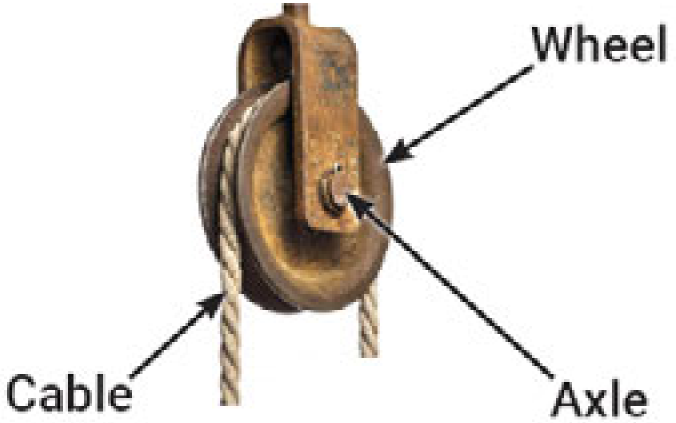
Engineering Discoveries:
Pulley

The Pulley

A **pulley** is a simple machine that consists of a **wheel** and **axle** with a groove cut into the edge of the wheel to accept a **cable**. The pulley allows the cable to be attached to a load and transfers the downward pull of the cable to raise the load.

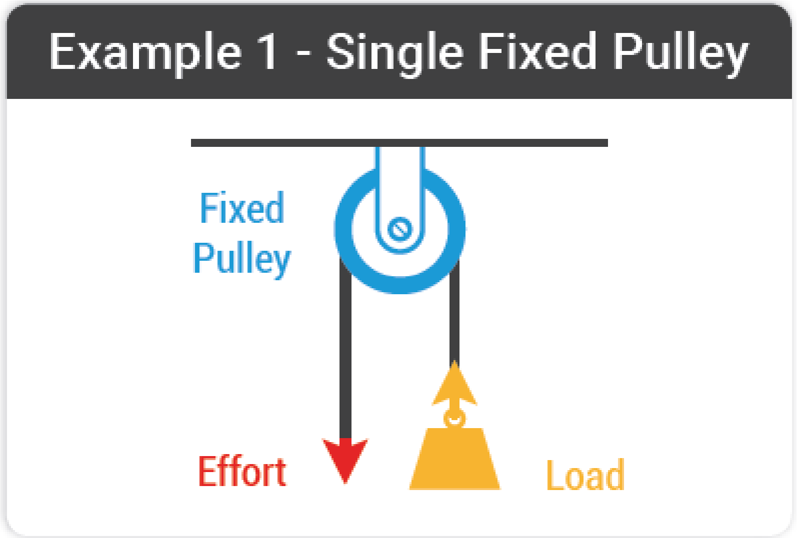


Purposes

Pulleys can be used to **redirect motion** or to reduce the amount of effort needed to raise a load by creating **mechanical advantage**.

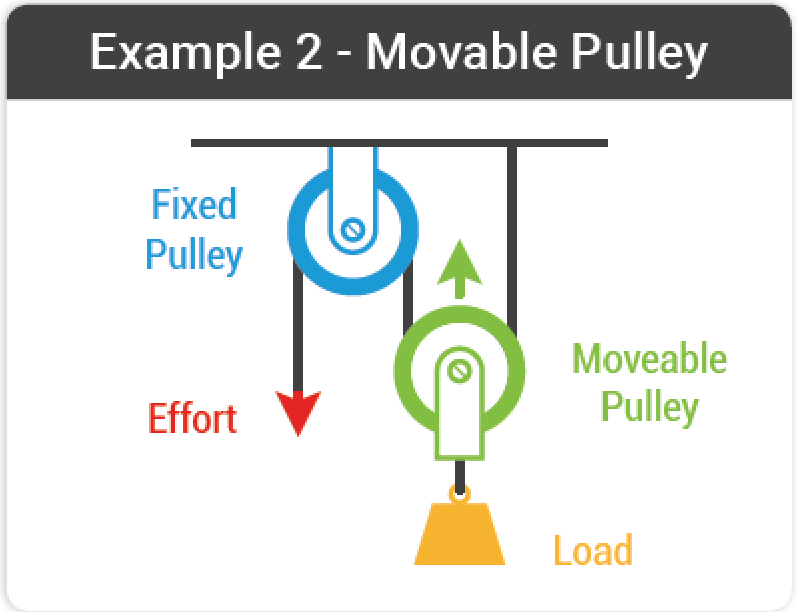
Redirecting Motion

In a **single fixed pulley system** (example 1), the amount of effort needed to raise the load must be more than the load itself. For example, if the load was 100lbs, a force greater than 100lbs would be needed to raise the load. A single fixed pulley system is only used to redirect motion. If a user pulls down on one end of the cable (**Effort**), the other end (**Load**) will raise up an equal distance in the opposite direction.



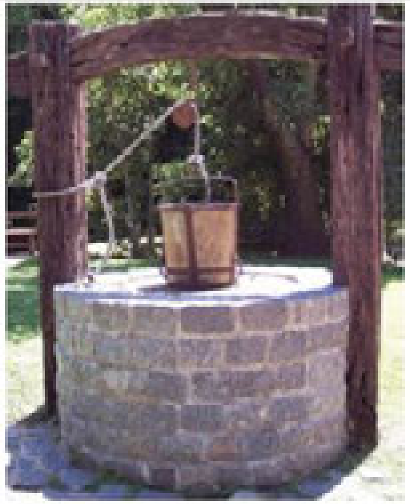
Creating Mechanical Advantage

Pulleys are used to reduce the amount of effort needed to raise a load by creating mechanical advantage. To create mechanical advantage in a pulley system, a **movable pulley** must be attached directly to the Load (example 2). A movable pulley system trades increased distance for reduced Effort.



Block & Tackle

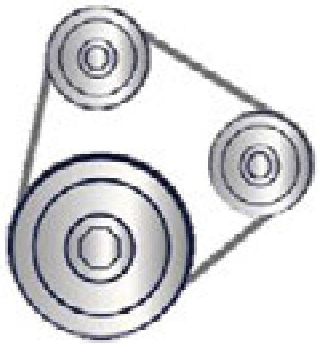
Water Well



Crane Truck

Flag Pole

Belt Pulleys



Building Basics

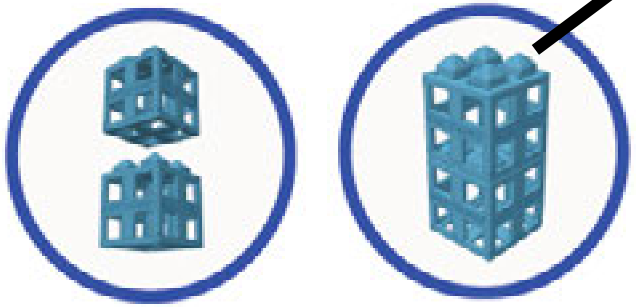
Building Basics with Rokenbok

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

Pyramids or connectors

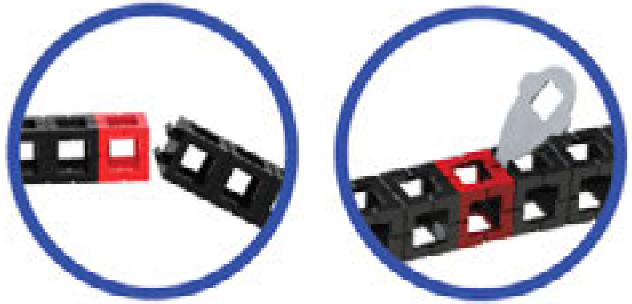
Connecting/Separating ROK Blocks:

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



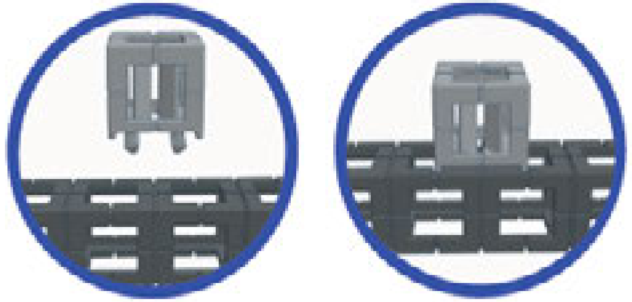
Connecting/Separating Rokenbok Components

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.



