Screw

STEM-Maker CURRICULUM

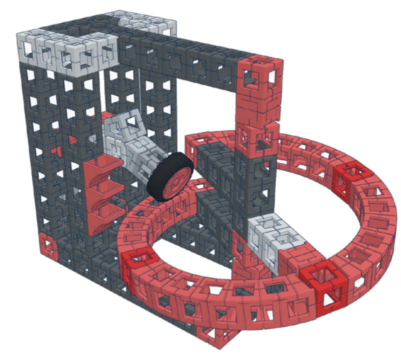
v2.0

Progression: Applications in Design & Engineering - Section 6

Curriculum Packet

Introduction

This Rokenbok STEM-Maker lesson will use the following steps to learn about the screw.



1. Learn
- Elements of a screw
- Purpose of a screw
- Real world applications
- Mechanical advantage in a screw

2. Build & Modify
- Build a screw
- Test a screw
- Modify a screw to increase mechanical advantage

3. Design & Engineer
- Design and engineer a custom screw to solve a challenge

Learning Objectives

- Understand the basic elements and purpose of a screw.
- Calculate the amount of mechanical advantage in a screw.
- Modify a screw to increase mechanical advantage.
- Design and engineer a custom screw to solve a challenge.

Resources

SnapStack Module

*4 Students Per Module

or

Programmable Robotics Module

*4 Students Per Module

Key Terms

Simple Machine: A device that transmits or modifies force or motion.

Screw: An inclined plane wrapped around a cylinder that converts rotary motion into linear motion.

Screw Thread: The raised ridge going around a screw.

Screw Pitch: The distance between threads on a screw.

Friction: The resistance that one surface or object encounters while in contact with and moving across another.

Mechanical Advantage: The amount a machine multiplies force.

Radius: The distance from the center of a circle to the outside edge.

Diameter: The distance through the center of a circle from one side to another.

Circumference: The distance around a circle.

Pi: An irrational, infinite number (3.14....), that represents the ratio of a circle's circumference to its diameter.

Force: A push or a pull.

Work: Using a force to move an object a distance.

Effort: A force applied to a machine to do work.

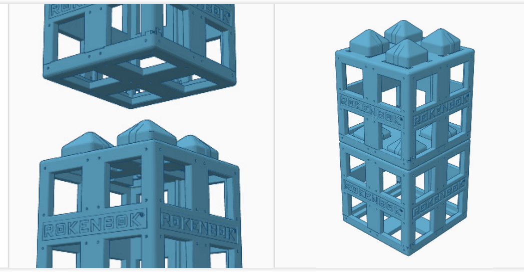
Load: The object or weight being moved or lifted.

Rokenbok Building Basics

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

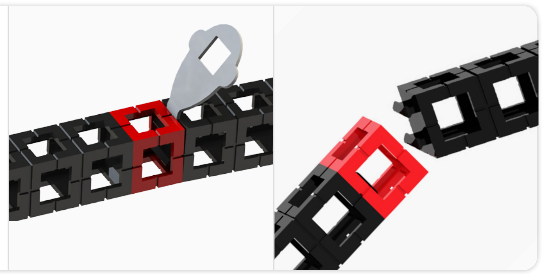
Connecting/Separating ROK Blocks:

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



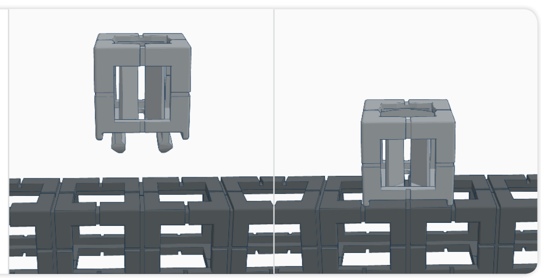
Connecting/Separating Rokenbok Components:

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.



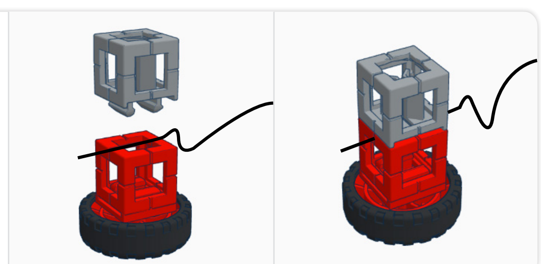
Snapping Across Openings:

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.



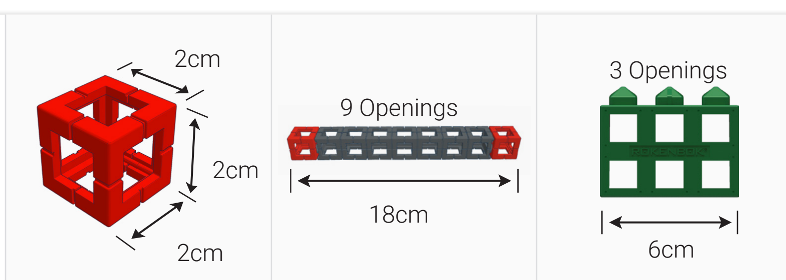
Attaching String:

In some instances, string may be needed in a design. Lay string across the opening and snap any Rokenbok component with tabs or pyramids into that opening. Be sure that the tabs are perpendicular to the string to create a tight fit.



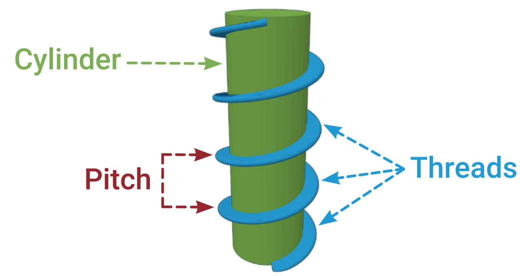
Measuring:

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



The Screw

A screw is an inclined plane wrapped around a **cylinder**. The incline or ridges that wrap around the cylinder are referred to as the **threads**. The distance between the threads is referred to as the **pitch**.



