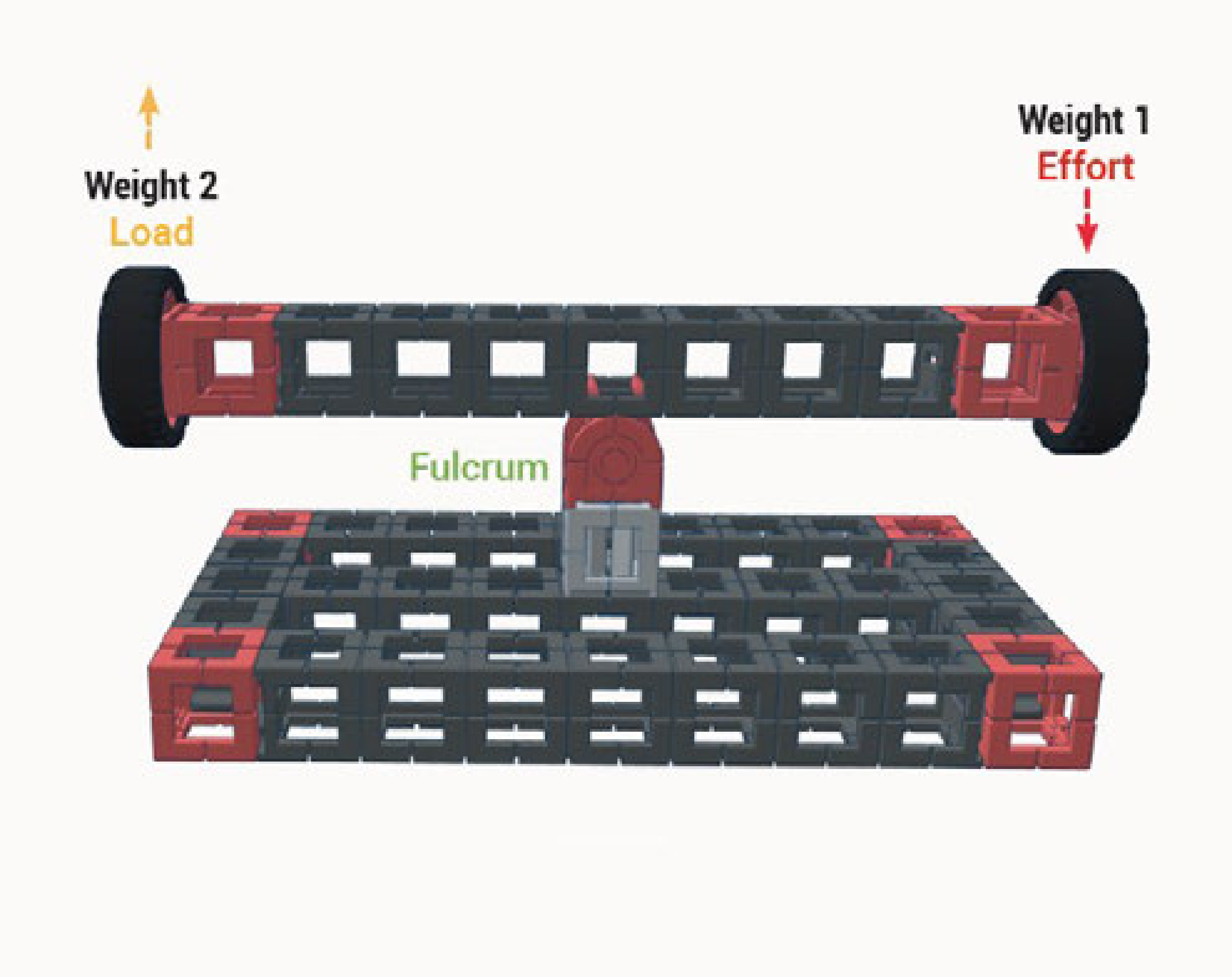
2x
Block

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.