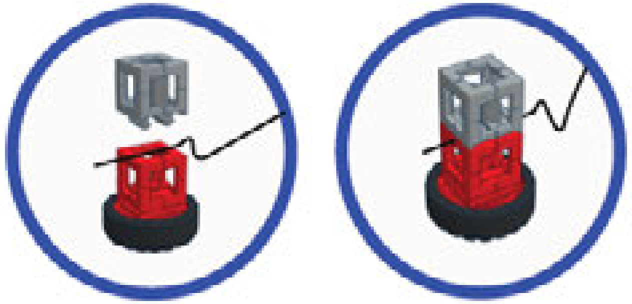
Snapping Across Openings

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:

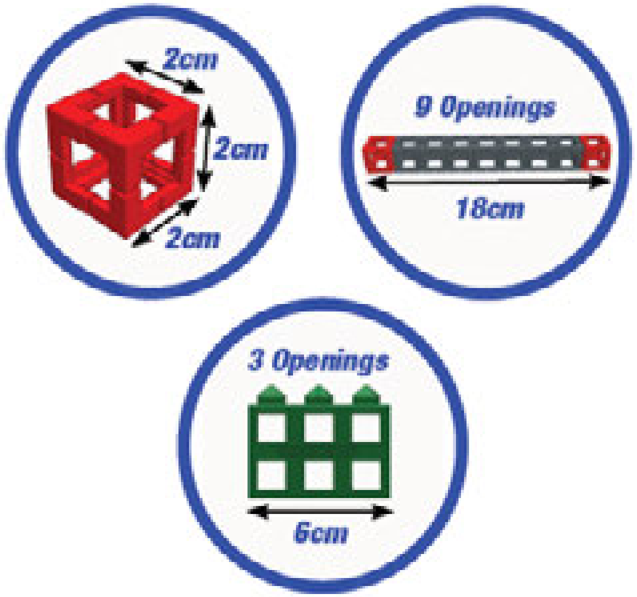
In some instances, string may be needed in a design. Lay string across opening. Snap any Rokenbok component with tabs or pyramids into opening. Make sure tabs run perpendicular to string for a tight hold.



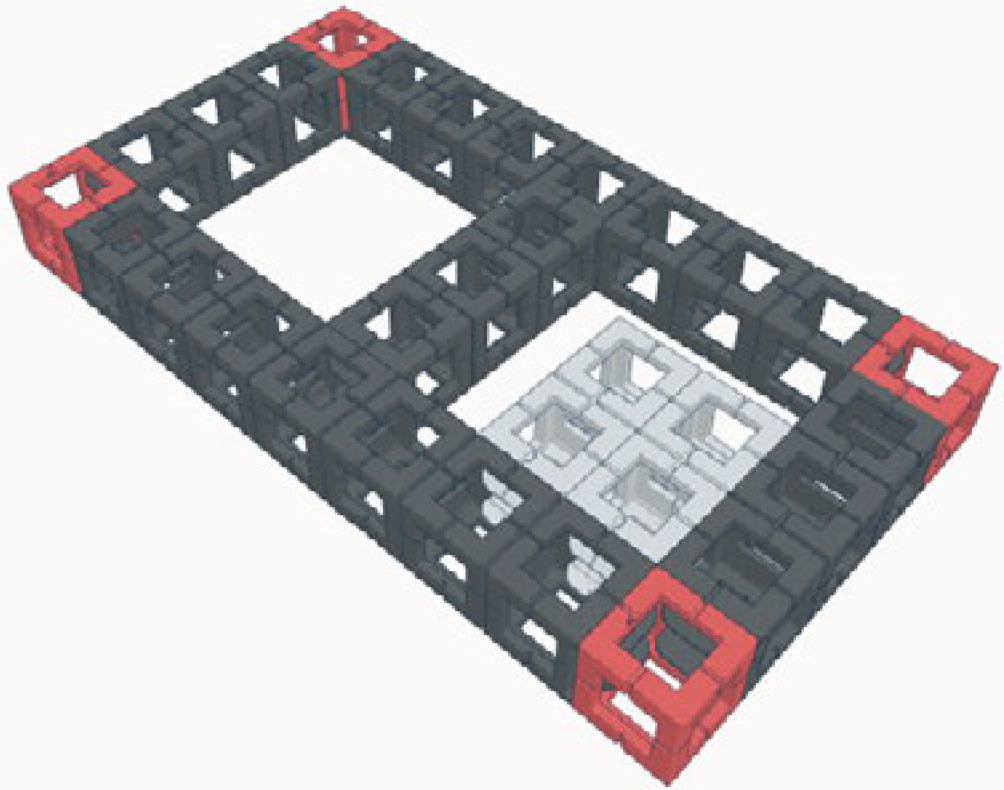
Measuring:

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

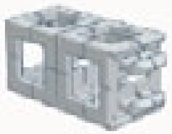


4x
Block

2x
Beam

3x
Half Beam

2x
Riser

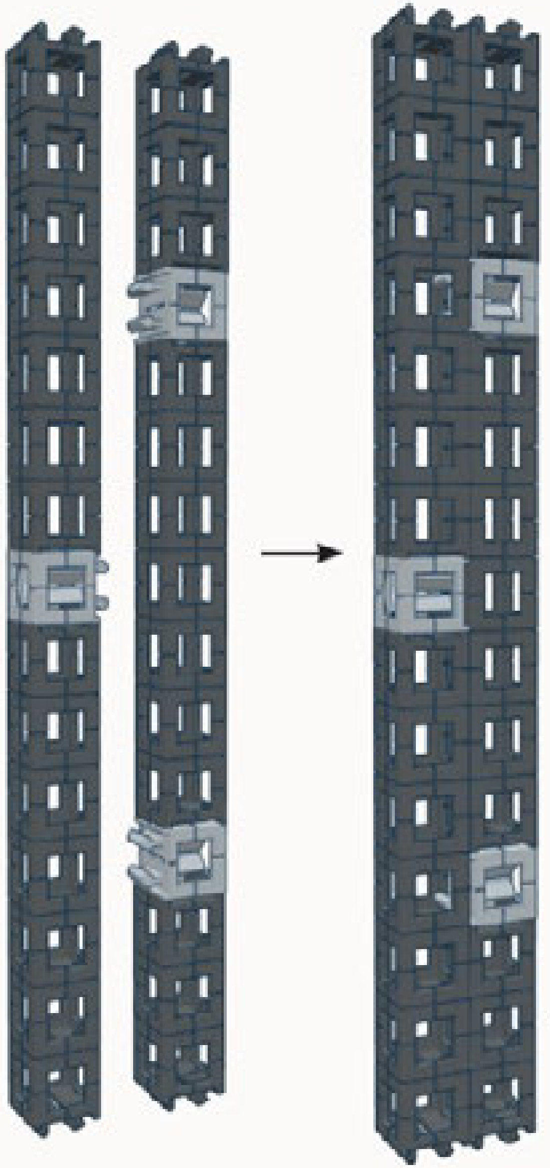


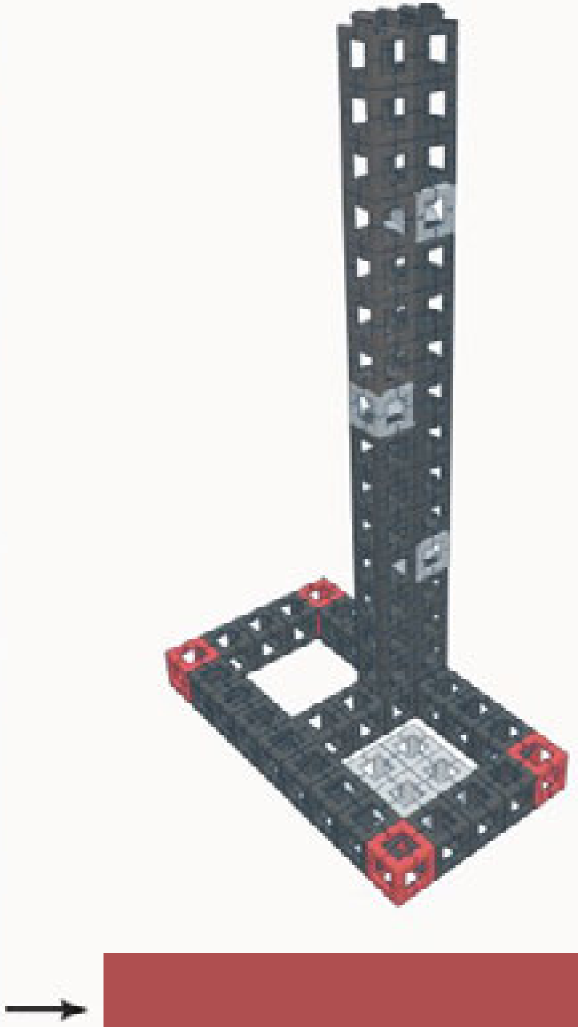
3x
Beam

2x
Half Beam

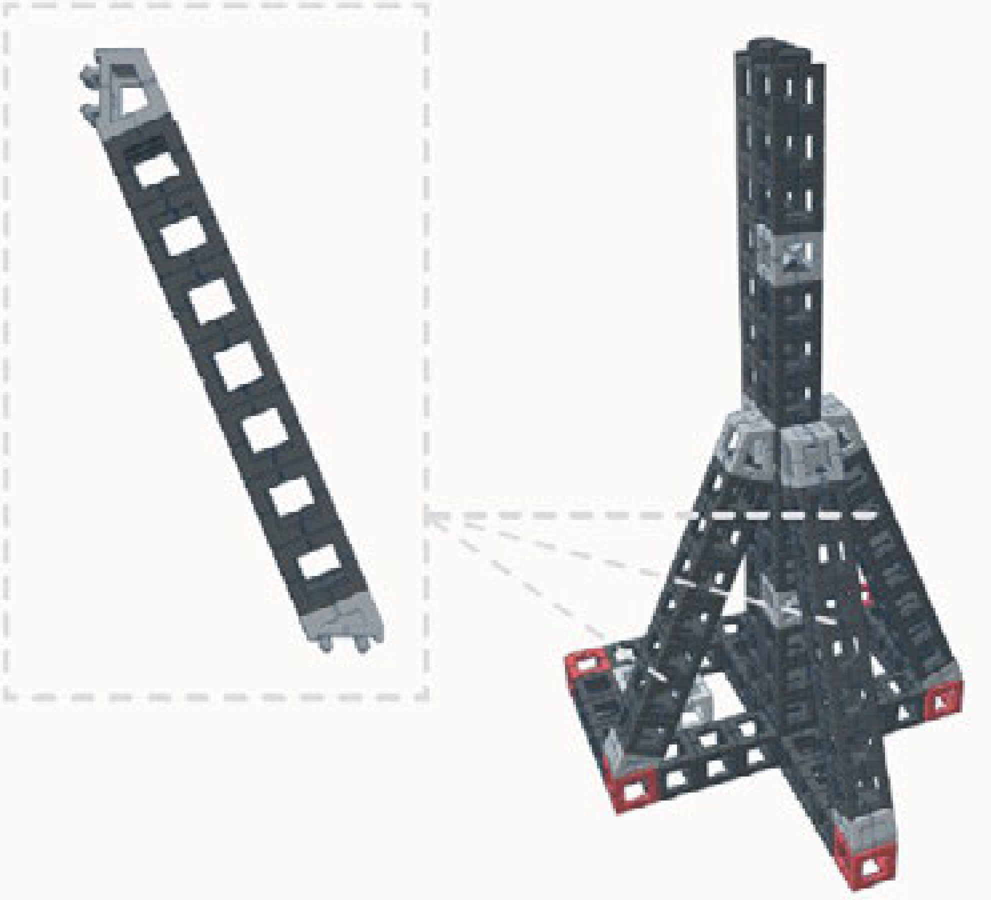
3x
Single Snap Block

2



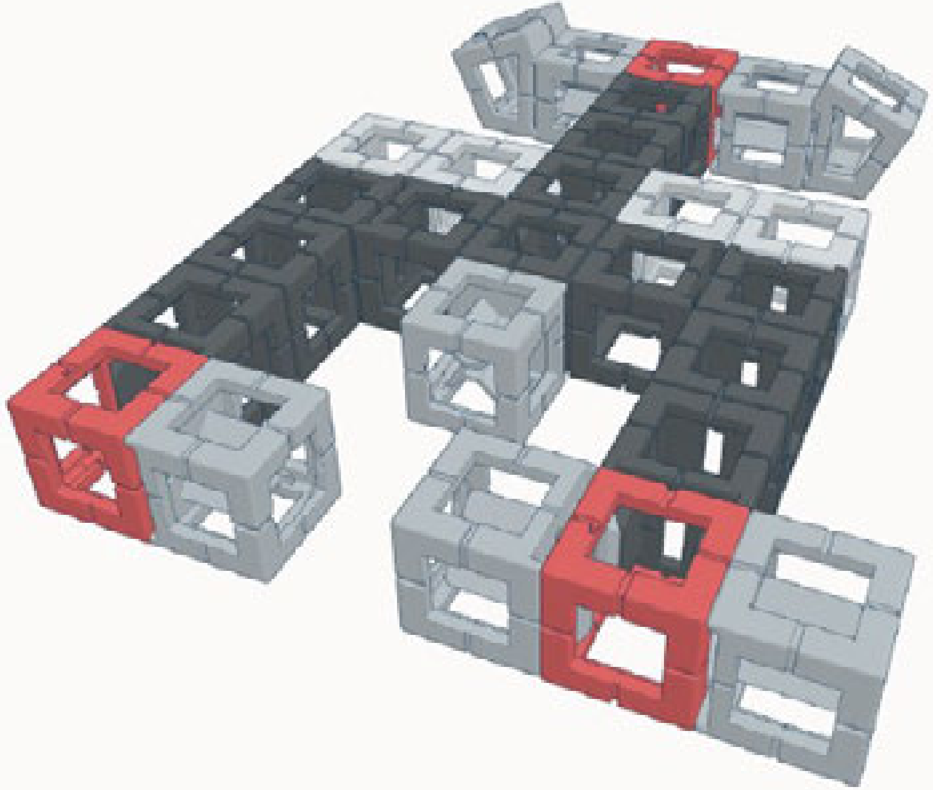


3



1x Block	3x Beam	1x Half Beam	3x 60° Block	3x 30° Block

