Civil Engineering, Physics, Structural Engineering

B R I D G E S

Objectives: Students will

- Learn there are different types of bridges
- Learn the forces that act on bridges
- Design and build a bridge

Supplies:

- Craft sticks
- Glue
- Paper
- Blocks
- Pennies
- Small foam sheets
- Rubber bands
- Rope
- Wooden plank
- Paper

❖ **Icebreaker: Little Genius Rap/ Go Go Circle/**

<u>Vocabulary Words:</u>

- **Arch**
- **Bridge**
- **Suspension**
- **Force**
- **Foundation**
- **Load**
- **Compression**
- **Tension**

❖ **Introduce area of science for today: Engineering**

Today's area of science is **Engineering**. The focus will be on Bridges.

KWL Chart
What do you know about Engineering and bridges?

What do you want to know?

Overview

- Structural and Civil Engineering are fields of study that deal with the design and construction of all types of structures. Structures include buildings, tunnels, power plants and bridges (and many more that we don't have time to name). Engineers use many skills in their work. They are creative, artistic, and good communicators. They also know math and science. These engineers are men and women who research/study the forces that affect bridges and create a design that can **withstand** the forces that work against it. (Maybe this sentence can be clarified?)
- What is a force? A force is a push or pull on an object. On bridges there are forces that are directed up and down and those that are directed on the sides. Lets talk about some of these forces:

    - **Gravity –** This is the force that pulls an object toward the earth (Up and down) ***Drop bean bag
    - **Tension –** The force of pulling apart. **Pass out rubber bands.** ***Take this rubber band and stretch it, it is being pulled apart by tension.
    - **Compression –** This is a pushing force (When you stand on something). **Pass out foam sheets** *** Hold the foam sheet and bend in toward center. The side that bends inward is compressed; the part that bends outward (bottom) is under tension.

Do you think wind is a force? Take responses…Wind is a force that pushes on the side of bridges. What about weight? Take responses…The weight of cars and trucks and people are all forces that push down on bridges. Can you name anything else that might act as a force? (Water, rain, etc.)

A bridge is a …….
Today we will talk about four types of bridges that are built to handle compression and tension forces. The Beam Bridge, Suspension Bridges, Arch Bridge and Truss Bridge.

***Leadership – Male Mentor Presentation**

***SNACK/AFRICAN AMERICAN INVENTOR**

THE FIRST BRIDGES

- The first bridge builders were our ancestors during the time of the Stone Age more that 500.000 years ago. How do you think they built the first bridges? Take responses. ***Pass out 2 blocks and 1 craft stick**. If you guessed by putting a

fallen tree over a waterway you are correct. Our ancestors would have moved or chopped a tree to fall over a body of water and the **banks/edges** of the waterway supported the tree creating the first **Beam Bridge. Have students create a simple beam bridge.** As our early ancestors moved about they may have had a need for a longer bridge and built these longer bridges with several tree trunks with a large boulder or a collection of stones to support the middle. ***Pass out 1 additional block and craft stick. Show what this must have looked like. In this way our ancestors were able to travel without having to change course because of the water.

- As more tools were invented and wood was cut into planks from the tree trunks to make flat planks Suspension Bridges were designed with a wooden walkway. What is a Suspension Bridge? This is a bridge built using rope (before ropes they twisted vines together) to cross a body of water. Two long ropes were the main supports for this type of bridge, with shorter ropes connecting the two long ropes and supporting the wooden walkway. The long ropes would be secured to a tree or boulder on either side. (Show example) Even today bridges have been designed using this simple suspension model, can anyone name a suspension bridge? Take responses (**The Golden Gate bridge in San Francisco, Ca and the Brooklyn Bridge in New York City).** These bridges are not made of wood and ropes; they have big woven-steel cables that support reinforced concrete decks/roadways.

Now lets talk about the bridge types we will discuss and work with during the rest of class today.

Bridge Types
Different shapes and materials are important in designing a bridge, because they add to the strength of the bridges.

- **Beam Bridges**
  - Half the bridges in the Unites States are beam bridges.
  - The have vertical (up and down) supports called piers and horizontal (sideways) beams.
  - As we discovered from the beginning of class this is the world's oldest type of bridge.
  - They can be long, but the piers are short and close together to support this type of bridge.
  - The weight (on top) of the beam bridge compresses on top and down the piers and the tension is under the bridge.

- **Suspension Bridges**
  - Suspension bridges are very long and cost a lot of money because they take so long to build.
  - They are built over harbors and are tall enough that ships can sail underneath.

