LESSON 2:
BUILDING BRIDGES

SUPPLIES

MAIN BIN

- Plastic Cups (20)
- Masking Tape (5 rolls)
- Straws (50)

PENCIL BOX

- Scissors (15)
- Pencils (15)
- Marbles (15)
- Rulers (6)

BIG FOLDER

- Paper (50 sheets)

OBJECTIVES

- ☑ To understand the history behind bridges and distribution of weight.
- ☑ To use the engineering process to create a bridge that can support the weight of 3 marbles.

HOOK

2-3 min

Ask the students if they think it's possible to create a strong bridge using only paper. Then, complete the demonstration on the next page!

INTRODUCTION

3-5 min

Bridges have been around for thousands of years, helping people cross rivers, valleys, and other obstacles. The first bridges were simple, made from logs or stones placed across streams. As people needed to cross larger distances, they started building more complicated bridges. In modern times, we have many different types of bridges, like suspension bridges, which use cables to hold up the roadway, and beam bridges, which are supported by strong beams underneath.

Building bridges comes with many challenges. Engineers have to make sure that bridges are strong enough to hold the weight of cars, trucks, and even trains. They also have to think about natural forces like wind and water. To make bridges strong, engineers use materials like steel and concrete, and they design the bridges in special ways to make sure they stay standing.

For this project, you'll be designing your own bridges using paper, and then a more complicated bridge using straws and and tape. Think about how you can make your bridge strong enough to hold as much weight as possible. What shapes and designs might help?

BUILDING BRIDGES

DEMONSTRATION

3-5 min

- Set up two plastic cups, upside down about 3 inches apart. Put a piece of paper over the top and ask the kids to think about what would happen if you added five marbles to the bridge.
  - Add 5 marbles to the bridge to demonstrate that the bridge would collapse.
- Ask students: Did this bridge work? Why?
  - Some possible answers include:
    - The paper was too weak to hold the weight
    - The paper wasn't attached to the cups
    - The ends of the paper were not weighed down

DISCUSSION

5-10 min

Ask the class: What are some ways we can make this bridge stronger? Do you think we can make it strong enough to hold the marbles?

There are lots of ways to make structures stronger. In this class, we will discuss three main ideas that engineers use when designing structures like birdges: tension, compression, and strong shapes. Explain the following concepts to the class:

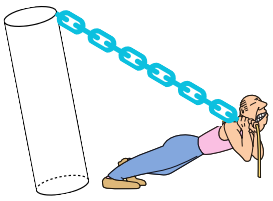
COMPRESSION

Compression (or being pushed on) is one way to stablize a structure. When a column is compressed, or pushed, the particles of the material become closer together and they become stronger.

- What would happen if you added another cup under the middle of your paper bridge? This column would compress, helping to hold the weight of the marble.

Tension (or being pulled on) is another way to stabilize a structure.

- For example, we could use cables or ropes to hold our bridge steady. Pulling on a rope makes it strong. We could also use tape to attah our bridge to the cups!



TENSION

STRONG SHAPES

Strong Shapes are the last way we can build a stable structure. Strong shapes are created by combining beams (for example, connecting multiple paper cylinders with tape)

- When beams are combined into different shapes, they are stronger!
- Triangles are the strongest shape. That's why you see so many bridges, towers, and other structures made up of triangles. Triangles support top and side loads much better than a square or rectangle—all the weight can be supported from a single point on the top. Think about how you can use triangles when building a bridge!

BUILDING BRIDGES

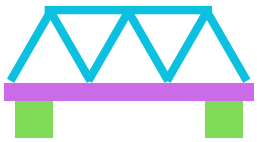
Tell the students you will be talking about a few different types of bridges. It's okay if they don't learn all the names– it's more important to be thinking about how the concepts we've been learning relate to the bridges.

TYPES OF BRIDGES

BEAM BRIDGE

Beam bridges are bridges where beams are laid across the distance.

- An effective beam bridge needs a strong material that can support the weight of objects crossing all on its own. The longer the beam bridge, the stronger the material has to be.

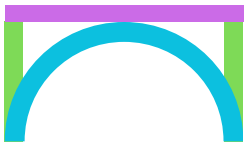


TRUSS BRIDGE

A truss bridge uses beams arranged as triangles to support the length of the bridge. These triangles form a tunnel over the bridge for traffic to pass through.

SUSPENSION BRIDGE

A suspension bridge is supported by cables or ropes. The cables and ropes are attached to concrete at their end. The ropes and cables are pulled to create tension, supporting the weight and load of the bridge.



ARCH BRIDGE

An arch bridge rests on top of an arch. The arch structure distributes the weight of the bridge and its load through the beams.

DESIGN & BUILD

20 min

Today, students will be building two bridges: a paper bridge and a straw bridge. In both cases, the bridge will be between two cups. The cups have to be spaced at least 4 inches apart. They are only allowed to use one sheet of paper, and they cannot use tape. Their bridge should support 3 marbles.