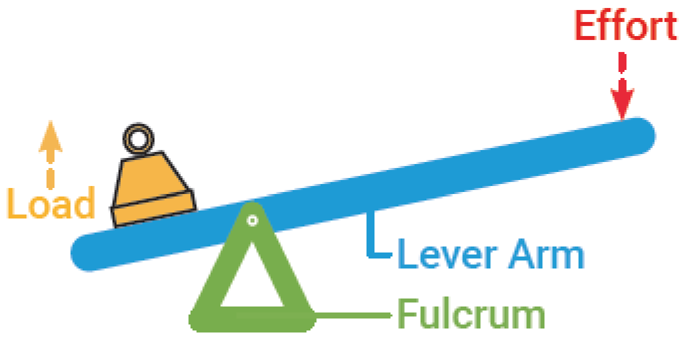


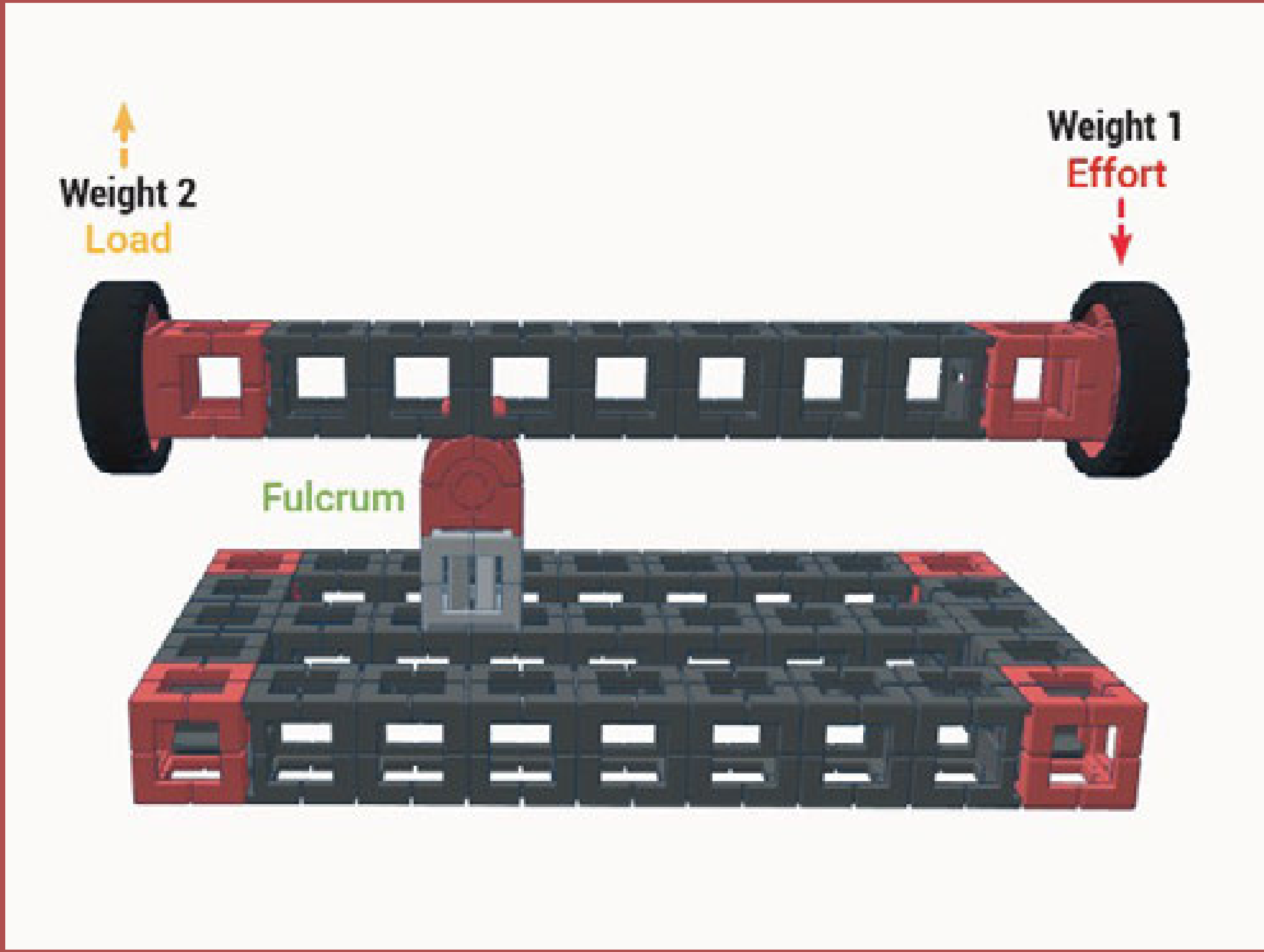

Weight 2
Load
Weight 1
Effort
Fulcrum

Modifying the First Class Lever

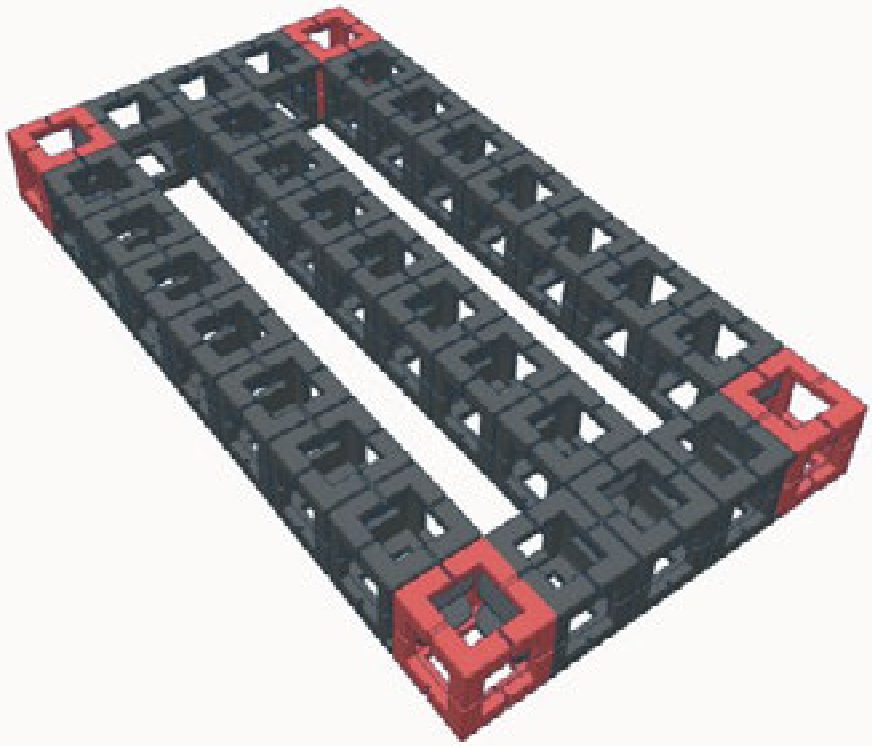
In a first class lever, the amount of effort needed to raise a load is reduced as the fulcrum is moved closer to the load. Move the fulcrum 1.5 openings towards **Weight 2** (Load) as shown in the figure to the right. Now, lift **Weight 1** (Effort) as high as possible and let go. Observe how **Weight 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

