Ratios, Proportions, and Scale Drawings

v3.0

Applied Mathematics | Curriculum Packet

Overview:

In this lesson, students will learn about ratios, proportions, and scaled drawings using Kid Spark engineering materials. Then, students will apply what they have learned throughout the lesson to complete a fun design and engineering challenge.

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Learning Objectives & NGSS Alignment:

- Define ratio.
- Determine the proportional relationship of two ratios.
- Use scale drawings to represent a reduced or enlarged visual of a real object.

Scientific/Engineering Practice - Using mathematics
Crosscutting Concept - Scale, proportion, and quantity

Activity Time:
120 Minutes

Targeted Grade Level:
3 - 5

Student Grouping:
Teams of 2

Additional Lesson Materials:
- Teacher Lesson Plan
- Student Engineering Workbook

Kid Spark STEM Lab:
STEM Pathways

Note: *Two teams can share the engineering materials from one Kid Spark STEM Lab.*

Convergent Learning Activity:

1. **Ratios**

A **ratio** is a relationship or comparison between two numbers. Ratios express how much of one thing there is compared to another. Ratios can be written as a fraction, using the word "to", or with a colon (:).

In example 1, the square has a length and depth of 2 cm. The ratio of the length to the depth can be written as 2/2, 2 to 2, or 2:2.

In example 2, the square has a length and depth of 10 cm. The ratio of the length to the depth can be written as 10/10, 10 to 10, or 10:10.

While the dimensions in examples 1 and 2 are different, their ratios are actually equivalent. **Equivalent ratios** are two ratios that express the same relationship or value. In example 2, the length and depth of the square are each five times larger than the length and depth of the square in example 1.

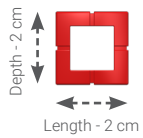
Example 1

$$\begin{matrix}\text{length}\\ \text{depth}\end{matrix}\ \frac{2\text{ cm}}{2\text{ cm}}\ \begin{matrix}\times 5\\ \times 5\end{matrix}\ =\ \begin{matrix}\text{length}\\ \text{depth}\end{matrix}\ \frac{10\text{ cm}}{10\text{ cm}}$$

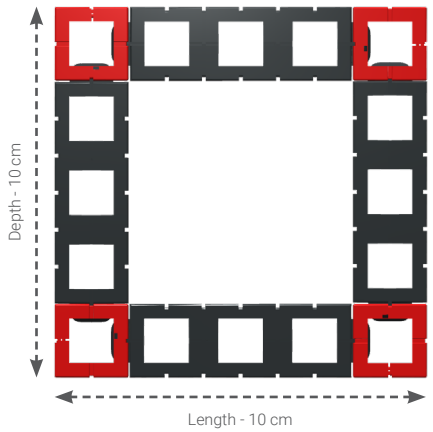
Example 2

Instructions: Build a square that has a length and depth that is ten times larger than the square in example 1. Do not disassemble the square as it will be used in the following section.

Example 1
Ratio of length to depth - 2/2, 2 to 2, 2:2



Example 2
Ratio of length to depth - 10/10, 10 to 10, 10:10



2. Proportions

Proportions are statements that express two equivalent ratios. Proportions can be written as a fraction (a/b = c/d), or using a colon (a:b = c:d). Examples 1 and 2 have different dimensions, but their ratios are equivalent. Since both ratios (2/2 and 10/10) express the same relationship or value, they can be written as a proportion: 2/2 = 10/10.

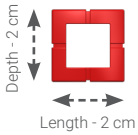
To check whether two ratios are proportional, they can be cross multiplied. In the example below, the ratios 2/2 and 10/10 have been cross multiplied. Since both cross products equal 20, we know the ratios are equal or "proportional".

$$\frac{2}{2} \times \frac{10}{10} \rightarrow 2 \times 10 = 20 \rightarrow 20 = 20$$

Instructions: In the previous section, each team was challenged to build a square that had a length and depth that was 10 times larger than the square in example 1. Determine the ratio (length to depth) of the new square. Then, make sure the ratio of the new square is proportional to the ratios of the squares in examples 1 and 2 by cross multiplying.