For the Paper Bridge:

1. Have students work in groups of three.

2. Give each group 3 pieces of paper, 3 marbles, 2 plastic cups, and 1 ruler.
   - Explain that the extra pieces of paper are for practice, but they can only use **one** in the final design

3. Have students turn the plastic cups upside down on the table and distance them 3 inches apart.

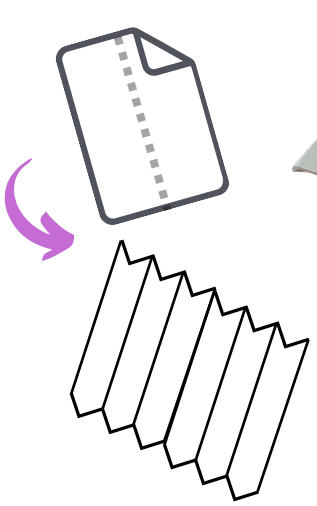
4. Give students 10 minutes to build their bridge. Provide regular reminders of time remaining.

5. Allow students to test their bridges throughout. If anyone builds a bridge that holds up the marbles, have them demonstrate! If no one is able to construct a strong enough bridge, move on the solution.

BUILDING BRIDGES

6. Demonstrate to students how to make an accordian fold. Fold the paper in half and then fold in accordian style. See example!

   Because this fold involves so many triangles, the bridge is much stronger than if the peice of paper was laying flat.



For the Straw Bridge:

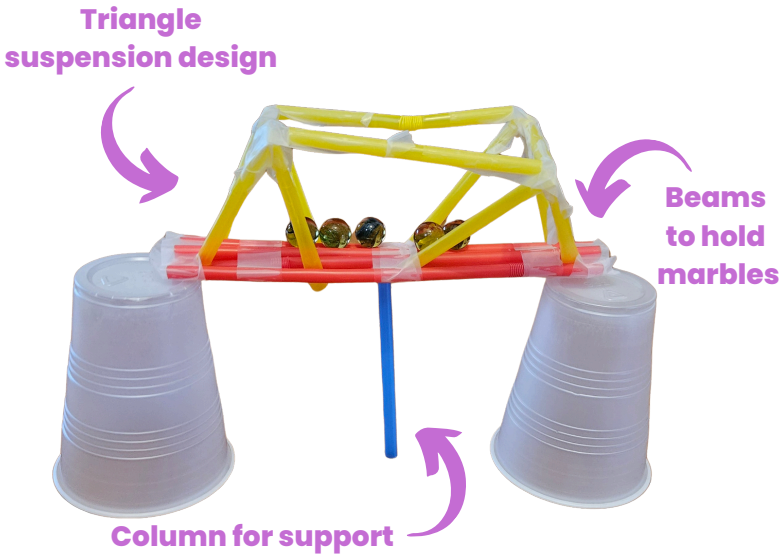
1. Have students work in groups of three.

2. Give each group 10 straws, 3 marbles, 2 plastic cups, roll of masking tape, scissors, and 1 ruler.

3. Encourage students to build a bridge using straws and masking tape. Remind students to use the scissors to cut the straws as needed, and to use as much tape as needed.

4. If students are unsure of how to approach their design, show them the example. Ask them how they can incorporate triangles, beams, and columns into a straw bridge.

   Once everyone has completed a straw bridge, have them test their design with 3 marbles.



EVALUATE & REDESIGN

5-10 min

At the end of the builds, go from group to group, and have all students test their bridges using the marbles. If this task was easy for most groups, you can move onto the extension activities on the next page.

Allow students to make changes to their bridge for a further 5-10 minutes if needed. Walk around to help groups that are struggling. Then, test the bridges again.

OBSERVE & EXPLAIN

2 min

Ask students to observe:

- What method was best for strengthening the paper?
- How does folding the paper strengthen it? Does adding triangles to our design make it a better bridge?
- What differences did you notice between the paper and the straws?
- How could this principle be used for other bridges and materials?

BUILDING BRIDGES

If there is time, students can vote on which extension activity they would like to do.

EXTENSION #1
Strong Bridge Challenge

Challenge the students to create the strongest beam bridge possible using 3 sheets of paper.

All groups' cups should be the same distance apart, and all groups should be given the same amount of paper. Encourage groups to use 1 peieces of paper to roll beams, and one 1 sheet of paper to make the same accordian surface.

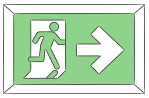
Add one marble at a time until the bridge collapses. The group whose bridge help the most marbles before collapsing wins.

EXTENSION #2
Long Bridge Challenge

Challenge the students to create the longest truss bridge possible using only straws and tape.

Students will work together to create the **longest** possible bridge using only straws and tape. For this challenge, the goal is to have the bridge hold it's own weight for 10 second, so no need to add a cup with marbles.

Encourage students to span the distance between two desks, tables, or chairs. Remind them to encorporate trangles in their design in order to keep the bridge as strong as possible!



Exit Ticket

Ask each student one of the following questions as they walk out the door.

- Q: What is an example of a type of bridge? A: Beam, Arch, Truss, or Suspension
- Q: What is an example of tension? A: stretched rope or cable
- Q: What is an example of compression? A: column
- Q: What is an example of a strong shape? A: triangle