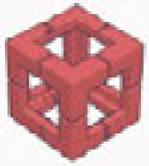



Weight 2
Load
Weight 1
Effort
Fulcrum

1



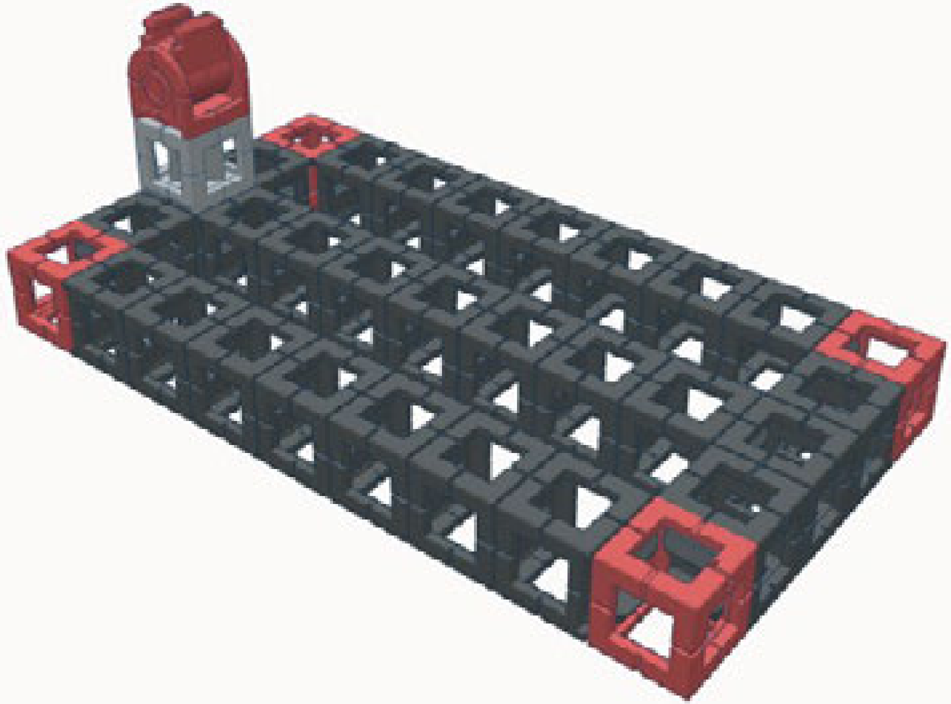
4x
Block



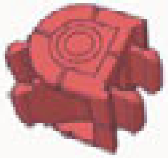
3x
Beam

2x
Half Beam

2

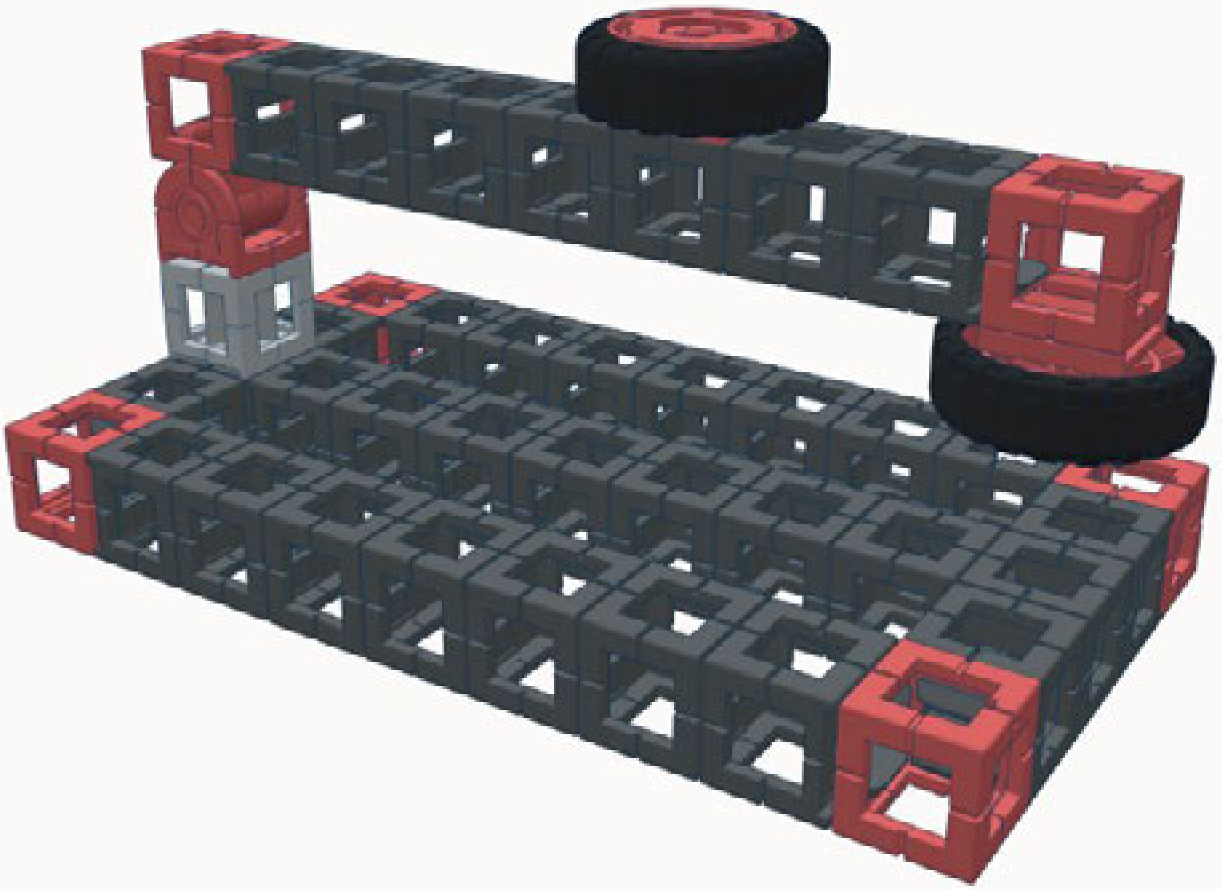


1x
Hinge Block



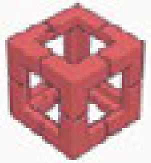
1x
Single Snap Block

3



2x
Snap-In Wheel

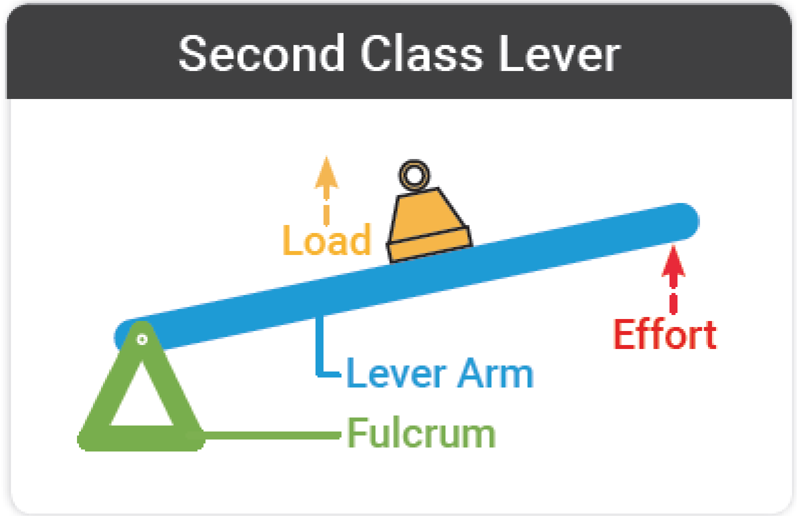
2x
Block

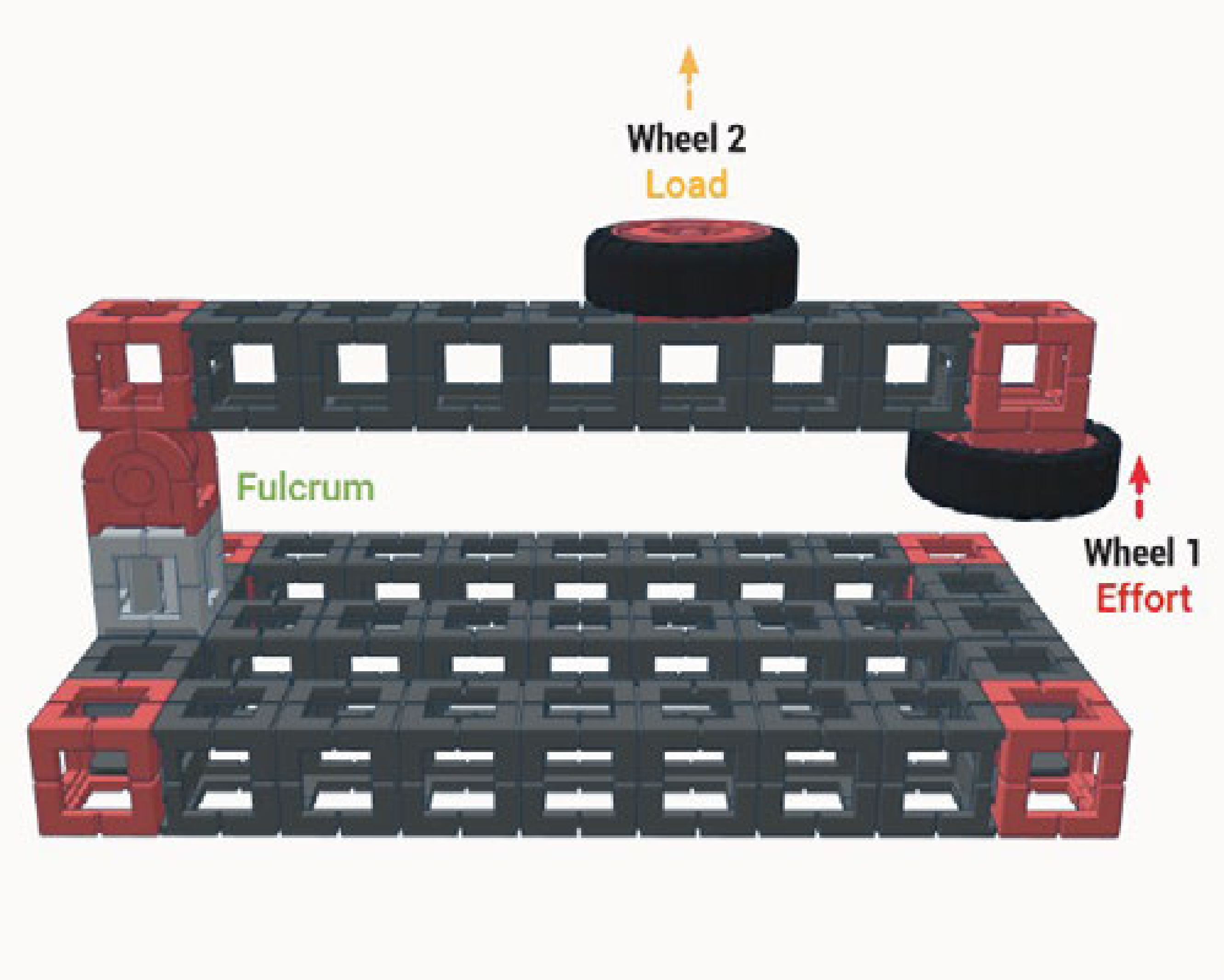


1x
Beam

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.