4



3x
Block

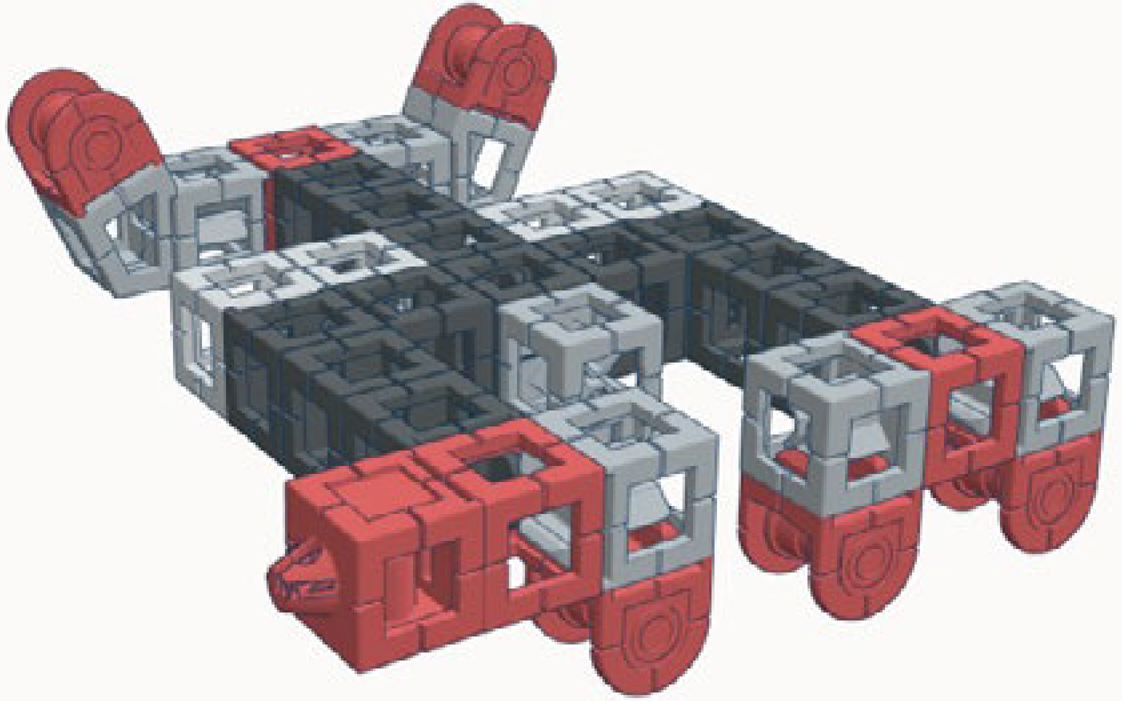
4x
Half Beam

2x
Riser

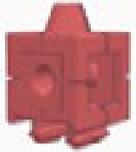
2x
60° Block

6x
Single Snap Block

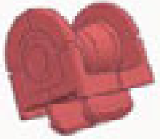
5



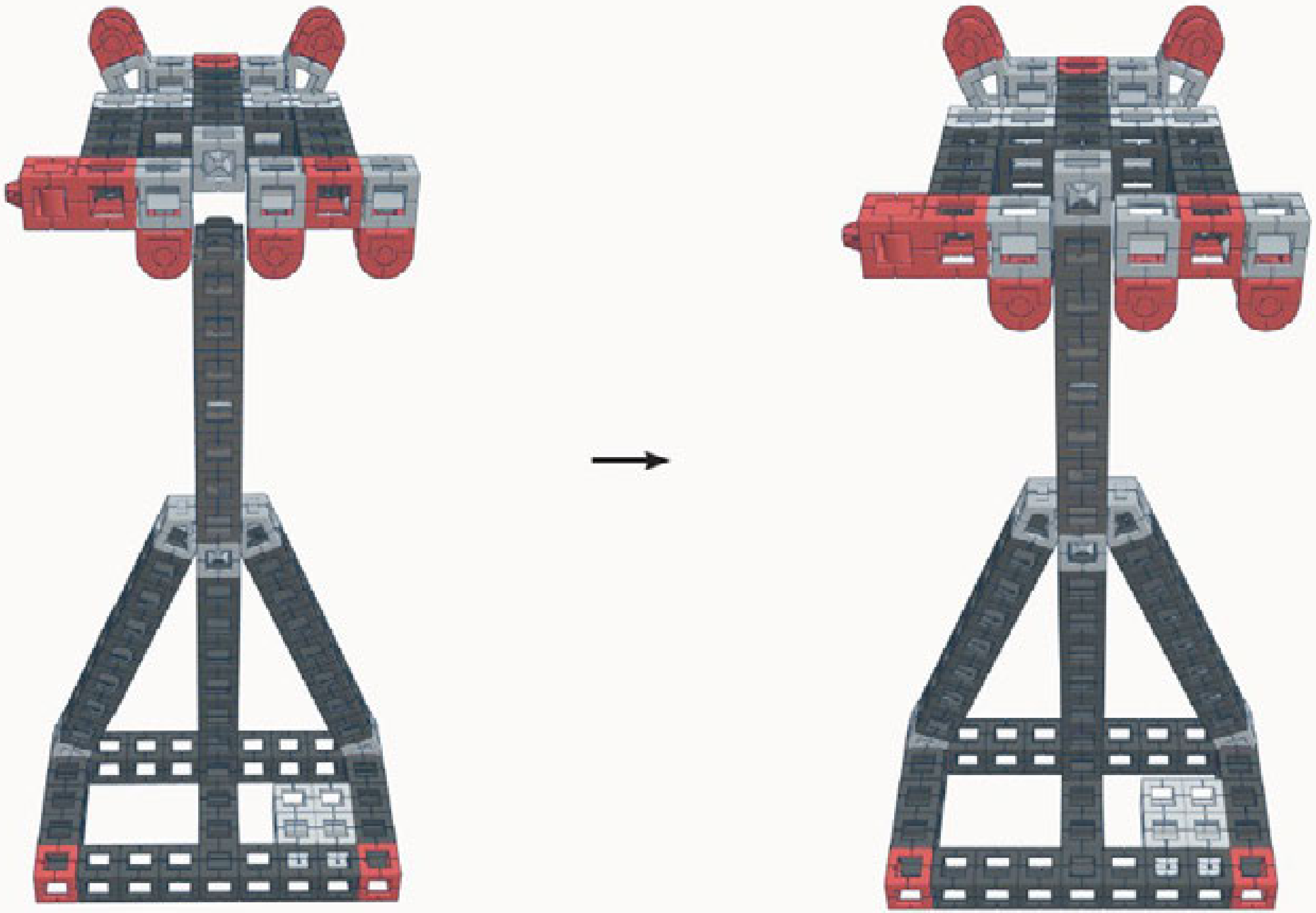
1x
String Block



5x
Pulley



6



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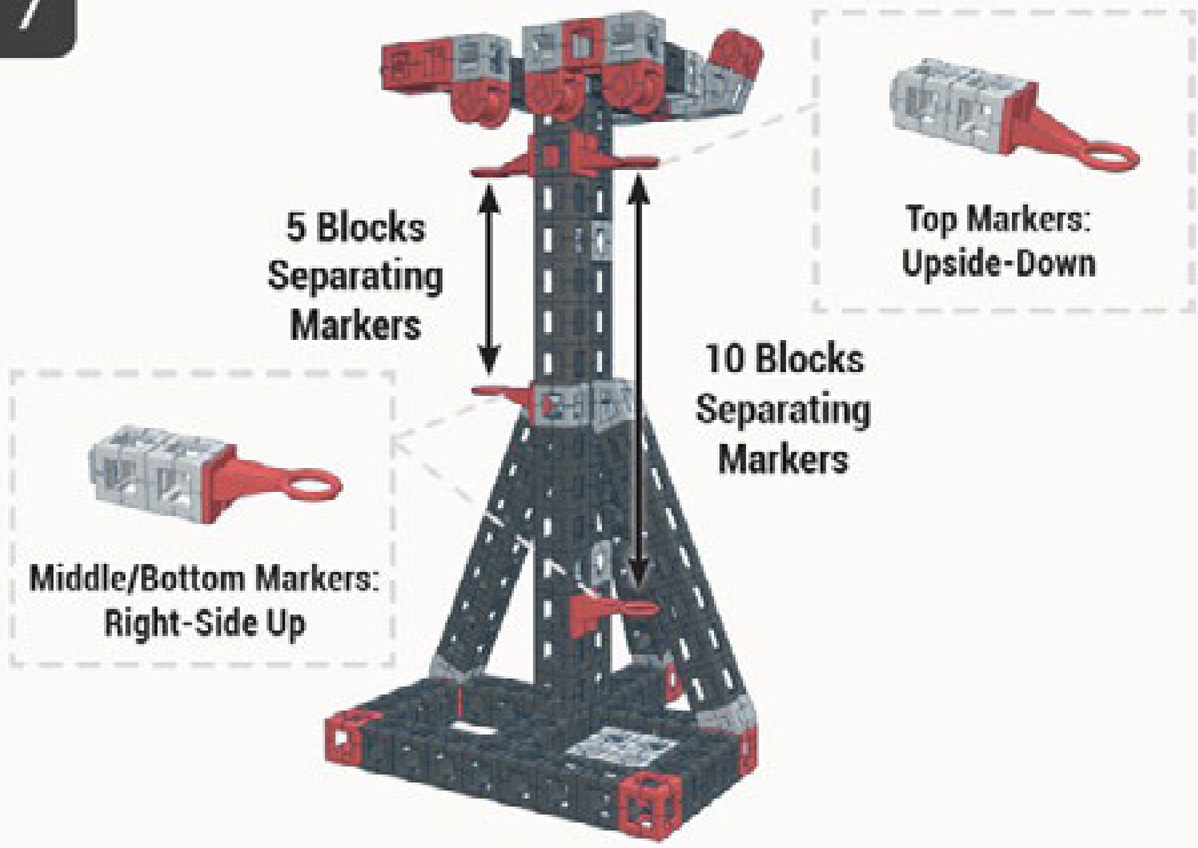
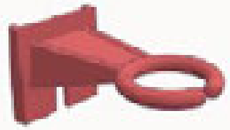