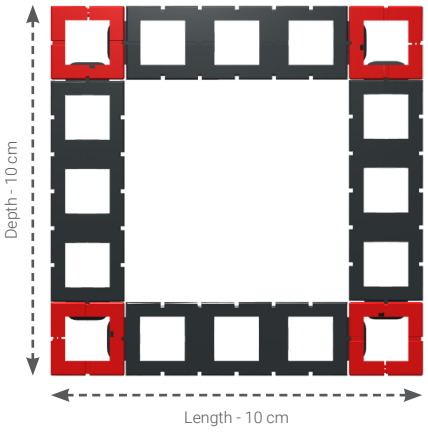
Example 1

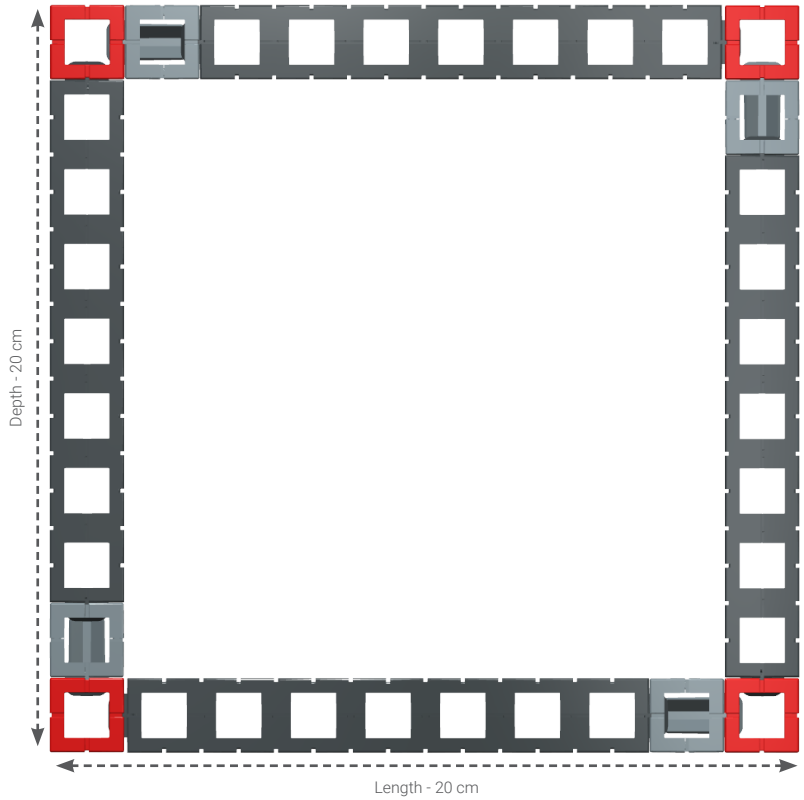
Ratio of length to depth - 2/2, 2 to 2, 2:2



Example 2

Ratio of length to depth - 10/10, 10 to 10, 10:10





3. Scale Drawings

A **scale drawing** is a drawing or illustration of a real object which has been reduced or enlarged from its original size, but still proportional to the real object. The proportion by which the drawing of an object is reduced or enlarged is referred to as the **scale ratio**.

Instructions: Place a red block on the illustration in example 3. Observe how the block and the illustration of the block are the same dimensions (length and depth are each 2 cm). The scale ratio of this illustration is 1:1, which means it is a full-scale (full-size) representation of the real object.

In example 4, the illustration of the red block has been scaled down and placed on a half-centimeter (.5 cm) grid. The red block has a length and depth of .5 cm, which means its dimensions are 4 times smaller than the real object. The scale ratio of this illustration is 1:4, which means every half-centimeter on the illustration represents 2 cm on the real object.

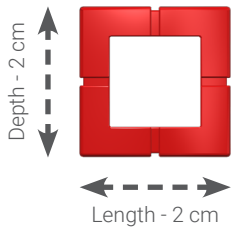
We can check to make sure the scale drawing and real object are proportional by cross multiplying. Since the cross products are equal, we know the dimensions of the illustration and the real object are proportional.