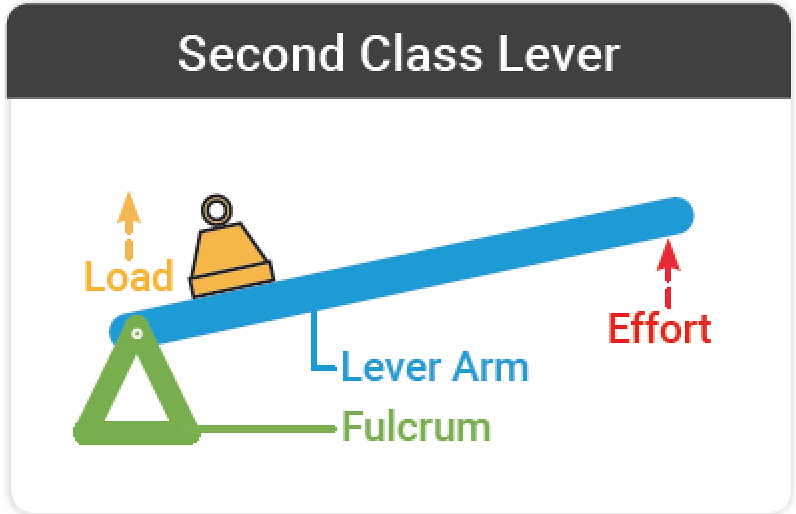


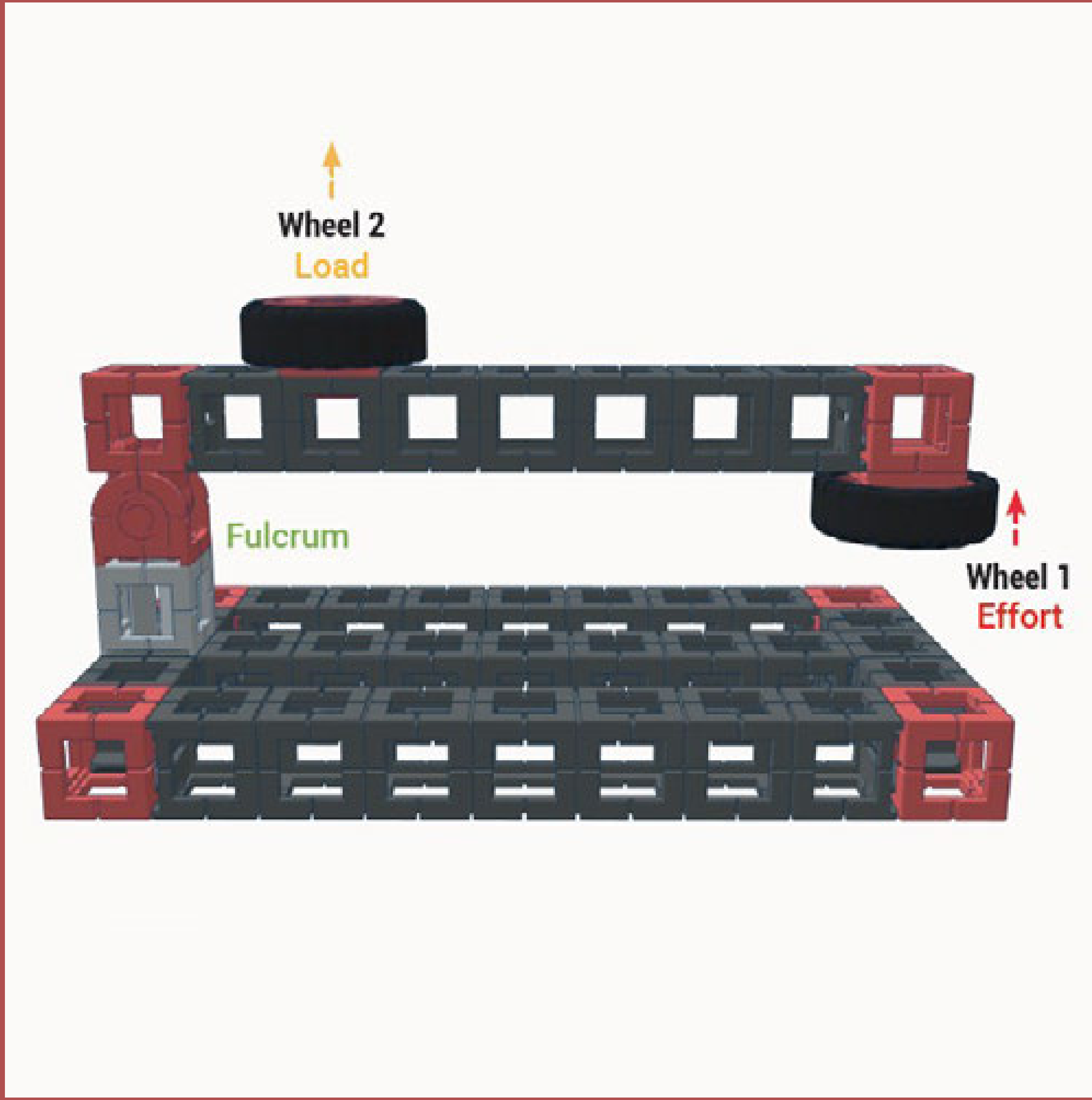


Wheel 2
Load
Fulcrum
Wheel 1
Effort

Modifying the Second Class Lever

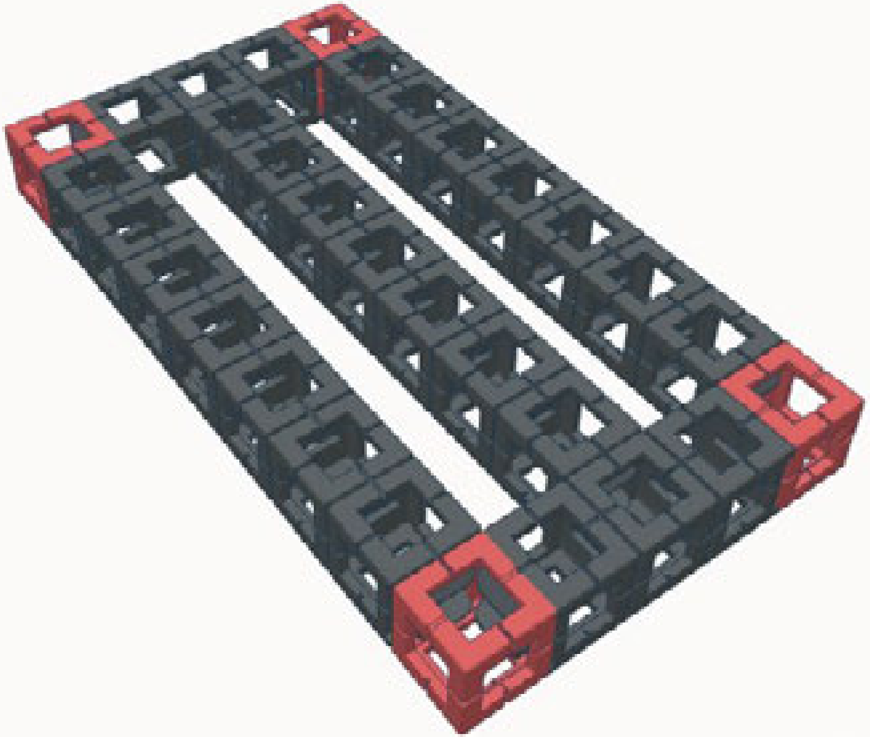
In a second class lever, the amount of effort needed to raise a load is reduced as the load is moved closer to the fulcrum. Move **Wheel 2** (Load) 3 openings towards the fulcrum as shown in the figure to the right. Lift **Wheel 1** (Effort) to raise **Wheel 2** (Load). There should be a noticeable difference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