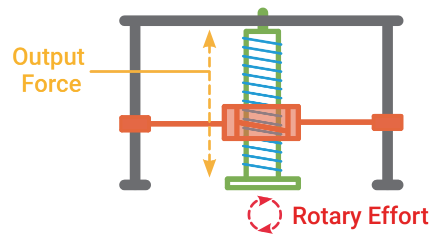
Purposes of the Screw

The screw can be used to push and pull objects, or to hold objects together. This is done by converting rotary motion (circular) into linear motion (in a straight line).

Push or Pull

A screw can be used to push or pull an object. In example 1, when the base of the screw is rotated in one direction, the connected orange box is raised. When the screw is rotated in the other direction, the connected orange box is lowered.

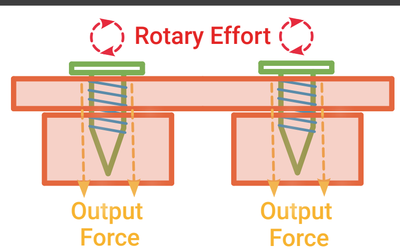
Example 1: Push or Pull



Hold or Fasten

A screw is commonly used to hold or fasten objects together. In example 2, two screws are being used to fasten a large board to two smaller boards.The screws in this example also include a wedged tip, much like a nail. The wedge tip separates the material of the board as the screw is driven inward by the turning threads.

Example 2: Hold

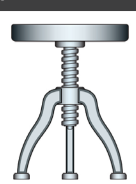


Real World Applications

The screw is used in many different ways to make work easier. Here are some real world examples.

Wood Screw

Adjustable Stool



Bolt and Nut

Scissor Jack

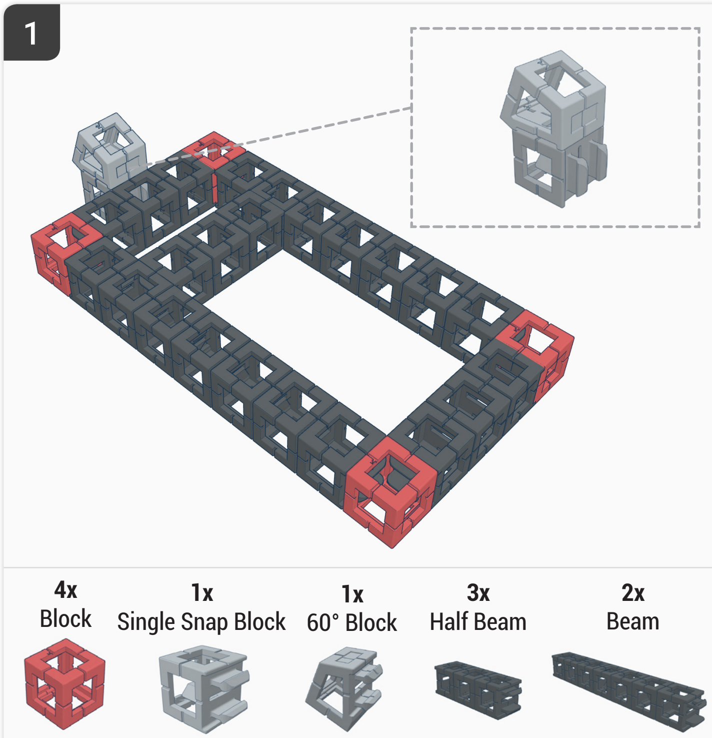
Bench Vise

Drill Bit

Instructions

Follow the step-by-step instructions to build a screw.

1



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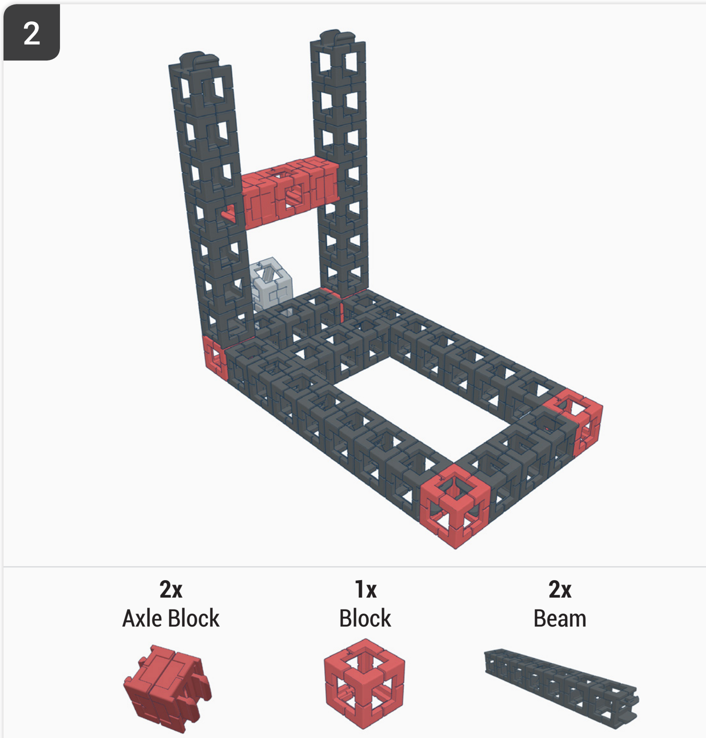