4x
Trailer Hitch



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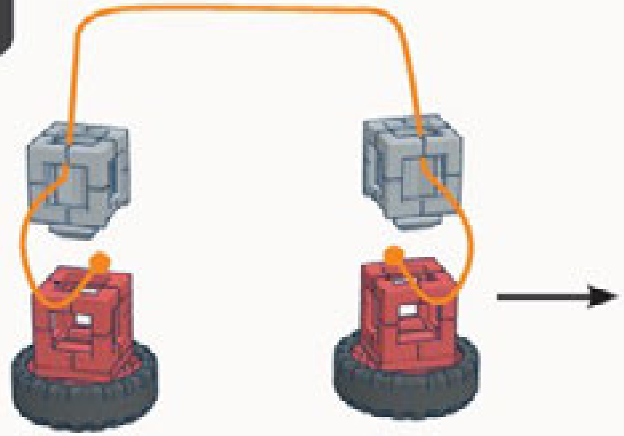
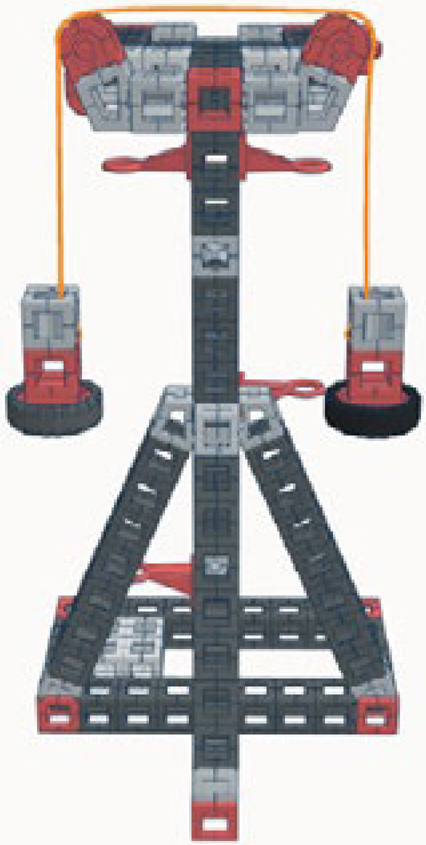




Cut a piece of string that is 40cm long. Feed each end of the string through the single snap blocks as shown. Lay string on top of the red connector blocks and snap into place. Once connected, place string of weights over fixed pulleys.

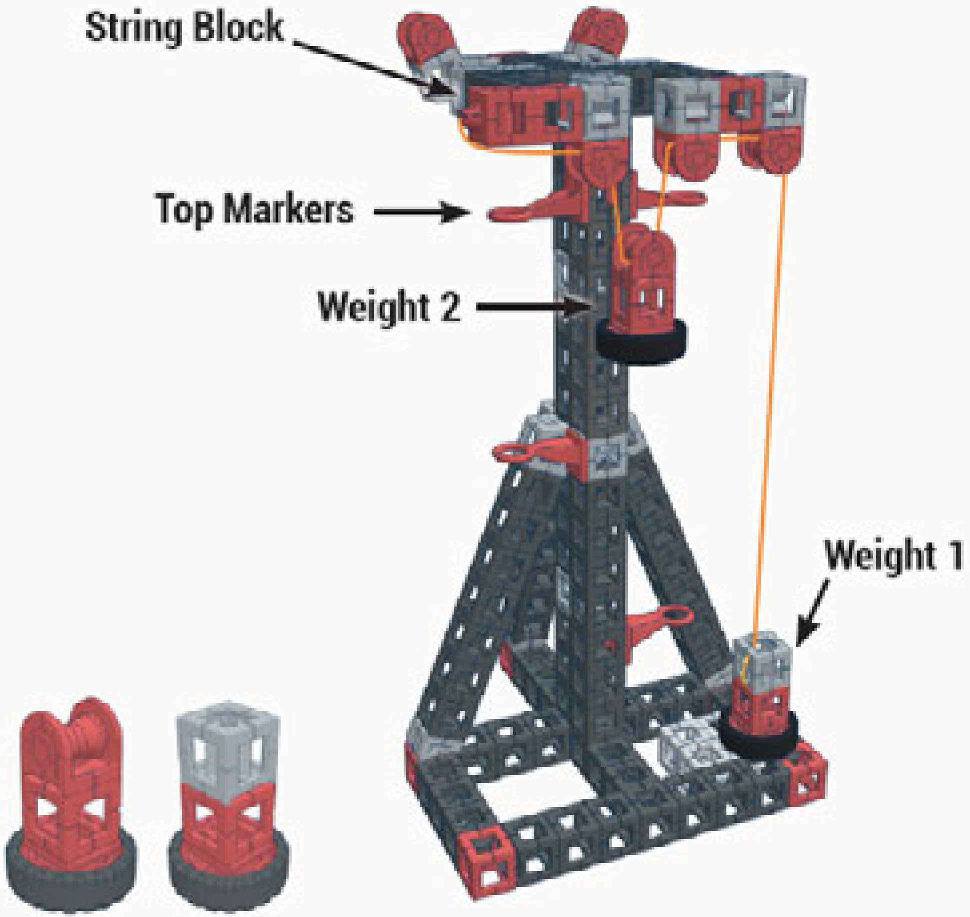
2x
Block

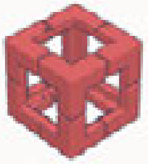
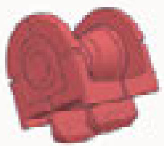
2x
Snap-In Wheel

2x
Single Snap Block

Assemble two weights using the listed components. Cut a piece of string that is 50cm long. Tie a knot in one end of the string and place knot in string block to secure into place. Feed other end of the string through the fixed pulleys and movable pulley (weight 2) as shown. Connect string to weight 1 to secure in place.

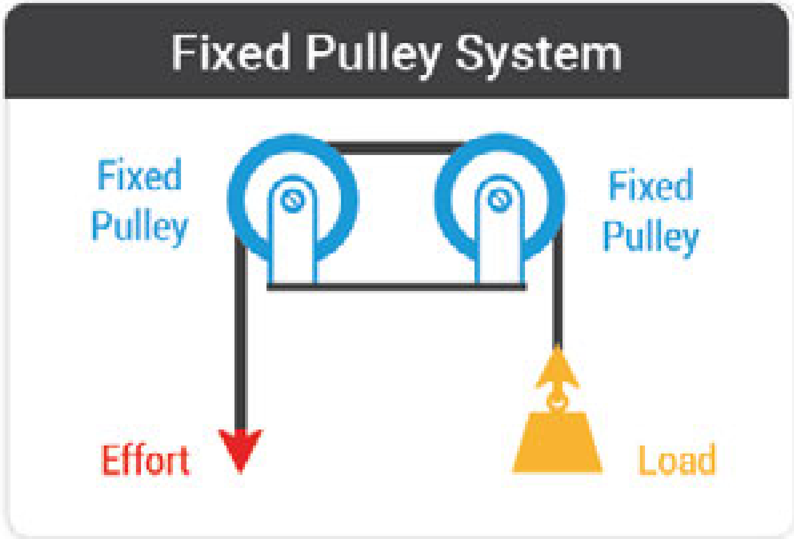
Note: *Adjust string if necessary so that when weight 1 is resting on frame, top of weight 2 is even with top markers.*

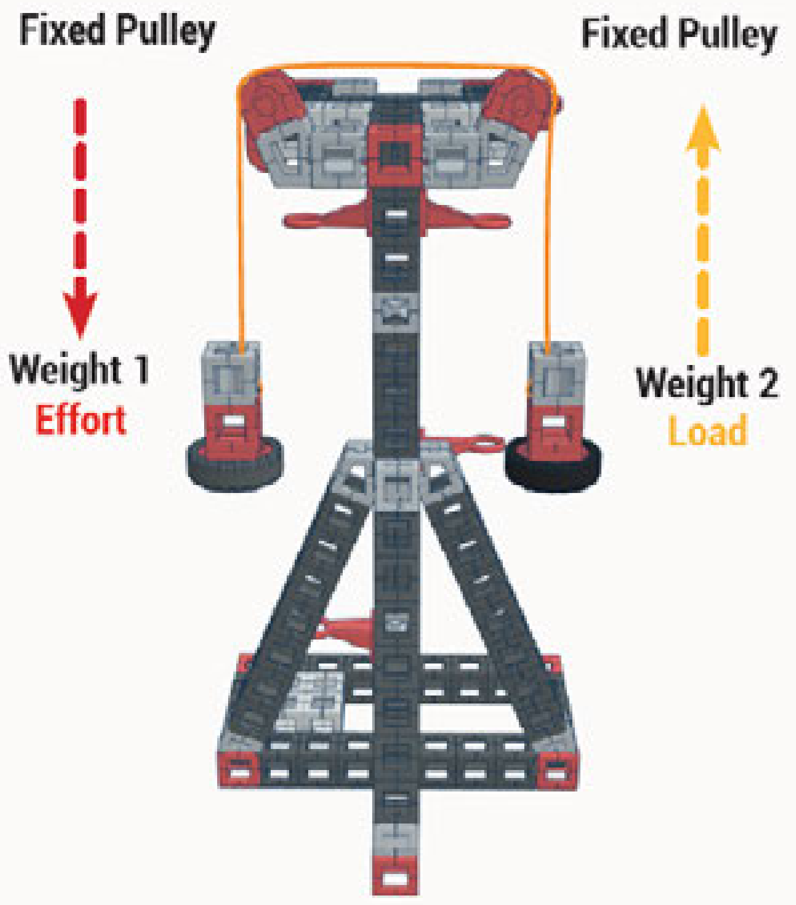


2x Block	2x Snap-In Wheel	1x Pulley	1x Single Snap Block
			

Fixed Pulley (Redirecting Motion)