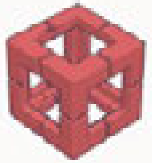


Wheel 2
Load
Fulcrum
Wheel 1
Effort

1



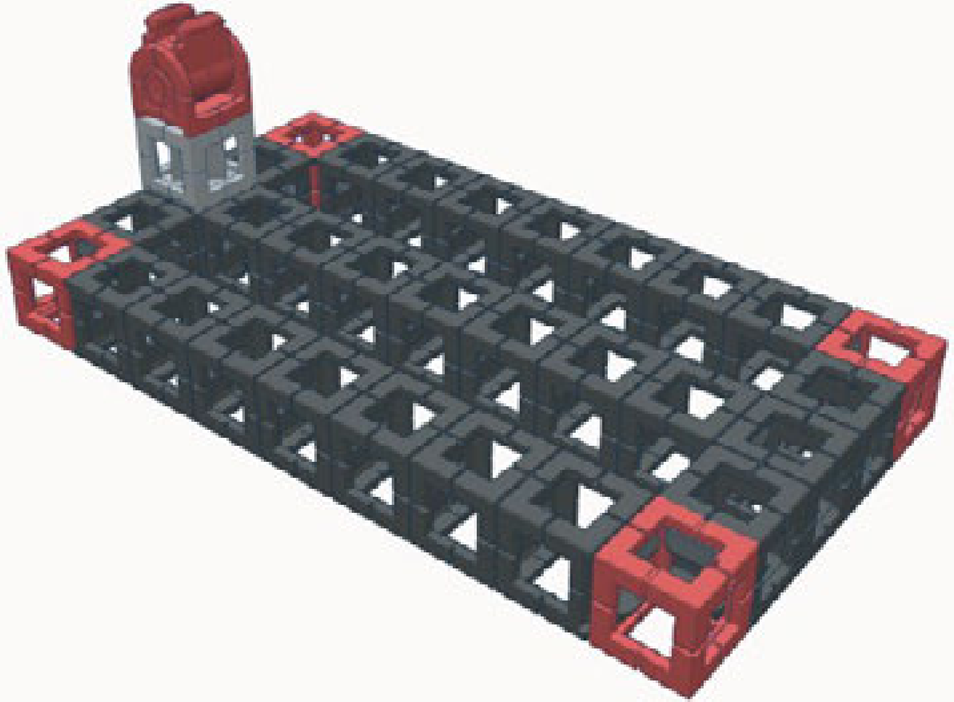
4x
Block



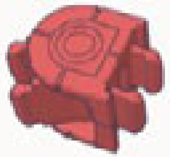
3x
Beam

2x
Half Beam

2

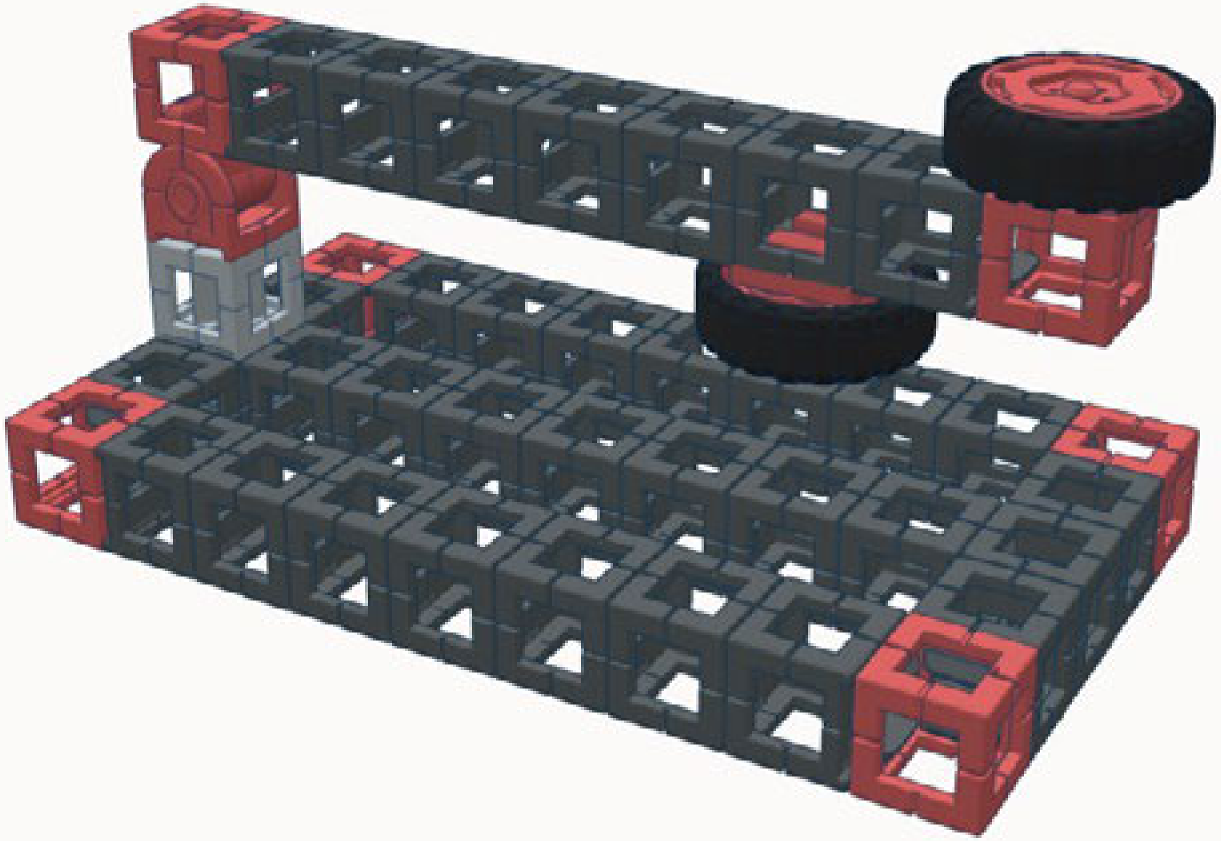


1x
Hinge Block



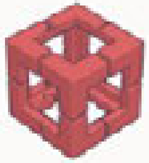
1x
Single Snap Block

3



2x
Snap-In Wheel

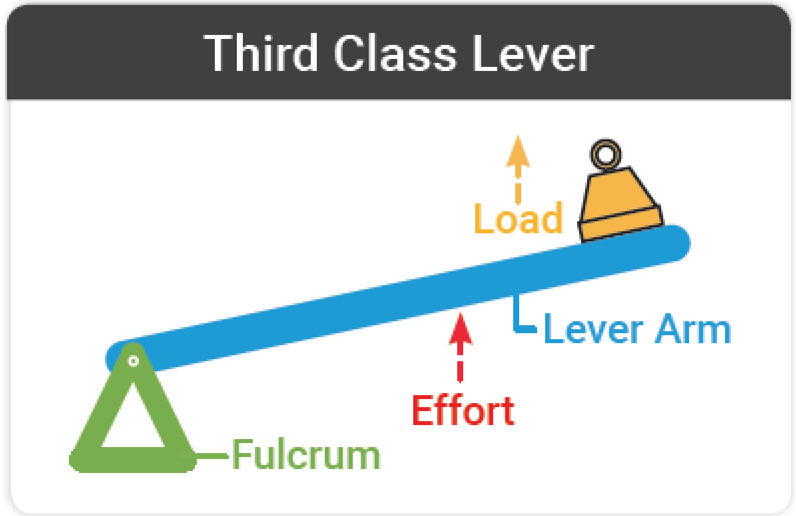
2x
Block