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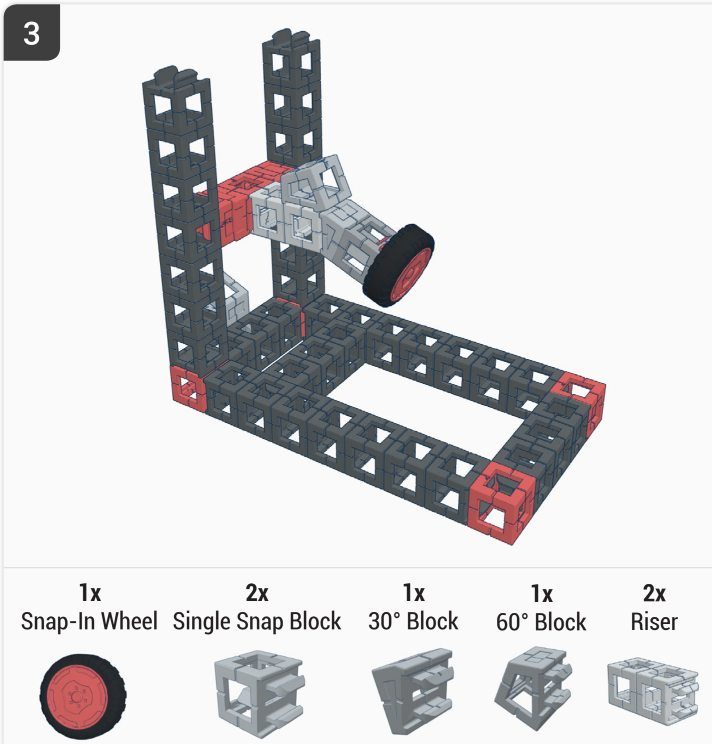

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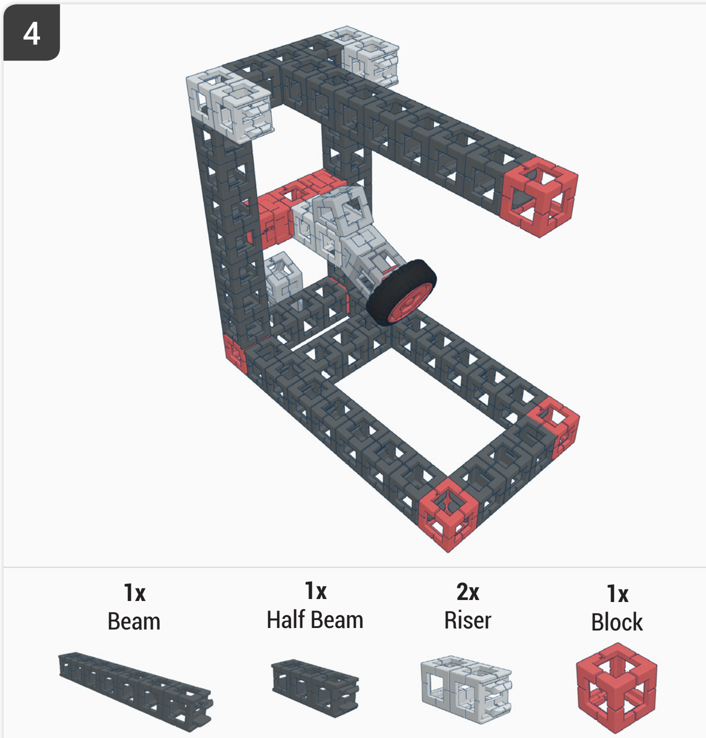
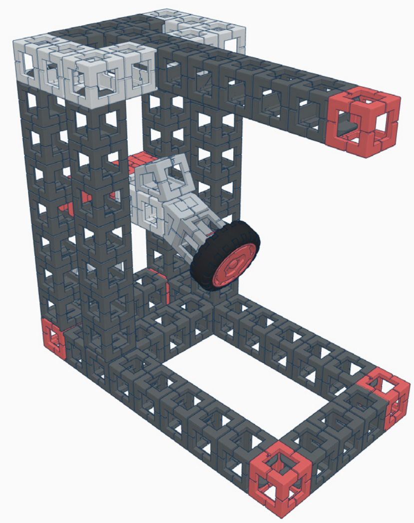


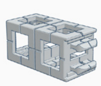
Instructions

Follow the step-by-step instructions to build a screw.

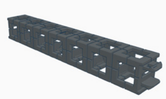
5



2x
Riser



2x
Beam



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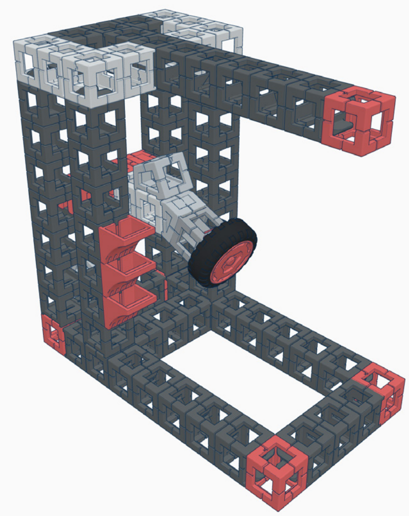
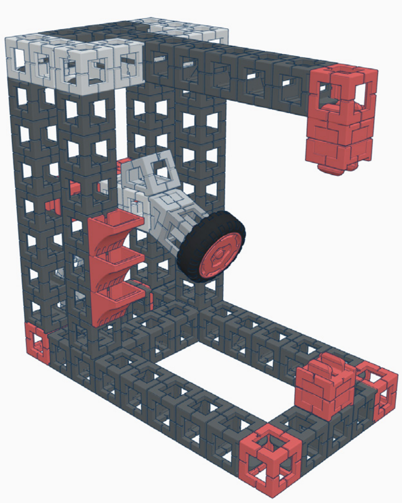


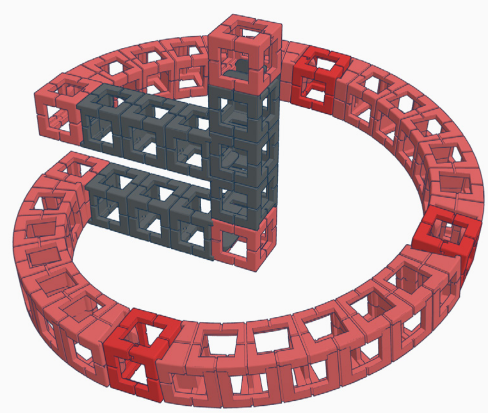
3x
Corbel

7



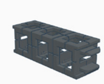
2x
Axle Block

8

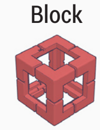


Note:
Small curved beams will flex as you attach them in the screw configuration.