- **The cables of a suspension bridge carry the force of the compression to the towers that support them and they also carry the tension force. (Please explain this and clarify…I don't understand??)**

❖ **Arch Bridges**
- This type of bridge was designed centuries (hundreds of years) ago by the Romans and is very strong.
- Arch bridges can be built of many materials.
- At the top of the Arch the compression force is the greatest and the tension force is greatest at the bottom

❖ **Truss Bridges**
- Arch bridges can be built of many materials.
- The Truss bridges are very strong and are most often used as railroad bridges.
- They are made with triangles that are locked together.
- The triangles carry the compression and tension forces.

Building Strong Bridges

❖ There are many bridges in our country and if you have driven in a car, rode a bus or taken a train you have seen one and been across one. Can anyone describe a bridge they have seen? (Enforce the following points) Some bridges have arches, towers, piers and cables to support them and don't forget the shapes we see in bridges such as semi-circles, triangles and rectangles.

❖ Every bridge has a **deck** (where you walk or drive), **supports (what are these?)**, a **foundation** (where the bridge rests) and **approaches** (the road or path that leads up to the bridges). All these parts of the bridge can be made from different materials and in different shapes. Shapes are important in designing a bridge, because they add to the strength of the bridges. Let's do some quick strength test so you can see for your self.

Bridge Strength Testing
(Supplies – paper, 8blocks, at least 20 pennies)

1st

1. Have students place blocks on table to make a foundation (about 7 inches apart)
2. Have students place flat piece of paper on top of blocks making a Beam bridge.

3. Place pennies on top of bridge.
4. When does it fall? Count pennies and record on chart.

2nd

1. Have students remove paper and push the blocks closer
2. Have students place the paper and make an Arch bridge between the block foundations.
3. Place pennies on top of bridge
4. When does it fall? Count pennies and record on chart.

3rd

1. Have students remove paper and instruct the to accordion fold the paper (pleats)
2. Have students place the folded paper on the block foundation.
3. Place pennies on top of bridge
4. When does it fall? Count pennies and record on chart.

Which design was the strongest – the beam bridge, the arch bridge or the truss (triangle bridge/accordion paper). Could you make a stronger bridge by combining any of these types? (If time permits let them try, pass out additional paper.) This is exactly what engineers do when they design bridges, they combine designs to make a bridge stronger and they know where the force is the greatest on these designs

Let's try some more strength testing so you can understand what the forces on a bridge fell like. How? By building a human bridge. Ask for three (3) volunteers

Human Bridge Strength Activity

1ST

1. Ask students why they think cables for a suspension bridge are secured past the ends of the bridge?
2. To demonstrate the answer, have all students stand.
3. Have students place their right hand on their head and pull gently.
4. What happens?
5. If you try to keep your head (the bridge) straight your neck feels compressed and pulled to the right. On a real bridge it collapses.
6. Now put both hands on your head and lace your finger together.
7. Pull with both arms.
8. What happens?
9. Your head and neck feel compressed but your neck will not pull to the right or left because the forces are balanced between the right and left arm.

So if the bridge is not anchored/secured to the land the bridge collapses

2ND

1. Ask for three (3) student volunteers.

2. Have two (2) students form and Arch by stretching their arms toward each other and grab each other's hands.
3. Have students back up until they are as far apart as possible without breaking the Arch.
4. Ask our third volunteer to "Gently" pull on the Arch until it separates.
5. Ask the bridge volunteers what happened? How did it feel? Describe the force that broke the Arch.
6. Ask the class, "What can we do to stop the force from breaking the bridge apart?" Take responses. Add more supports (students)
7. Ask for two (2) more volunteers to help make the bridge stronger.
8. Ask students what can we do to make the Arch stronger with these 2 volunteers. Take responses.
9. Have the two volunteers create a support base for the standing Arch volunteers called a Buttress. They sit with their backs against the calves of the standing volunteers.
10. Once the bridge arch is ready have the force volunteer pull "gently" on the Arch.
11. What happens? How did it feel?
12. Was the Arch stronger with or without the supports?

NOTE: You can continue with this activity as time permits, using different volunteers and combinations in the Arch design.

The Arch was stronger with the supports because the force of the pull was not only acting on the arch, but also on the buttress supports.

So we have learned so far that bridges can be simple or complicated, that different shapes can affect the strength of a bridge, that they all have decks and that some are wooded while other may be made of steel and concrete.

Now as our final activity you will design and build a bridge beginning with the supplies in class.

Hands On Science Activity

Pass out supply bags (glue, craft sticks, blocks, pieces of wire)

1. Have students check their supply bags.
2. Explain to students they can use any or all supplies for their bridge
3. Draw a design for your bridge.
4. Begin construction
5. Complete your bridge construction at home using additional supplies you may have at home.

There are many more types of bridges than what we talked about today and the library has many books that will show you how they are built.

Now let's finish our KWL chart

What did you learn today about Engineering and Bridges?

- **HOMEWORK**
  Finish your bridge