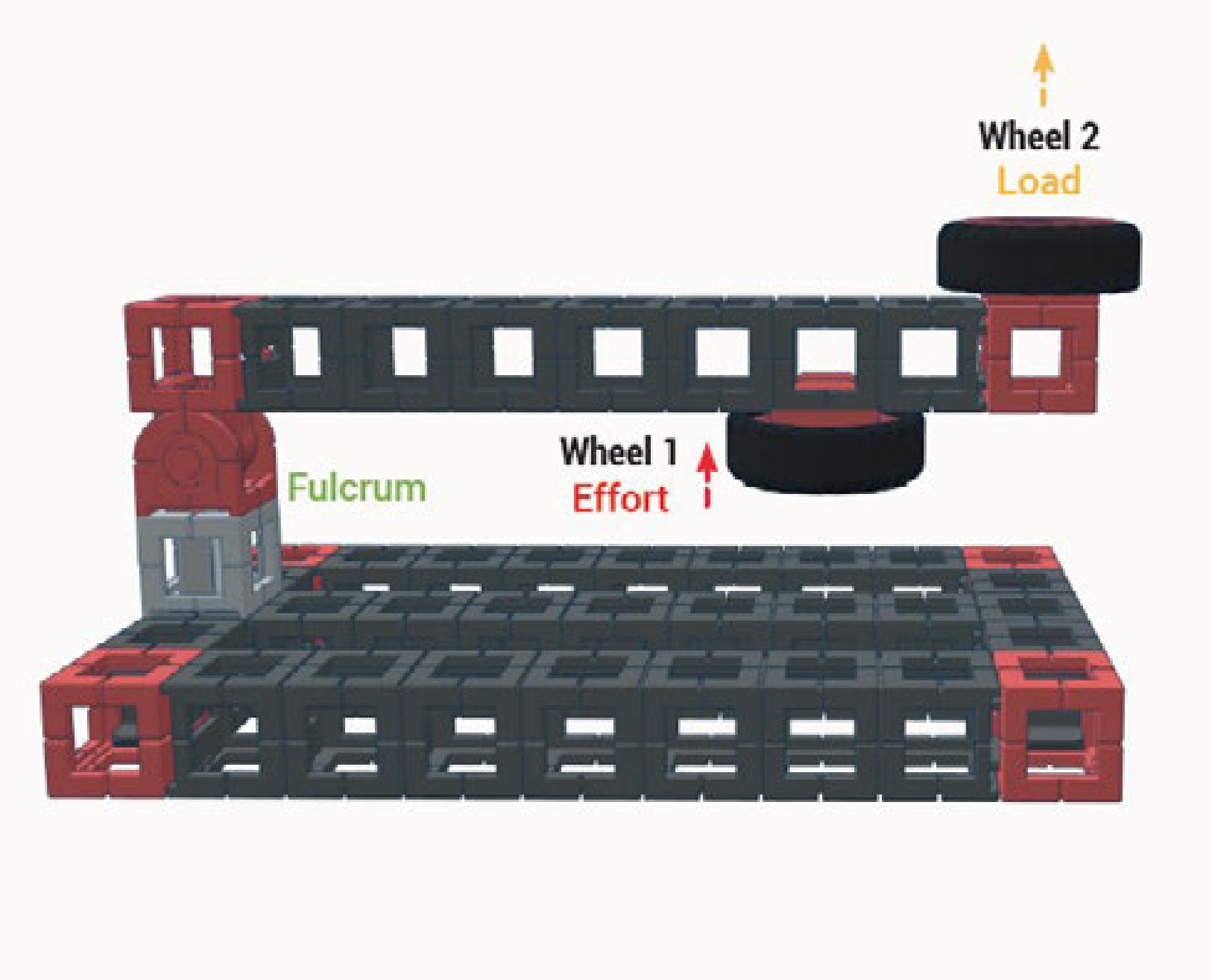


1x
Beam

Testing the Third Class Lever

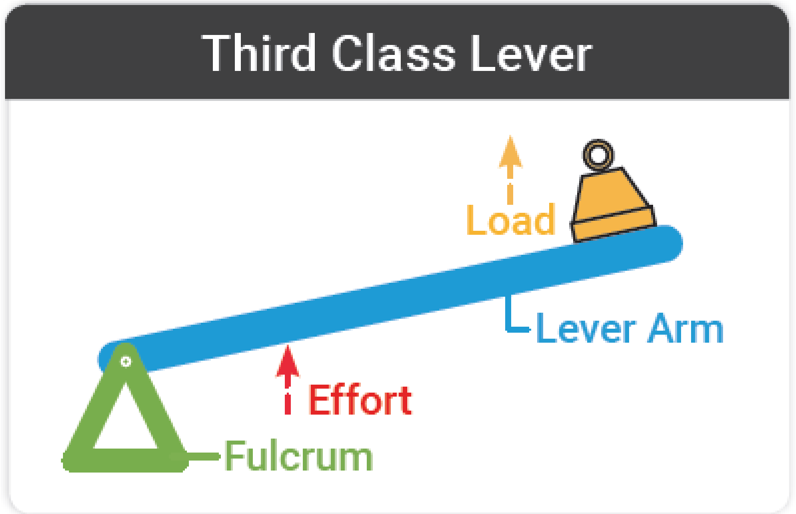
In a third class lever, the effort is applied between the fulcrum and the load. In this example, when **Wheel 1** (Effort) is raised, **Wheel 2** (Load) is raised in the same direction. The amount of effort needed to raise a load is reduced as the effort is applied closer to the load.