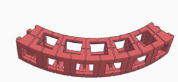
3x
Half Beam



7x
Block



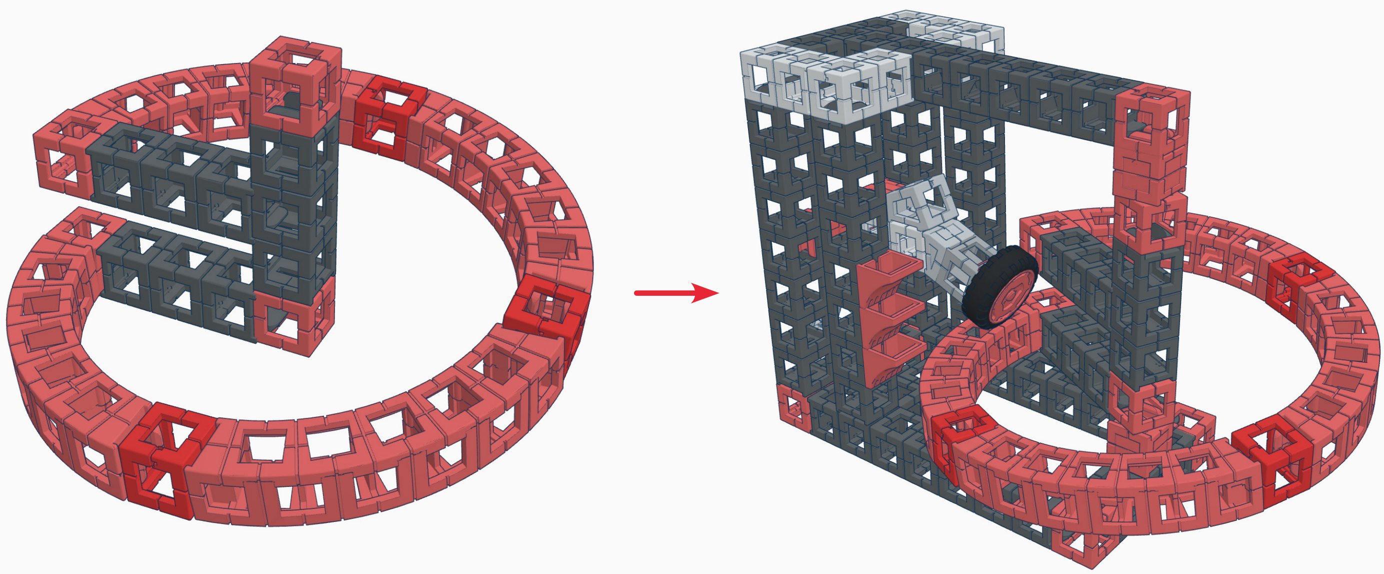
4x
Small Curved Beam



Instructions

Follow the step-by-step instructions to build a screw.

9



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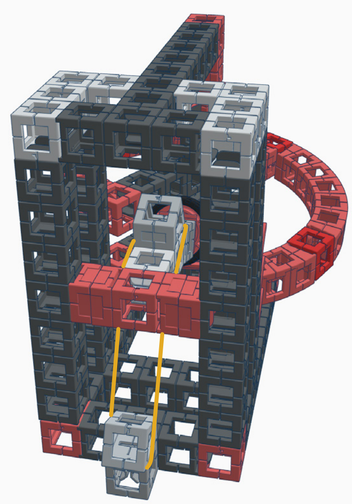
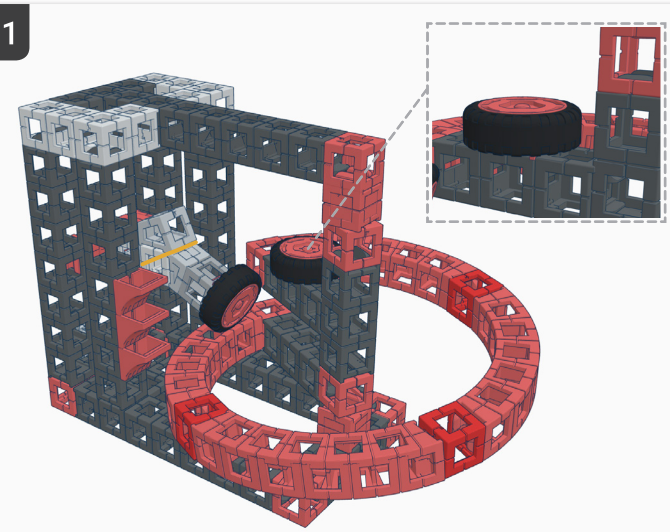