Scale Drawing		Real Object	
length	$\frac{.5\text{ cm}}{.5\text{ cm}}$	$\frac{2\text{ cm}}{2\text{ cm}}$	length
depth			depth

$$\frac{.5}{.5} \times 4 \quad \frac{2}{2} \times 4 \quad .5 \times 2 = 1 \quad .5 \times 2 = 1 \quad 1 = 1$$

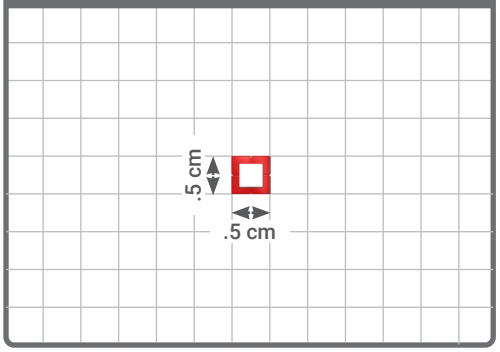
Example 3

Scale ratio - 1:1 (2 cm = 2 cm)



Example 4

Scale ratio - 1:4 (.5 cm = 2 cm)

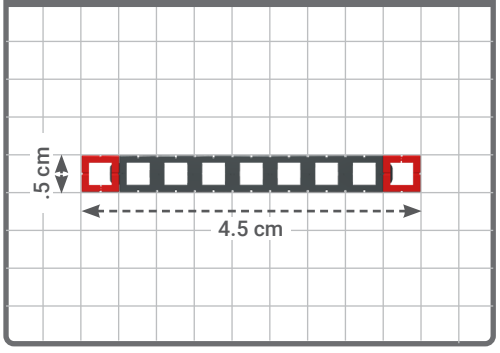


= .5 cm

Instructions: Determine the actual dimensions of the beam shown in example 5.

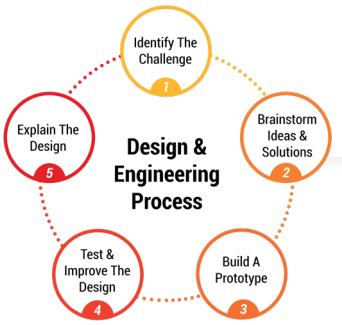
Example 5

Scale ratio - 1:4 (.5 cm = 2 cm)



= .5 cm

Divergent Learning Activity:



Scenario:

A local animal shelter is trying to find families to adopt dogs in need. The Spark City Construction Company has offered to build free dog houses for anyone that is willing to adopt one of the dogs. The construction company is currently trying to decide on a design they can prototype and build.

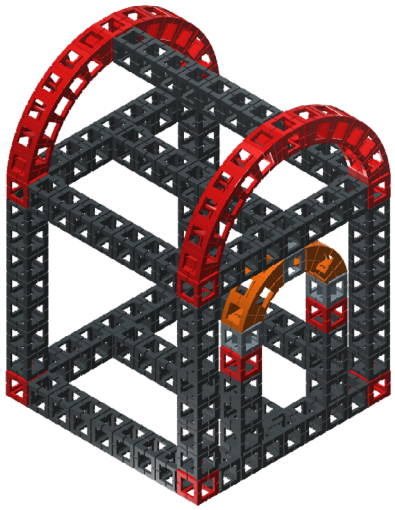
Design & Engineering Challenge:

Design and engineer a simple dog house. *See example below.*

Specifications/Criteria:

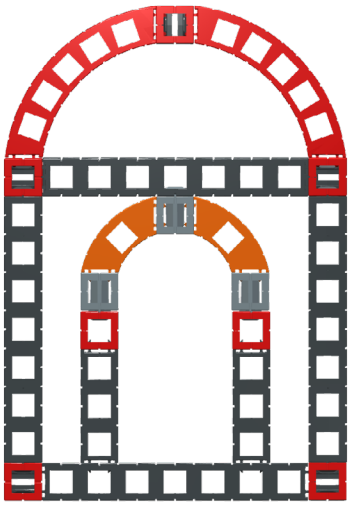
1. Teams can work in teams of two to complete this challenge. Teams should record their progress in their student engineering workbooks.
2. Teams must work through each step of the Design & Engineering Process to design, prototype, and refine a simple dog house. Teams will present their designs to the class when they are finished.
3. The exterior dimensions of the physical dog house should not exceed a length of 30 cm, depth of 30 cm, and height of 34 cm.
4. Teams must produce four scale drawings of the dog house on the provided half-centimeter grids. Drawings should be simple, two-dimensional drawings of the front, rear, side, and top of the dog house. *See examples on pages 5 - 6.*
5. Teams must determine how much they would need to scale up their design in order for an average-sized dog (length - 30 cm, depth - 95 cm, height - 90 cm) to comfortably use the dog house. *See example on page 7.*

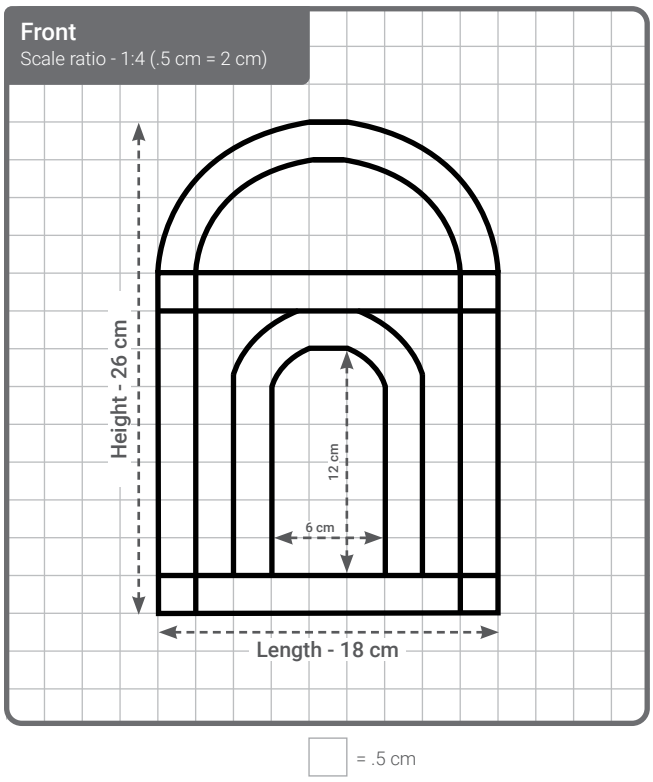
Example Solution:

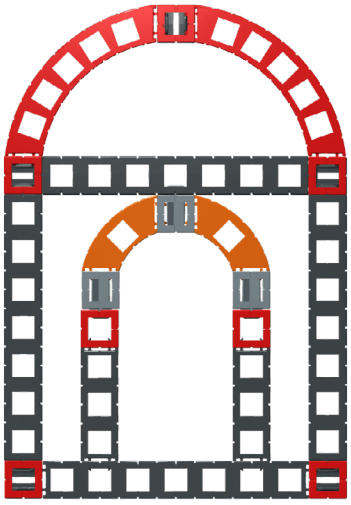


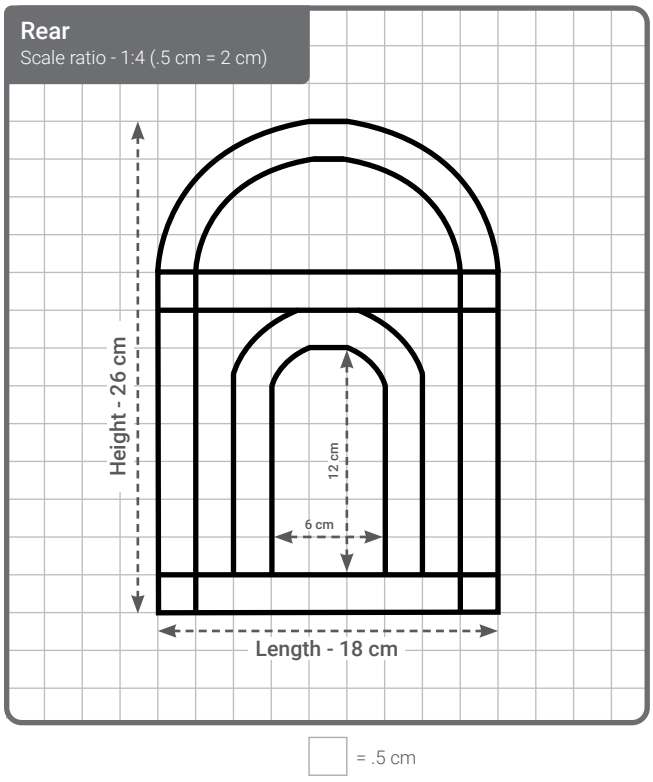
Scale Drawing Examples

The scale drawings below represent the front and rear of the example dog house.