Wheel 2
Load
Fulcrum
Wheel 1
Effort

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).**

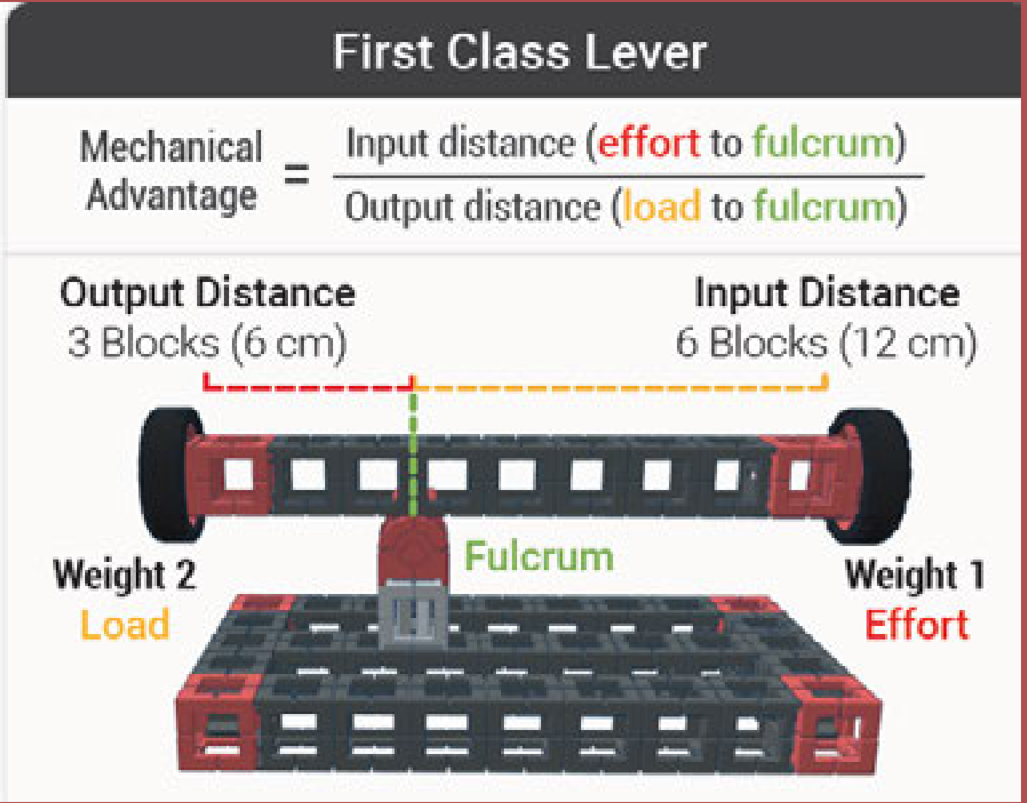


Wheel 2
Load
Wheel 1
Effort
Fulcrum

First Class Lever

A first class lever can be used create mechanical advantage by placing the fulcrum closer to the load. To calculate how much mechanical advantage is in a first class lever, divide the **Input distance** (distance from the **effort** to the fulcrum) by the **Output distance** (distance from the load to the fulcrum).

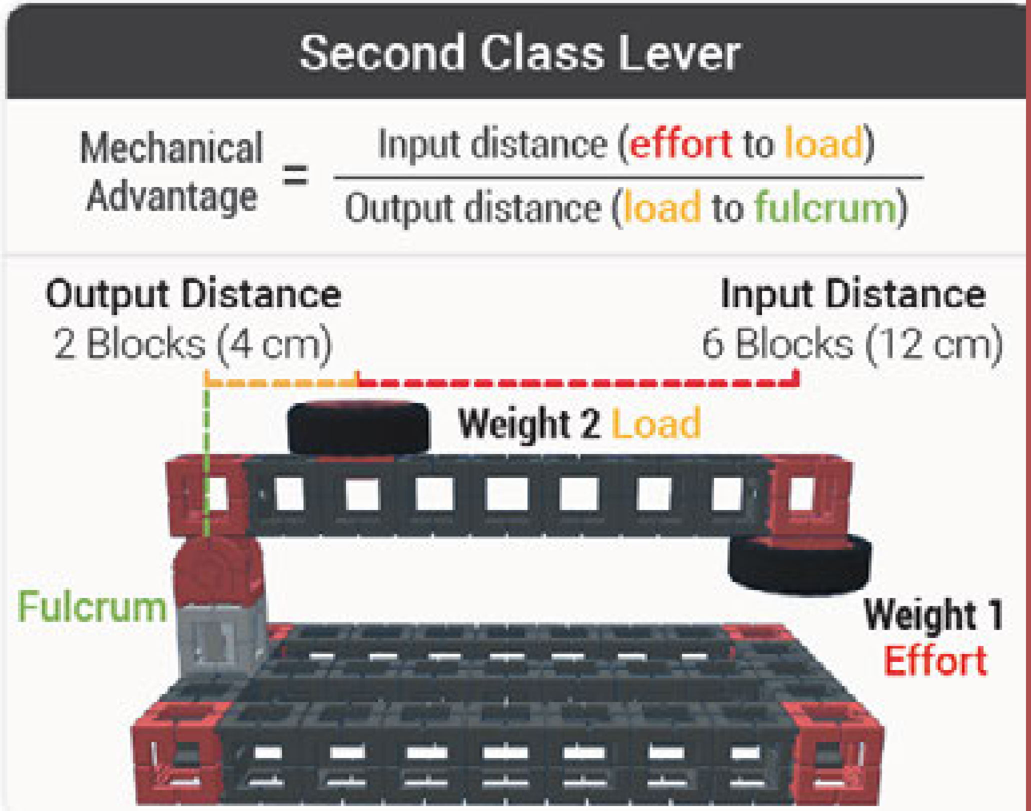
In the modified first class lever, the input distance was 6 blocks (12 cm), and the output distance was 3 blocks (6 cm). Divide 12/6 and this will give a mechanical advantage of 2:1. This lever is able to output two times the amount of force that is applied to it. **Wheel 1 (Effort)** will travel twice the distance of **Wheel 2 (Load)** in order to reduce the amount of effort needed to raise the load.



Second Class Lever

A second class lever can be used create mechanical advantage by placing the load closer to the fulcrum. To calculate how much mechanical advantage is in a second class lever, divide the **Input distance** (distance from the effort to the load) by the **Output distance** (distance from the load to the fulcrum).

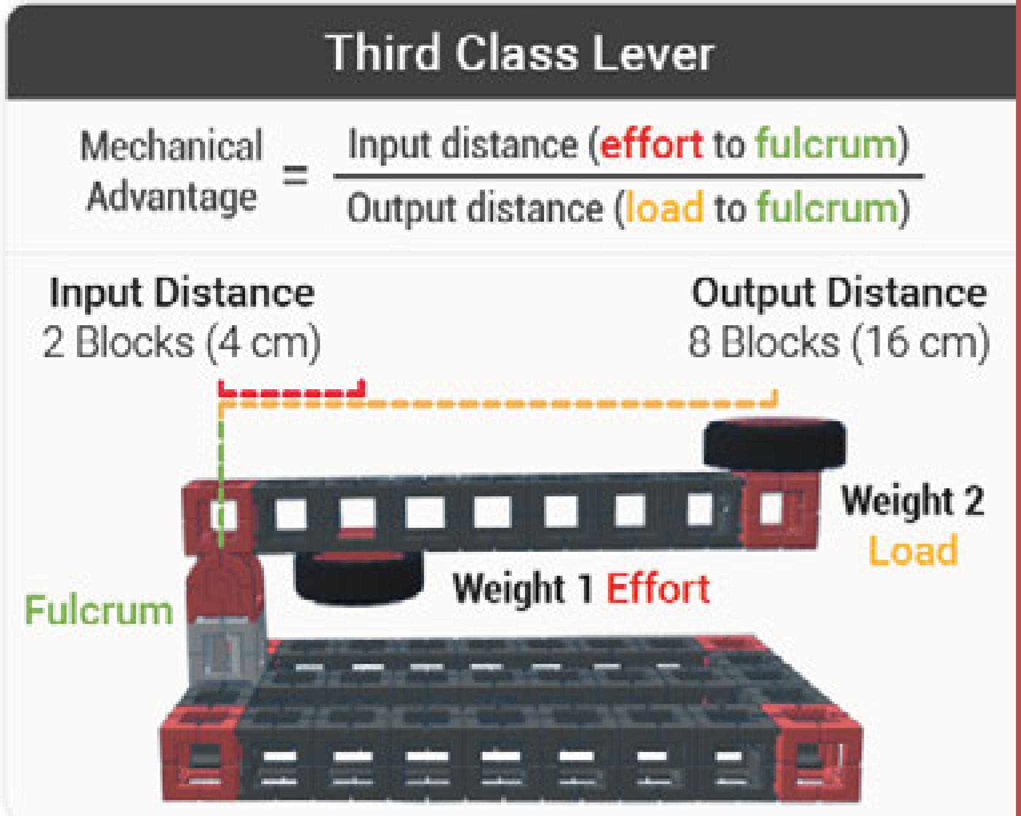
In the second class lever that was built and modified, the input distance was 6 blocks (12 cm), and the output distance was 2 blocks (4 cm). Divide 12/4 and this will give a mechanical advantage of 3:1.This lever is able to output three times the amount of force that is applied to it. **Wheel 1** (Effort) will travel three times the distance of **Wheel 2** (Load) in order to reduce the amount of effort needed to raise the load.