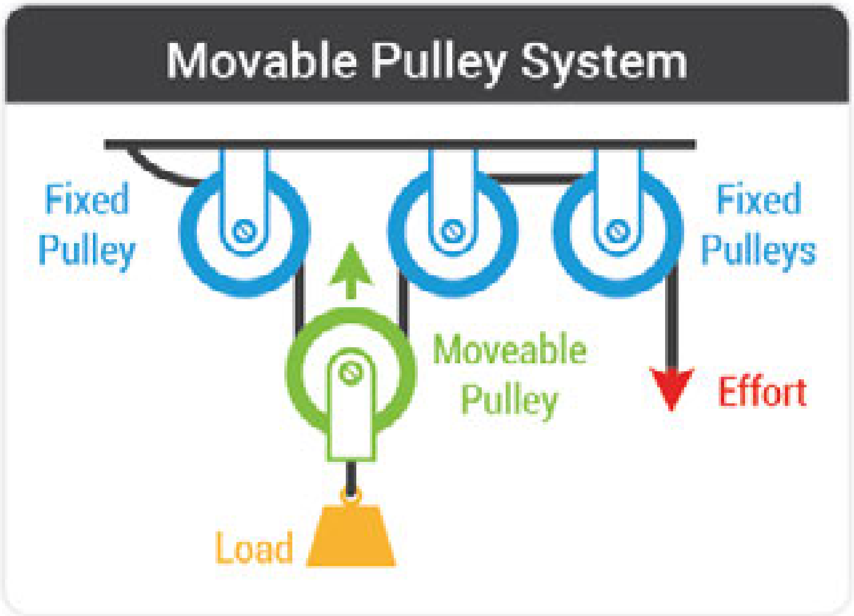
Turn the pulley system so that you can test the fixed pulley system. Observe how the weights balance each other out. Pull down on **Weight 1** (Effort) and observe how **Weight 2** (Load) moves an equal distance in the opposite direction.

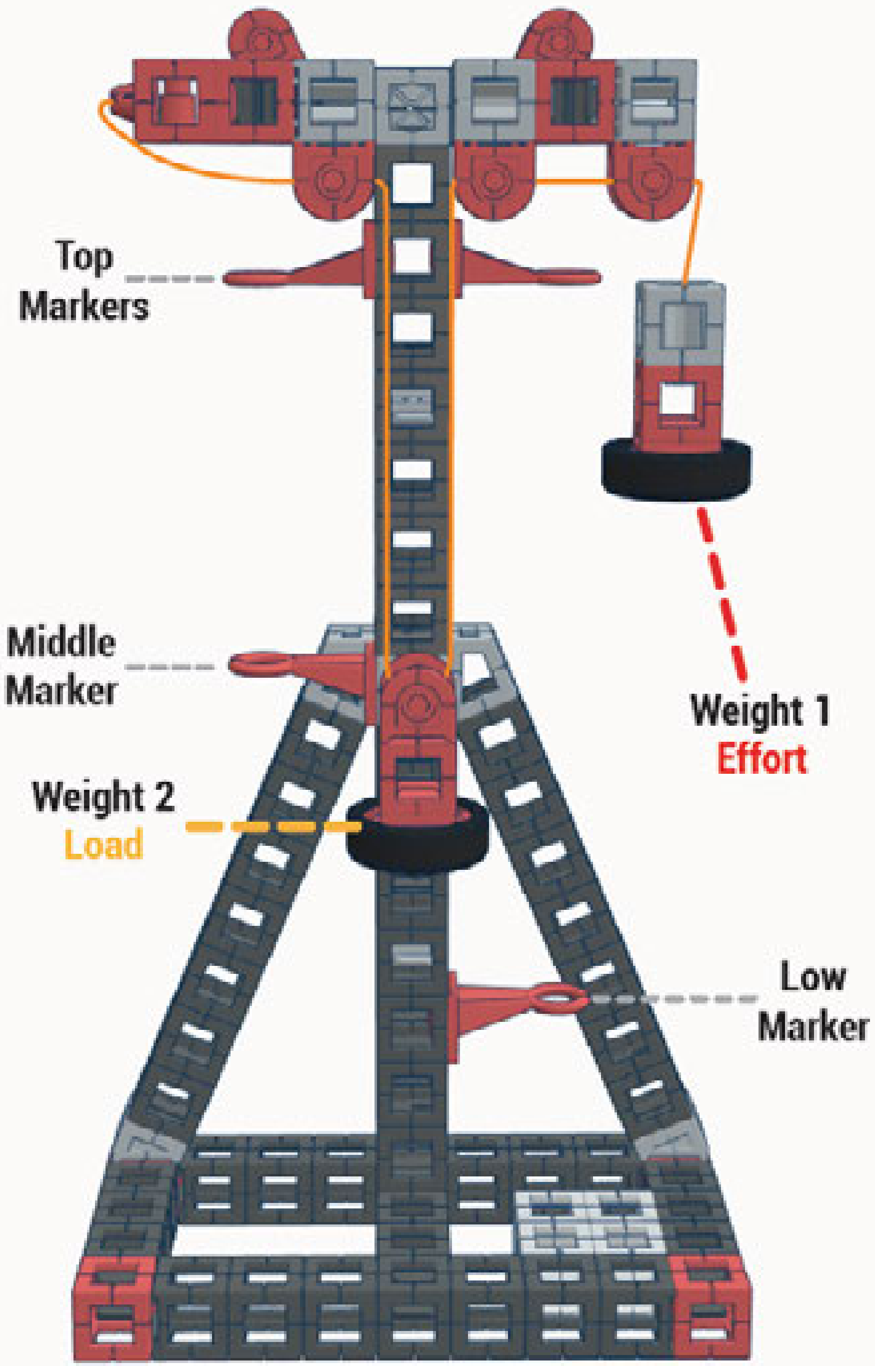




Movable Pulley (Mechanical Advantage)

Turn the pulley system around to the side with the movable pulley. Lift **Weight 1** (**Effort**) until the top is even with the top markers. At this point, **Weight 2** (**Load**) should be even with the middle marker. Let go of **Weight 1** (**Effort**) and observe how it is able to raise **Weight 2** (**Load**) to the top markers.





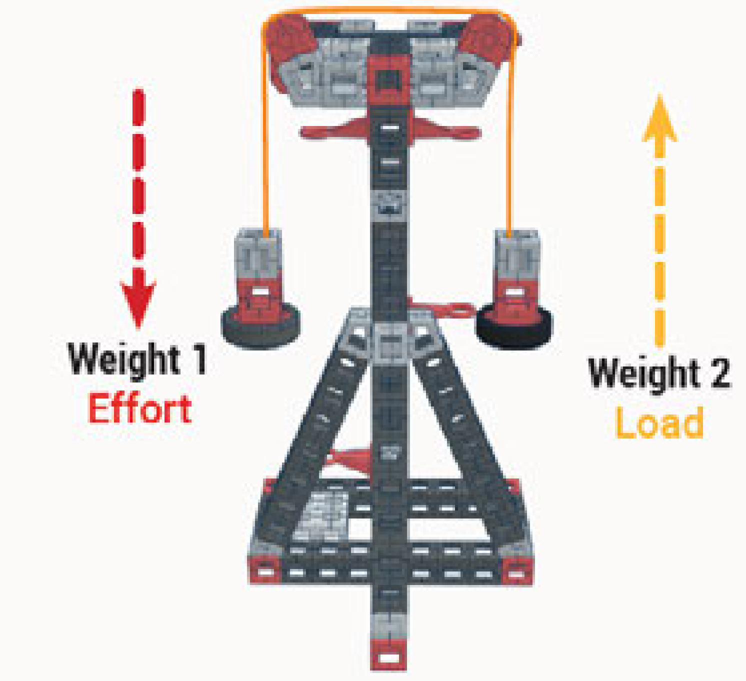
Understanding Mechanical Advantage

The main purpose of a simple machine is to make work easier. This means 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.