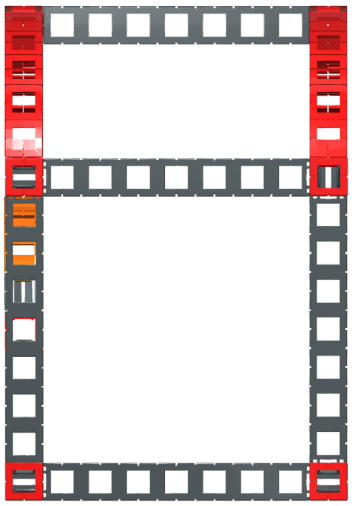


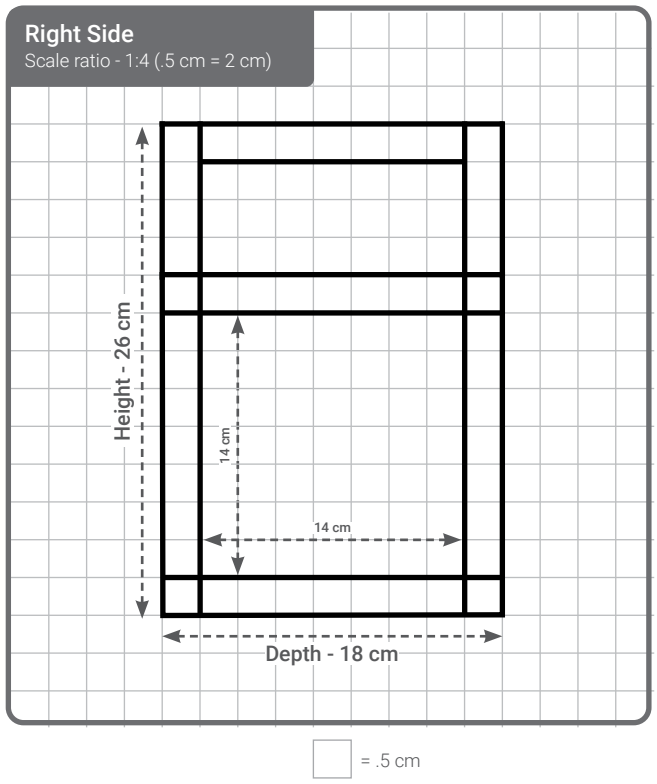


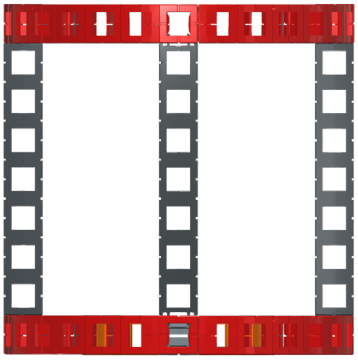


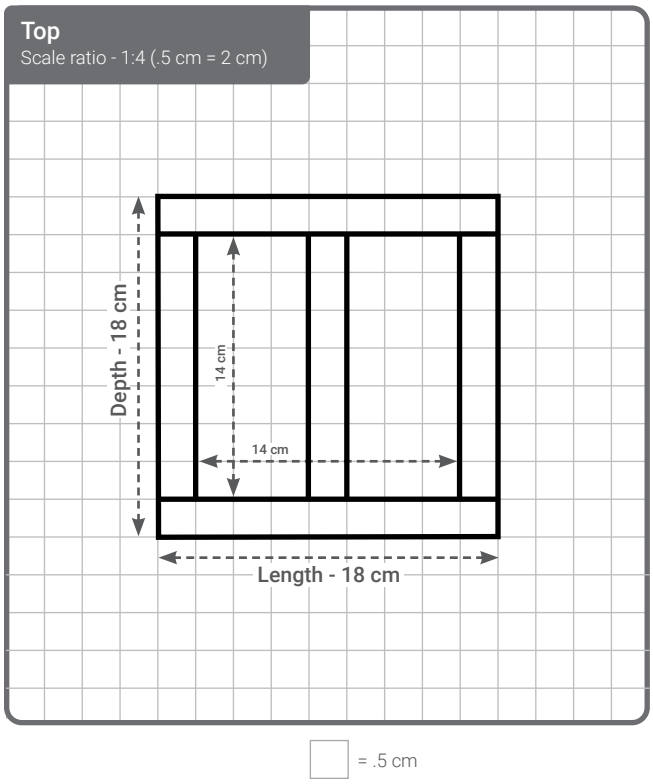
Scale Drawing Examples

The scale drawings below represent the right side and top of the example dog house.



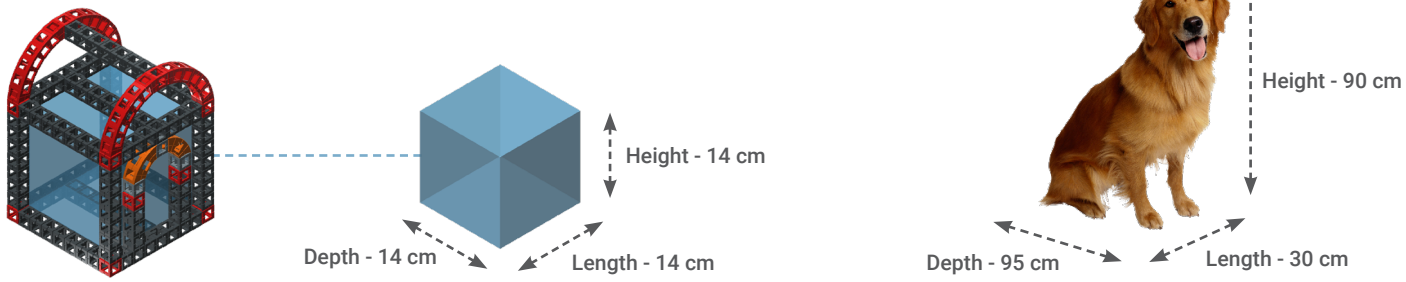






Scaling Up Example

Listed below, you will find the interior dimensions of the example dog house and the dimensions of an average-sized dog. In this example, it is easy to determine that the example dog house is not large enough to accommodate the dog.



The example dog house can be scaled up by multiplying each dimension by the same number. By multiplying each dimension by the same number, we know the larger dog house will be proportional to the original model.

In this example, the dog house would need to be scaled up 7 times (ratio - 1:7) larger for the dog to fit inside. While the dog would technically fit, it would have little room to move around. If the dog house is scaled up 10 times (ratio - 1:10) larger, the dog would have plenty of room to be comfortable inside the dog house.