1x
Rubber Band

11



1x
Snap-In Wheel

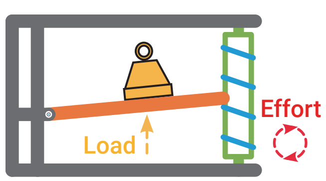
Test and Modify the Screw

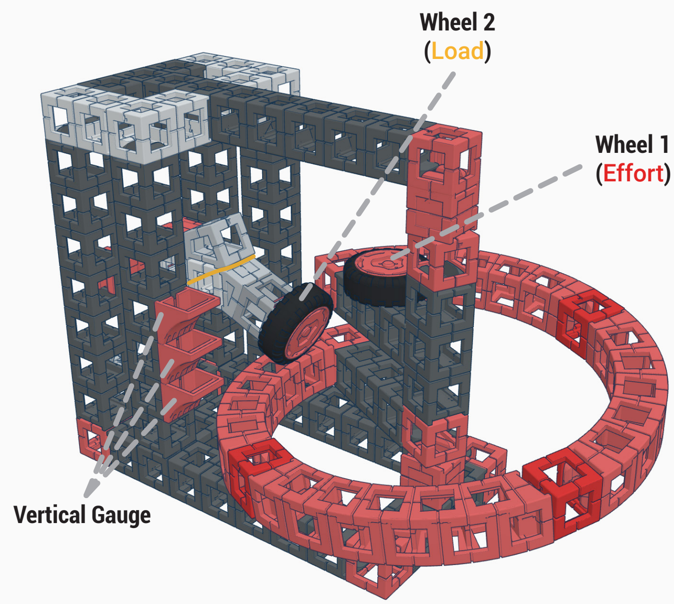
Follow the instructions to test and modify the screw model.

Testing the Screw

Grab **Wheel 1** (**Effort**) and rotate the screw clockwise. Observe how **Wheel 2** (Load) rolls up the incline of the screw, and the tension from the rubber band becomes greater as the screw is rotated. Notice how **Wheel 2** (Load) starts at the lowest point on the **Vertical Gauge** and is raised to the top point as the screw completes one rotation.

Screw: Raising Load

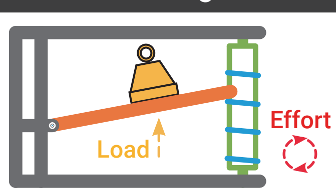


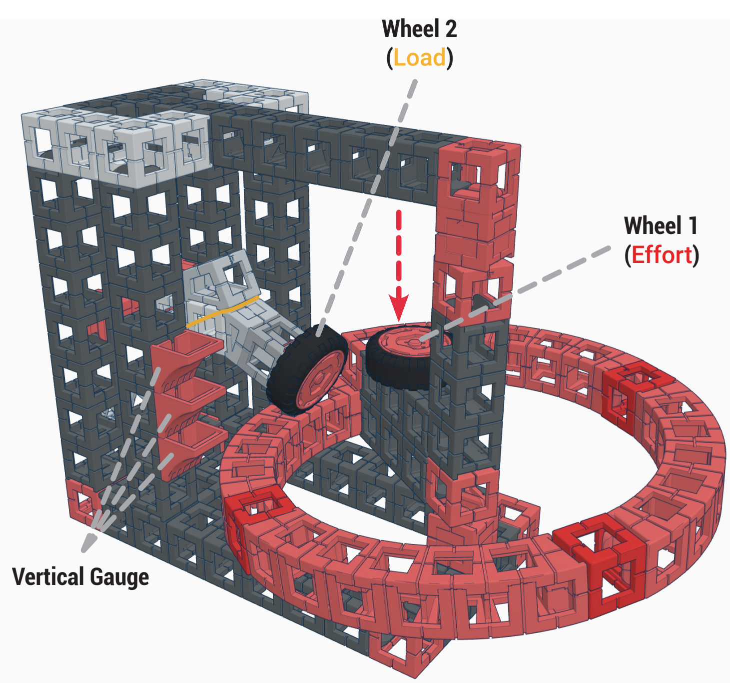


Modifying the Screw

Adjust the pitch of the screw by lowering the top of the incline one block as shown in the figure to the right. Grab **Wheel 1** (**Effort**) and rotate the screw clockwise. Observe how **Wheel 2** (Load) rolls up the incline of the screw, and the tension from the rubber band increases more slowly as compared to the previous model. Notice how **Wheel 2** (Load) starts at the lowest point on the **Vertical Gauge** and is raised to the middle point as the screw completes one rotation. By lowering the incline, **Wheel 2** (Load) isn't able to rise to the same height as the previous model, but the amount of effort needed to raise the load has been reduced. There is a noticeable difference in the amount of resistance when rotating the two screws.

Screw: Raising Load



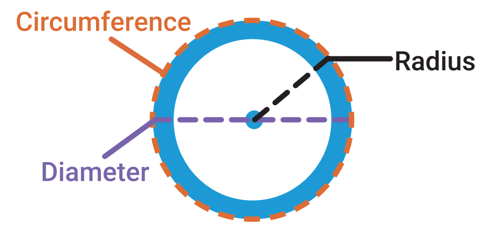


Understanding Mechanical Advantage

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

Attributes of a Circle

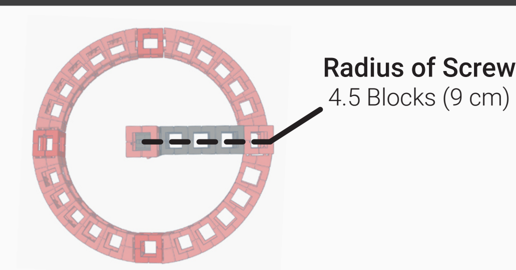
To have a better understanding of how a screw creates mechanical advantage, it is important to be familiar with the different attributes of a circle. This includes the **radius**, diameter, and circumference. These attributes will be used to calculate the amount of mechanical advantage that exists within the Rokenbok screw models.



Radius

The **radius** is the distance from the center of a circle to the outside edge. In the Rokenbok model, the **radius** of the screw is 4.5 blocks (9 cm).