Calculating Mechanical Advantage

Calculating the mechanical advantage in a pulley system can be done by dividing the distance the effort travels by the distance the load travels. If the pulley system has a movable pulley, the number of strings connected to the movable pulley can also be used to determine the mechanical advantage.

Fixed Pulley System



Fixed Pulley System

In the fixed pulley system, if **Weight 1 (Effort)** is pulled down, then **weight 2** will raise and equal amount in the opposite direction. Divide 8/8 and this will give a mechanical advantage of 1:1. This means that for every unit of measurement the **effort** travels, the **load** will travel an equal unit of measurement in the opposite direction. This demonstrates how there is no mechanical advantage in a fixed pulley system. In order to raise one of the weights, extra effort or mass would be needed to overcome the mass of the load.

Distance Formula

$$\text{Mechanical Advantage} = \frac{\text{Distance effort travels}}{\text{Distance load travels}}$$

Movable Pulley Systems

of strings connected to movable pulley = Mechanical Advantage

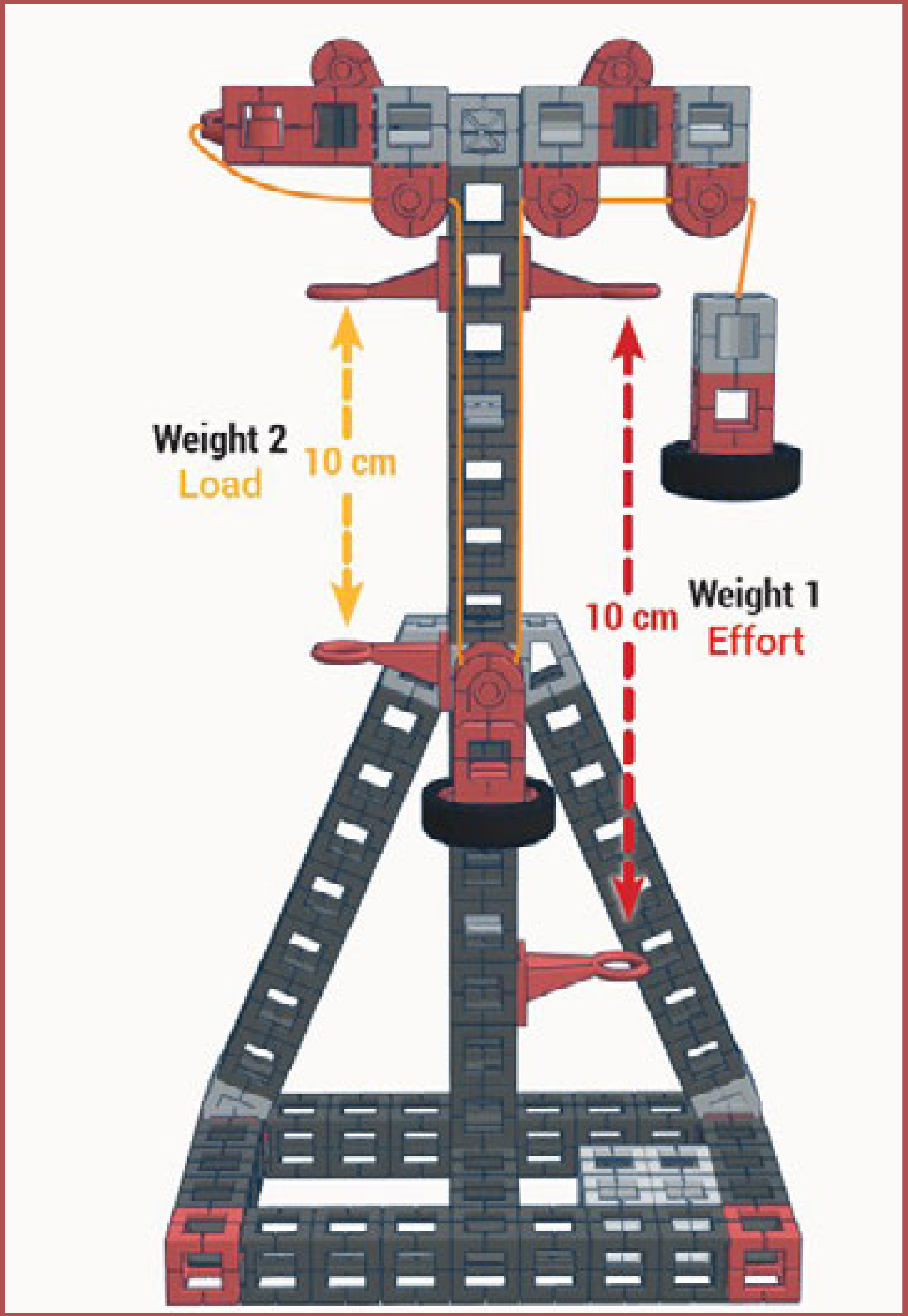
Movable Pulley System

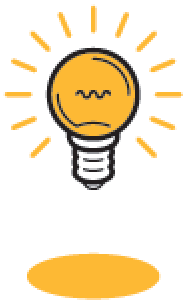
In the movable pulley system, **Weight 1 (Effort)** travels a distance of 10 blocks (20 cm). **Weight 2 (Load)** travels a distance of 5 blocks (10 cm). Divide 20/10 and this will give a mechanical advantage of 2:1. This means that for every two units of measurement the effort travels, the load will travel one unit of measurement in the opposite direction. There are two strings connected to the movable pulley in this example, which also confirms that this pulley system has a mechanical advantage of 2:1. This pulley system is able to output a greater force than the input force that was applied to it.

Movable Pulley System

$$\frac{\text{Effort - 20cm}}{\text{Load - 10cm}} = 2$$

2 of strings connected to movable pulley = 2





Modify: Pulley System

Now that you have built a pulley system that has a mechanical advantage of 2:1, slightly modify the system to increase the mechanical advantage to 3:1.