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).

In the third class lever that was built and modified, the input distance was 2 blocks (4 cm), and the output distance was 8 blocks (16 cm). Divide 4/16 and this will give a mechanical advantage of .25:1. This means that **Wheel 2 (**Load**)** will travel four units of measurement for every one unit of measurement **Wheel 1 (**Effort**)** travels in the same amount of time. The mechanical advantage of a third class lever will always be less than 1, which means it is not actually creating any mechanical advantage. Its primary purpose is to increase output speed. Output speed is increased as the effort is applied closer to the fulcrum.



Extension Activity

Design Brief: Scenario

A local museum is looking to add a medieval times themed area to a newly renevoted part of their building. They would like to include an interactive display that can be used by children to test a small, working, medieval catapult system. Children will have fun testing the catapult for distance and precision, while also learning how the devices were used in medieval times.

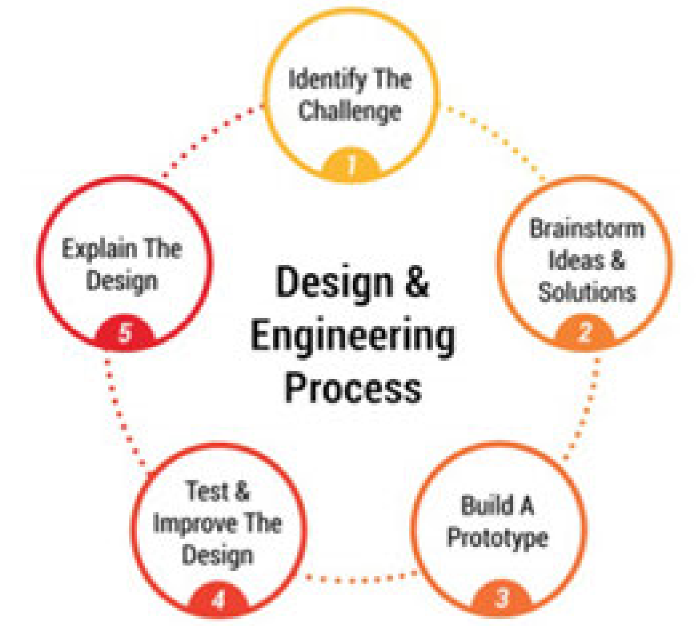
Design & Engineering Challenge

Your challenge is to design and engineer a catapult device that can precisely launch Rokenbok balls to hit close and long range targets.

***Instructor will have close and long range targets set up for testing catapults.**

Specifications

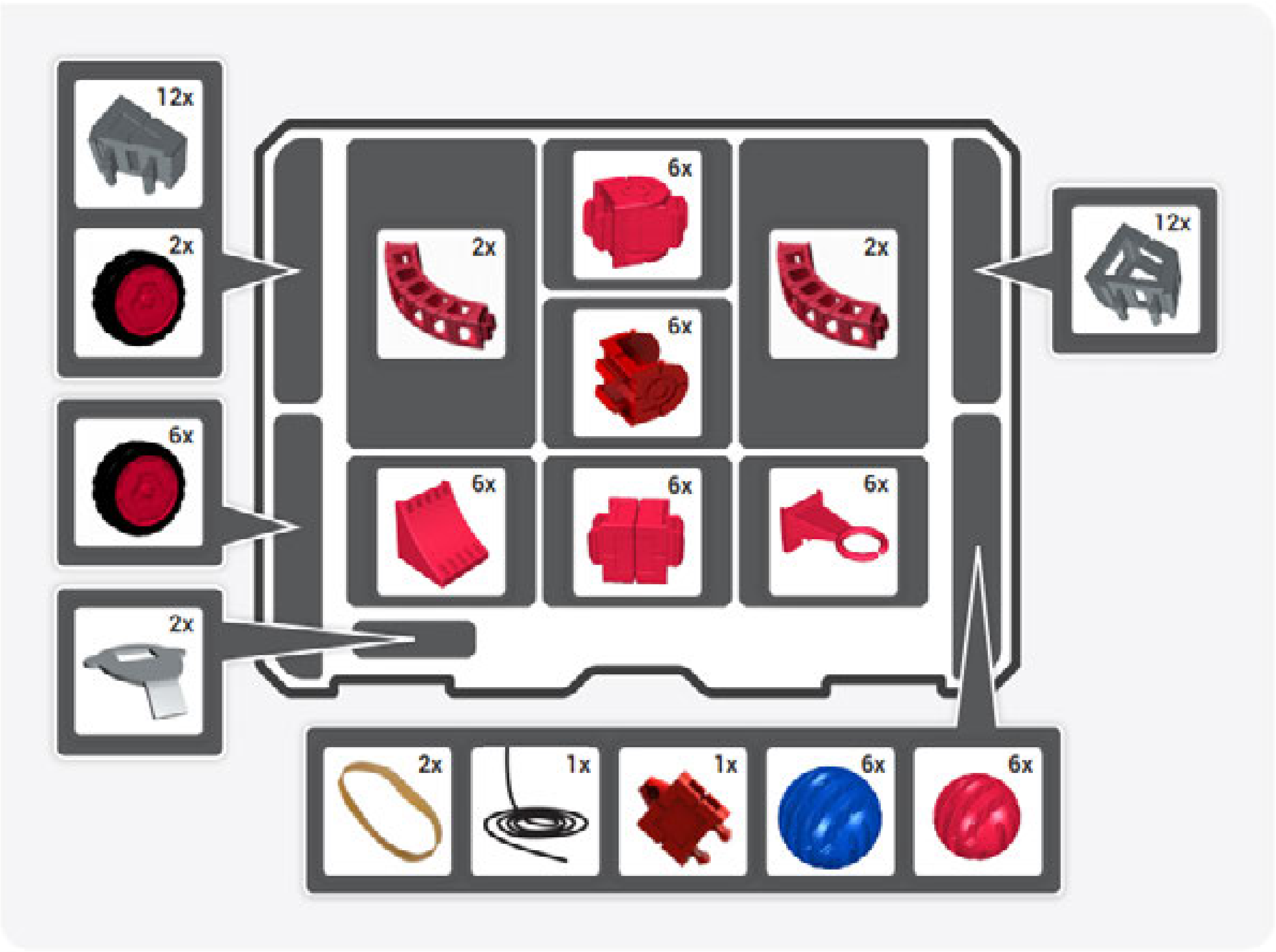
- Students will work in teams to complete this challenge
- Teams must work through each step of the design & engineering process to design, prototype, and refine a custom inclined plane.
- With each building component costing $2, the catapult must cost less than $140.



Design and Engineering Process

Clean Up

BOTTOM OF MODULE



REMOVABLE
BINS