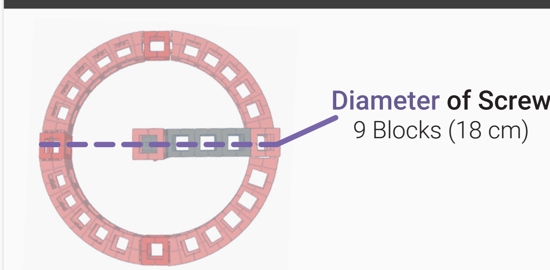
Radius



Diameter

The diameter is the distance through the center of a circle from one side to another. In the Rokenbok model, the diameter of the screw is 9 blocks (18 cm). The diameter of any circle is always twice the distance of the **radius**.

Diameter



Circumference

The circumference is the distance around the circle. For any circle, dividing its circumference by its diameter will give the exact same number of 3.141592... The greek letter **Pi (π)** is used to represent this value. Pi is an irrational number, meaning it is a real number that cannot be expressed as a ratio of integers, i.e. as a fraction. Irrational numbers, when written as decimals do not terminate, nor do they repeat. To simplify calculations, Pi is represented as **π=3.14**.

To calculate the circumference in a circle, the constant pi (π) is used in the following formula:

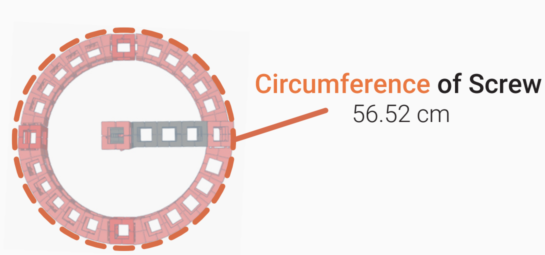
Circumference Formula

$$C = 2 \pi r$$

r = radius

In the Rokenbok model, the **radius** of the screw is 9 cm. To determine the circumference, multiply (2 x 3.14 x 9 cm) to get 56.52 cm. This means the circumference of the screw is 56.52 cm.

Circumference



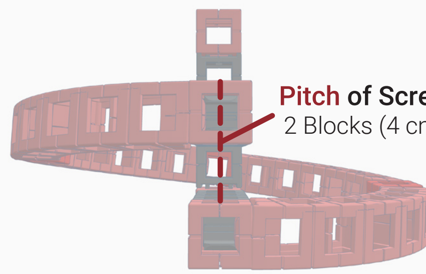
Calculating Mechanical Advantage

The screw reduces the amount of effort needed to push, pull, or hold objects by creating mechanical advantage. The amount of effort needed to rotate a screw is reduced as the pitch of the screw is reduced. The following formula can be used to calculate the mechanical advantage in a screw:

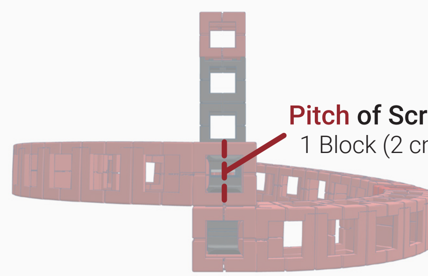
Formula

$$\text{Mechanical Advantage} = \frac{\text{Circumference of Screw}}{\text{Pitch of Screw}}$$

Example 1: Screw



Example 2: Modified Screw



Understanding The Screw Model

The Rokenbok model that was built demonstrates how a screw can be used to reduce the amount of effort needed to raise an object. In the first screw that was built (Example 1), the **circumference** of the screw was 56.52 cm, and the **pitch** of the screw was 4 cm. Divide 56.52/4 and this will give a mechanical advantage of 14.13:1. This means as the screw is rotated, **Wheel 2** (**Load**) will rise 1 unit of measurement for every 14.13 units of measurement it travels along the thread of the screw.

In the modified screw(Example 2), the **circumference** remained 56.52 cm, but the **pitch** was lowered to 2 cm. Divide 56.52/2 and this will give a mechanical advantage of 28.26:1. This means as the screw is rotated, **Wheel 2** (**Load**) will rise 1 unit of measurement for every 28.26 units of measurement it travels along the thread of the screw. By lowering the incline, **Wheel 2** (**Load**) isn't able to rise to the same height as the previous model, but the amount of effort needed to raise the load has been reduced. There is a noticeable difference in the amount of resistance when rotating the two screws.

Nails vs. Screws

The most common use of the screw is to hold or fasten objects together. Unlike the nail, a screw has threads around the shaft. It is harder to drive a screw into a piece of wood because the ridges on the screw create a lot of friction and resistance. This results in a much tighter and stronger hold as compared to the nail.

To drive a screw into a piece of wood, an effort force is applied to a screw by turning a screwdriver. That force is then transmitted down the thread to the tip of the screw. The movement of the screw tip into the wood is the resistance force. Each complete turn of the screwdriver produces a movement of only one thread of the screw tip into the wood.

Nail

Screw

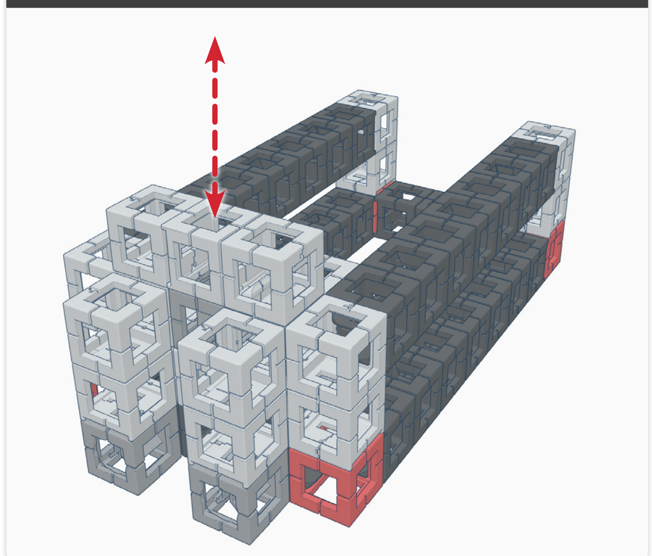
Design & Engineering Challenge: Screw

In this challenge, each team must design and engineer a custom lift that features the screw. Read carefully through the design brief below, then use the design and engineering process to develop a solution to the challenge.