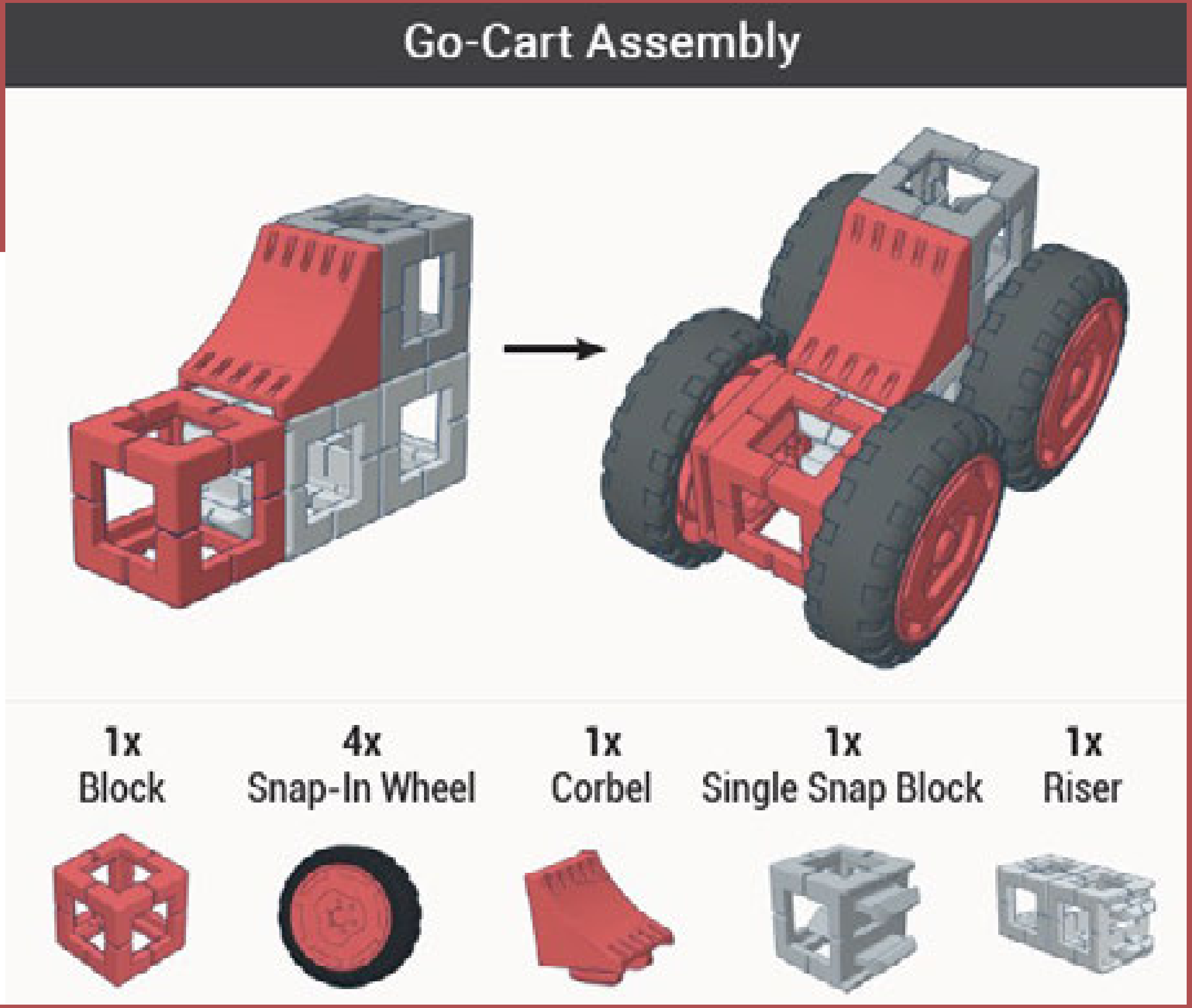
Extension Activity

Design Brief: Scenario

You have just inherited a motorized go-cart from your uncle. It is in good shape, but needs an oil change before you can ride it. The drain plug for the oil is underneath the go-cart frame so it is difficult to change the oil while it is on the ground.

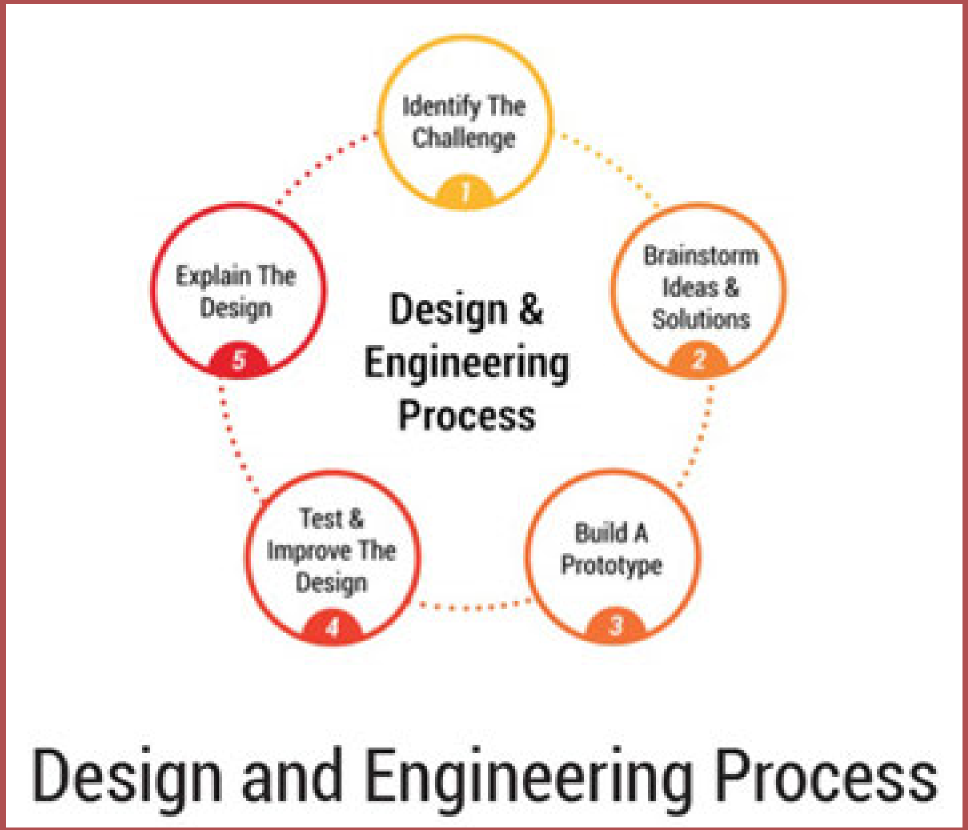
Design & Engineering Challenge

Your design challenge is to design and engineer a pulley system that can raise and lower a go-cart so routine maintenance can be done on it.



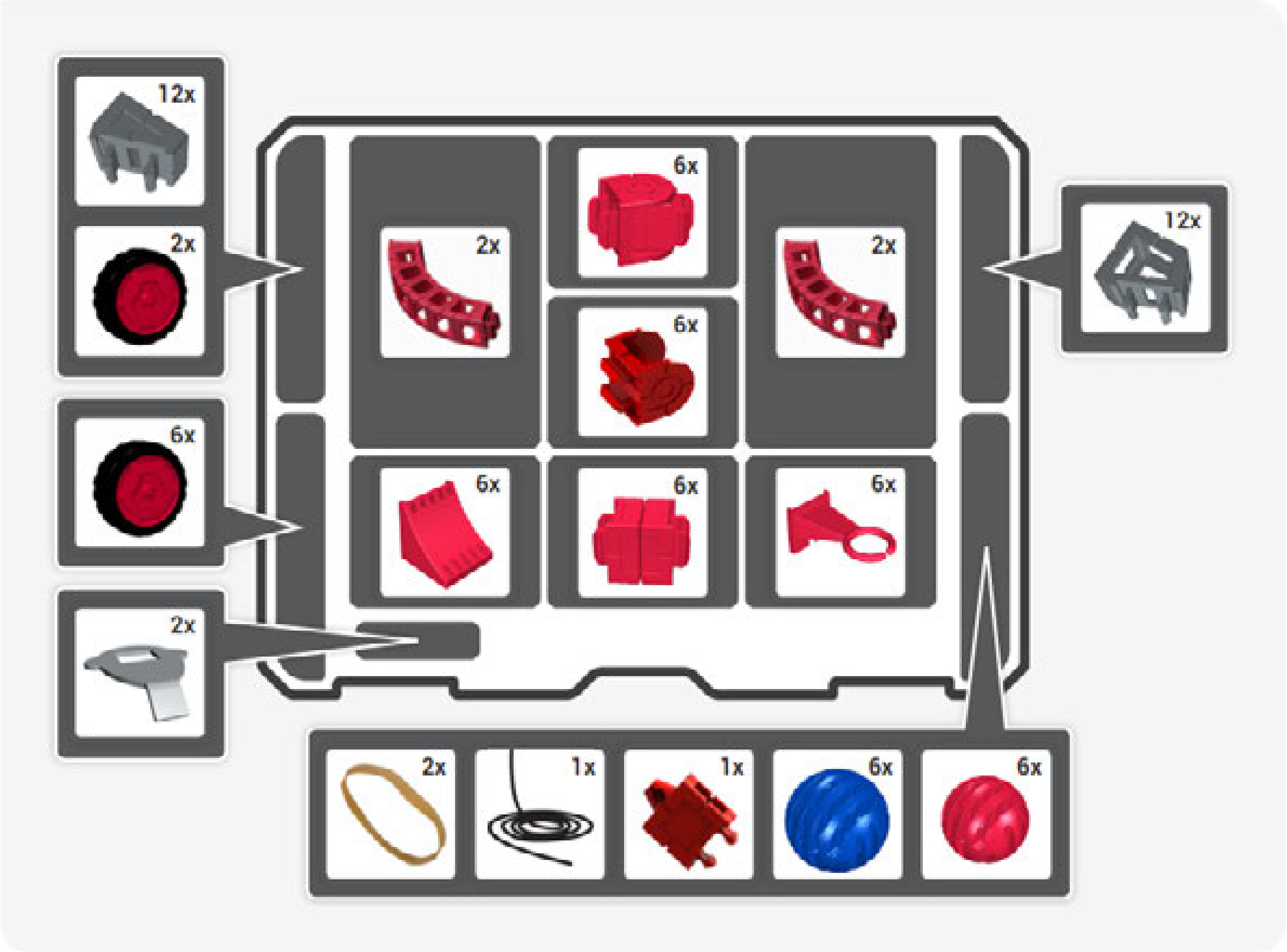
Specifications

- 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 pulley system must cost less than $120. (The components in the go-cart do not count towards the budget of $120).



Clean Up

BOTTOM OF MODULE



REMOVABLE BINS