

Pasta Bridges

Grades: 6-8

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Goals: National Science Standard B: Motions and Forces
National Science Standard E: Abilities of Technological Design
National Science Standard F: Science and Technology in Society
NCSCOS: Grades: 6-8 Goal 1: The learner will design and conduct investigations to demonstrate an understanding of scientific inquiry.
NCSCOS: Grade 6-8: Goal 2: The learner will demonstrate an understanding of technological design.
NCSCOS: Grade 5: Goal 4: The learner will conduct investigations and use appropriate technologies to build an understanding of forces and motion in technological designs.

Objectives: This activity can be used to demonstrate how force is distributed in weight bearing structures such as a bridge. This project uses different kinds of pastas to determine which shapes are stronger and why. This is also a good activity to use when studying civil engineering.

Engagement: Students will be told that they are going to design a bridge that will hold the most weight.

Materials: Various types of pasta: (wagon wheels, spaghetti, lasagna, linguine, rotini, ziti, shells), Glue, Tape, String, Matchbox Car, ½ and 1 lb. Baggies of Sand or alternate weights, Paper Plates, scales

Procedure:

Set Up: Make a pasta selling station. Use box tops or similar to sort the pasta into piles by type. Have a scale near this so that you may weigh the pasta. You may want to have paper plates to lay the pasta on as you weigh it. Each group will be allowed to use 1lb of pasta. You may want to limit them to one or two lasagna noodles, depending on how difficult you want to make the activity. There will be some scrap, but bridges will not be weighed at the end, so tell students to use as much as possible. Groups will not be allowed any more pasta. Nor will they be allowed to return or trade the pasta they take in the initial buying session, so remind them to plan first!

Instruction: Place students into groups of 2-4. Each group will have to build a bridge for a matchbox car to cross. The students need to be sure that there are places for the tires so that the car does not fall through the bridge as it crosses. The bridge also needs to span 12 inches across two classroom chairs.

Have the students determine how many ways you can test these bridges, then choose the method that most students agree is fair. Tell the students to build the bridges according to

the rules you all agreed upon. Each group of students will be allowed the same amount of pasta by weight. They may choose any combination of noodles, as long as it totals 1 ¼ pounds. Have groups come to the pasta selling station to choose their pasta. You will weigh it for them.

Once all bridges are completed, set them up at the front of the room. Ask students to predict which will do the best. One by one, set the bridges 12 inches across 2 chairs, run the matchbox car across to be sure it fits, and begin putting sandbags or weights on using the method that was agreed upon by all groups. Make sure that you have allowed for a place to put the sandbags or weights. (A good way to do this is to build a tester using string and a small basket. Suspend the basket from the bridges using two loops of string. The basket can then hold the sand bags.)

Pre-Building Discussion Questions:

What geometric shapes do you think are the strongest?

Do you think you may want to include them in your design?

Which pastas might be most useful for roads or supports in your bridge?

Follow Up Questions:

Share what you did:

How did most people attach the pasta together?

How did your group come to agreement on what pasta to use?

What types of pasta were the most popular?

Process what's important:

How would the results change if you placed the weights on a different part of the bridge?

What geometric shapes did you often see in the best designs?

What bridge styles performed the best?

What did you learn about weight distribution?

If you were to do this project again, what would you change about your bridge?

Generalize to your life:

Which shapes do you see most often in the real world?

Why is it important for engineers to test different designs before building them?

Web Resources:

<http://pghbridges.com/basics.htm> basic bridge design information

<http://www.geocities.com/thesciencefiles/bridge/building.html> pictures and examples of successful toothpick bridges

<http://school.discovery.com/lessonplans/programs/bridges/> a Discovery lesson plan with a simulator

Vocabulary:

Weight Distribution

Stress

Torsion

Arch

Background Information

Civil Engineering: Civil Engineering can take many forms including bridge building. Civil Engineers are responsible for city planning, roads, water treatment plants, and many other structures and systems that are so vital to our daily lives. Civil Engineers are also developing things like high speed trains, dams, and even helping to design modules for space exploration. The following web site has ample information about Civil Engineering: <http://www.asce.org/kids/> American Society of Civil Engineering; Just for Kids section. This is an excellent resource to share with the students about the value of Civil Engineering and the prospective career paths.