Design Brief: Scenario

There is a lake just outside of ROK City that overflows frequently due to the high amount of rainfall. City workers are required to open a sluice gate to redirect some of the excess water when the lake begins to overflow. A sluice gate is a sliding gate for controlling the flow of water, especially in a lock, dam, or reservoir. The sluice gate can be dangerous and difficult to open due to high water pressure. The city is looking for ways to make this process safe and easy for its workers.

Sluice Gate



Design & Engineering Challenge

Your challenge is to design and engineer a custom lift that can raise and lower the sluice gate.

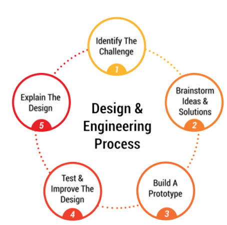
***Instructions to build the sluice gate are on page 11.**

Specifications & Sub-Challenges

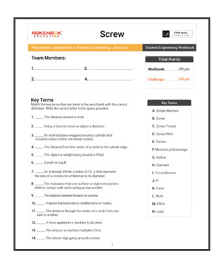
1. Teams can work in groups of up to four to complete this challenge.
2. Teams must work through each step of the design and engineering process to design, prototype, and refine a custom lift to raise the sluice gate. Teams will be responsible for written documentation in the student engineering workbook.
3. **Sub-Challenge:** The lift must feature a screw that creates mechanical advantage. The lift can include other simple machines.
4. **Sub-Challenge:** The lift must feature a locking pin that can lock the sluice gate in place when fully opened.
5. **Sub-Challenge:** The lift must raise the sluice gate at least 2 cm (1 block) from its base.
6. **Sub-Challenge:** With each building component costing $2, the lift must cost less than $180. Components that are used to build the sluice gate do not count towards the budget.
7. The sluice gate lift must be well balanced, structurally strong, and aesthetically appealing.
8. Each team will be required to effectively explain all aspects of brainstorming, prototyping, testing and improving the design.

Design & Engineering Process

To develop a high quality design, teams will work through each step of the design & engineering process. Teams should track all progress in the student engineering workbook.