Example Dog House (Interior Dimensions)	Ratio - 1:5	Real Dog House (Interior Dimensions)	Does the dog fit?	Does the dog fit comfortably?
Length - 14 cm	x 5 =	Length - 70 cm	Yes [X] No	Yes [X] No
Depth - 14 cm	x 5 =	Depth - 70 cm	Yes [ ] No [X]	Yes [ ] No [X]
Height - 14 cm	x 5 =	Height - 70 cm	Yes [ ] No [X]	Yes [ ] No [X]

Example Dog House (Interior Dimensions)	Ratio - 1:7	Real Dog House (Interior Dimensions)	Does the dog fit?	Does the dog fit comfortably?
Length - 14 cm	x 7 =	Length - 98 cm	Yes [X] No	Yes [X] No
Depth - 14 cm	x 7 =	Depth - 98 cm	Yes [X] No	Yes [ ] No [X]
Height - 14 cm	x 7 =	Height - 98 cm	Yes [X] No	Yes [ ] No [X]

Example Dog House (Interior Dimensions)	Ratio - 1:10	Real Dog House (Interior Dimensions)	Does the dog fit?	Does the dog fit comfortably?
Length - 14 cm	x 10 =	Length - 140 cm	Yes [X] No	Yes [X] No
Depth - 14 cm	x 10 =	Depth - 140 cm	Yes [X] No	Yes [X] No
Height - 14 cm	x 10 =	Height - 140 cm	Yes [X] No	Yes [X] No

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?
- **Team Collaboration:** How well did the team work together? Can each student describe how they contributed?
- **Design Quality/Aesthetics:** Is the design of high quality? Is it structurally strong, attractive, and well-proportioned?
- **Presentation:** How well did the team communicate all aspects of the design to others?

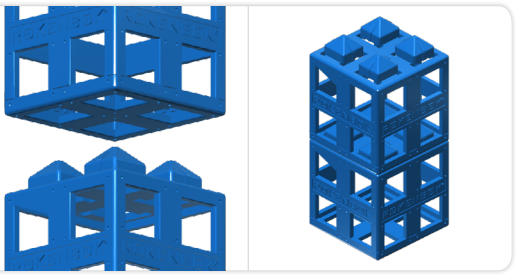
Grading Rubric	Advanced 5 Points	Proficient 4 Points	Partially Proficient 3 Points	Not Proficient 0 Points
Specifications	☐ Meets all specifications	☐ Meets most specifications	☐ Meets some specifications	☐ Does not meet specifications
Team Collaboration	☐ Every member of team contributed	☐ Most members 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
Presentation	☐ Great presentation/ well-explained	☐ Good presentation/ well-explained	☐ Poor presentation/ explanation	☐ No presentation/ explanation
Points	.....	.....	.....	.....
Total Points				...../20

Building Basics

The following tips will be helpful when using Kid Spark engineering materials.

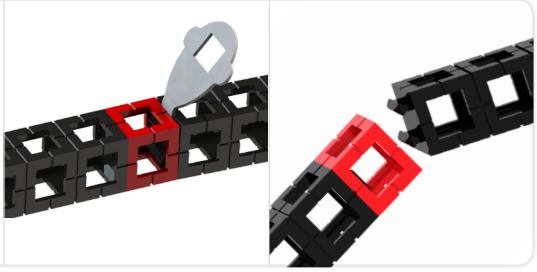
Connecting/Separating ROK Blocks:

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



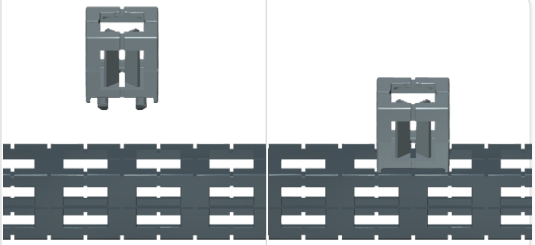
Connecting/Disconnect Smaller Engineering Materials:

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



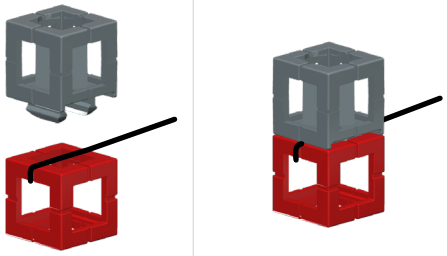
Snapping Across Openings:

Materials can be snapped directly into openings or 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 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 a basic connector block are 2 cm on each edge. This means the length, depth, and height are each 2 cm. To determine the size of a project or build in centimeters, simply count the number of openings and multiply by two. Repeat this process for length, depth, and height.