Bridges:

There are three major types of bridges:

- The **beam bridge**
- The **arch bridge**
- The **suspension bridge**

The biggest difference between the three is the distances they can cross in a single **span**. A span is the distance between two bridge supports, whether they are columns, towers or the wall of a canyon. A modern beam bridge, for instance, is likely to span a distance of up to 200 feet (60 meters), while a modern arch can safely span up to 800 or 1,000 feet (240 to 300 m). A suspension bridge, the pinnacle of bridge technology, is capable of spanning up to 7,000 feet (2,100 m).

What allows an arch bridge to span greater distances than a beam bridge, or a suspension bridge to span a distance seven times that of an arch bridge? The answer lies in how each bridge type deals with two important forces called **compression** and **tension**:

Compression is a force that acts to compress or shorten the thing it is acting on.

Tension is a force that acts to expand or lengthen the thing it is acting on.

A simple, everyday example of compression and tension is a spring. When we press down, or push the two ends of the spring together, we compress it. The force of compression shortens the spring. When we pull up, or pull apart the two ends, we create tension in the spring. The force of tension lengthens the spring.

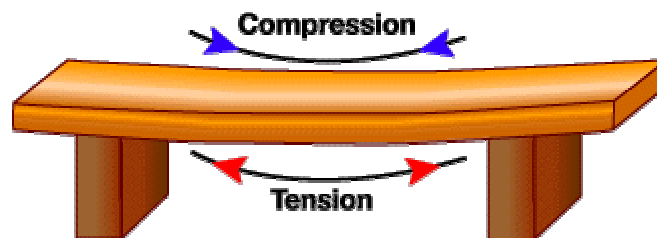
Compression and tension are present in all bridges, and it's the job of the bridge design to handle these forces without buckling or snapping. **Buckling** is what happens when the force of compression overcomes an object's ability to handle compression, and **snapping** is what happens when the force of tension overcomes an object's ability to handle tension. The best way to deal with these forces is to either dissipate them or transfer them. To **dissipate** force is to spread it out over a greater area, so that no one spot has to bear the brunt of the concentrated force. To **transfer** force is to move it from an area of weakness to an area of strength, an area designed to handle the force. An arch bridge is a good example of dissipation, while a suspension bridge is a good example of transference. Acknowledgements: <http://travel.howstuffworks.com/bridge1.htm>

The Beam Bridge (This is what the students will build.):

A beam bridge is basically a rigid horizontal structure that is resting on two piers, one at each end. The weight of the bridge and any traffic on it is directly supported by the piers. The weight is traveling directly downward.

Compression The force of compression manifests itself on the top side of the beam bridge's deck (or roadway). This causes the upper portion of the deck to shorten.

Tension The result of the compression on the upper portion of the deck causes tension in the lower portion of the deck. This tension causes the lower portion of the beam to lengthen. For example, take a two-by-four and place it on top of two empty milk crates -- you've just created a crude beam bridge. Now place a 50-pound weight in the middle of it. Notice how the two-by-four bends. The top side is under compression and the bottom side is under tension. If you keep adding weight, eventually the two-by-four will break. Actually, the top side will buckle and the bottom side will snap.



Dissipation Many beam bridges that you find on highway overpasses use concrete or steel beams to handle the load. The size of the beam, and in particular the height of the beam, controls the distance that the beam can span. By increasing the height of the beam, the beam has more material to dissipate the tension. To create very tall beams, bridge designers add supporting lattice work, or a **truss**, to the bridge's beam. This support truss adds rigidity to the existing beam, greatly increasing its ability to dissipate the compression and tension. Once the beam begins to compress, the force is dissipated through the truss. Despite the ingenious addition of a truss, the beam bridge is still limited in the distance it can span. As the distance increases, the size of the truss must also increase, until it reaches a point where the bridges own weight is so large that the truss cannot support it. Acknowledgements: <http://travel.howstuffworks.com/bridge2.htm>