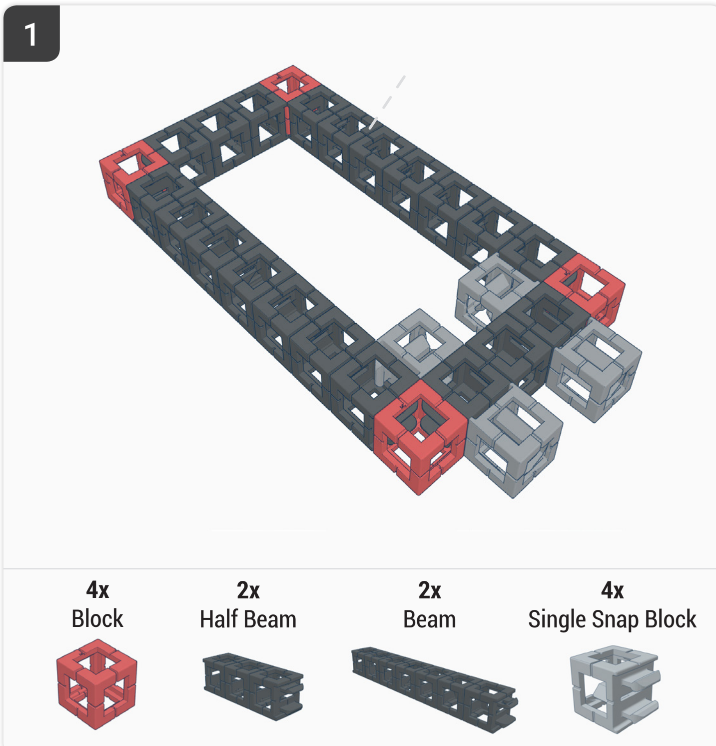
Design and Engineering Process

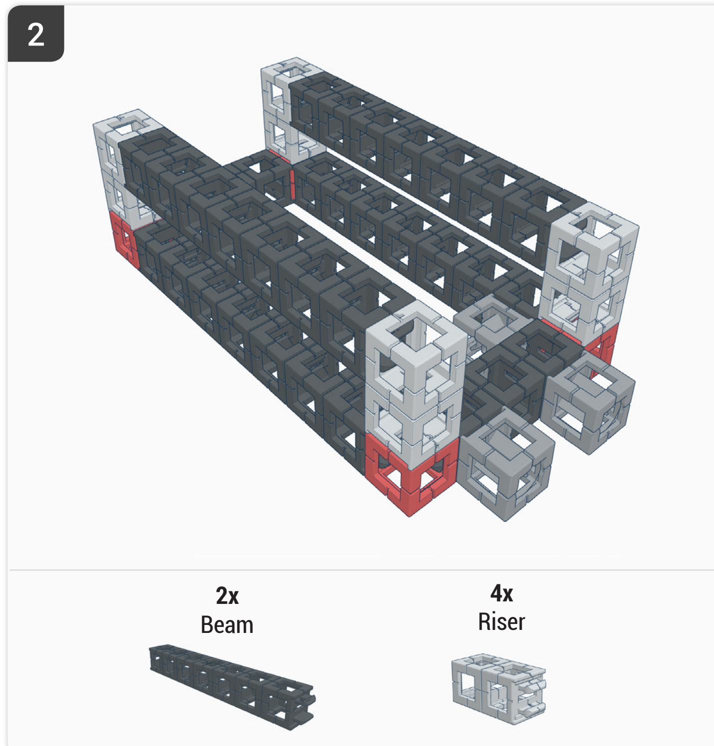


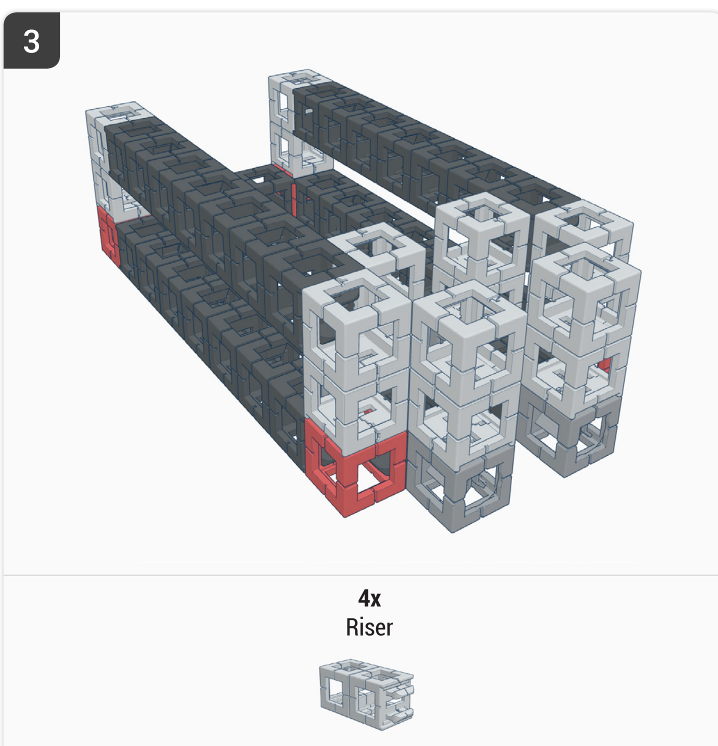
Student Engineering Workbook

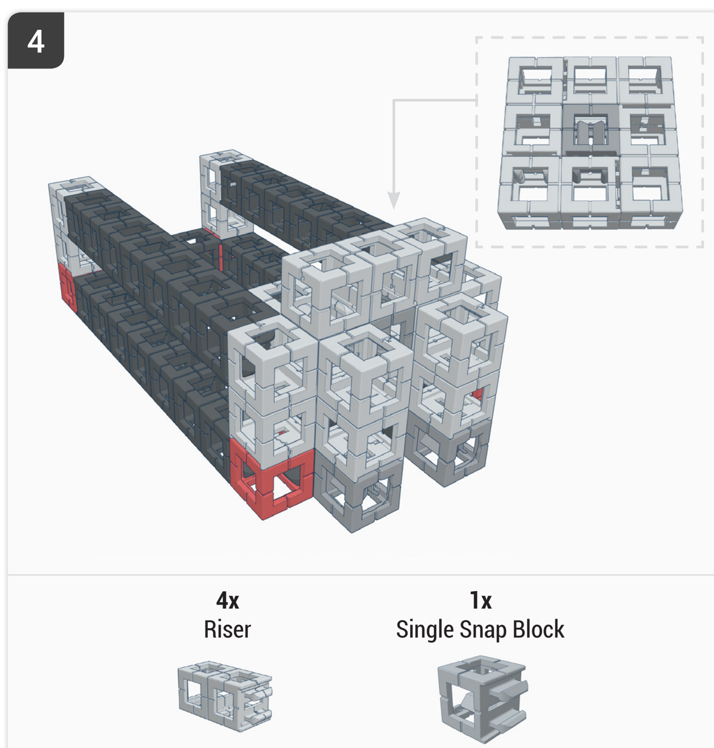
Instructions

Follow the step-by-step instructions to build the sluice gate.









Challenge Evaluation

When teams have completed the design & engineering challenge, it should be presented to the teacher and classmates for evaluation. Teams will be graded on the following criteria:

- **Specifications:** Does the design meet all specifications as stated in the design brief?
- **Performance:** How well does the design work? Does it function consistently?
- **Team Collaboration:** How well did the team work together? Can each student descibe how they contributed?
- **Design Quality/Aesthetics:** Is the design of high quality? Is it structurally strong, attractive, and well proportioned?
- **Material Cost:** What was the total cost of the design? Was the team able to stay on or under budget?
- **Presentation:** How well did the team communicate all aspects of the design to others?

Grading Rubric	Advanced 5 Points	Proficient 4 Points	Partially Proficient 3 Points	Not Proficient 0 Points
Specifications	☐ Meets all specifications	☐ Meets most specifications	☐ Meets some specifications	☐ Does not meet specifications
Performance	☐ Design performs consistently well	☐ Design performs well often	☐ Design is partially functional	☐ Design does not work
Team Collaboration	☐ Every member of team contributed	☐ Most members of team contributed	☐ Some members of team contributed	☐ Team did not work together
Design Quality/ Aesthetics	☐ Great design/ aesthetics	☐ Good design/ aesthetics	☐ Average design/ aesthetics	☐ Poor design/ aesthetics
Material Cost	☐ On Budget ($180 or Less)	☐ Slightly Over Budget ($181-185)	☐ Over Budget ($186-195)	☐ Significantly Over Budget ($196+)
Presentation	☐ Great presentation/ well explained	☐ Good presentation/ well explained	☐ Poor presentation/ explanation	☐ No presentation/ explanation
Points	....	....	....	....
Total Points				.... /30