



February 2011 – Bridges

Have you ever driven over a bridge and wondered what was holding it up? Learn about different types of bridges and the science that holds them up in this issue!

Bridge Science Projects

Build a Paper Bridge

Do you think you can build a bridge out of paper? Try it out and then see if you can make it stronger with these tips.

What You Will Need:

- a sheet of paper
- a few thick books
- pennies or other weights

What To Do:

1. Make two supports for your bridge by stacking books into two stacks that are the same height. They should rise several inches off of the table or floor and be about 6" apart from each other.
2. Lay a plain sheet of paper across the stacks of books. There should be an even amount of paper over each stack.
3. Place a penny, paperclip, pencil, or other light object in the center of the paper. Does your bridge support the weight? If so, add more until it collapses. If not, try to make it stronger.
4. A sheet of paper is very thin and without anything to support it in the middle, it will collapse easily. Can you think of any ways to make your bridge stronger? You could move the supports (stacks of books) closer together, or try folding the paper in different ways to make it stronger. Here are some tips:
 - Fold the sheet in half the short way so that you have a long, narrow piece. Tuck the ends under the flaps of the top book in each of your stacks and push up on the paper to make an arch (you may need to push the book stacks closer together). The extra layer of paper makes it slightly thicker and the arch shape can support more weight than a flat sheet of paper.

- Unfold the paper. Fold the short ends over twice to meet the center, so that you have 5 fold lines. Bend the paper up along the folds to make a four-sided box. Set it across the stacks of books and test it.
- Fold it accordion-style into a series of zigzags (you can start with a new unfolded sheet of paper). Start at bottom (short end) and fold the edge up a little more than an inch, then flip the paper over so that the folded flap is facing the table. Fold the already folded flap up the same amount. Flip the paper again and continue folding back and forth so that the folds make a zigzag pattern. Stretch the paper out slightly and set it across the space between the books. This triangular folding makes the bridge stronger, just like a truss bridge, because the weight is spread out more over the triangular shapes. This is why corrugated cardboard is stronger than ordinary cardboard - the folds inside of it make it more rigid. Try adding even more folds - does it make the bridge even stronger?
- Can you think of any other ways to fold your paper? Which makes the strongest bridge?
- Can you think of materials you have around your house that you could use to make a stronger bridge?

Arch Bridge Activity

Arches are one of the oldest types of bridge. Try this activity to learn more about them.

1. Take a thin piece of cardboard that is longer than it is wide and bend it into an arch shape.
2. Set it on the table, making sure it still has at least a slight arch.
3. Press on the top of the arch. What happens?
4. Now arch the cardboard again and place it between two stacks of books.
5. Press on the top of the arch again and notice what happens this time.

What's Happening?

The stacks of books act as *abutments* or supports to keep the ends of the arch from collapsing from the weight you put on it. Without them, there was nothing to support the weight of your hand and keep the ends of the arch from pushing outward and falling down.

For another simple project, use sugar cubes to build an arch. Taper the sides of the cubes with an old nail file (or scrape them with a butter knife) so that they fit snugly against each other to form an arch. Be sure to use an odd number of cubes, so that there's only one cube in the middle. If you used two cubes in the middle, the frictional force between those blocks would be overcome by the load force on the arch, causing it to buckle.

Suspension Bridge Activity

Make a model of a suspension bridge and learn why anchors for the cables are so important!

1. Pick two hardcover books that are the same height and about the same thickness. Stand them up on end, facing each other, several inches apart.
2. Tie a piece of string around the top of one of the books.
3. Letting the string hang loosely between the books, tie the other end to the top of the other book.

4. Now press on the center of the string suspended between the two books. What happens? (The books will fall over.)
5. Untie the string and set the books back upright, about 10" apart.
6. Place a stack of books on top of one end of the string. Pull the string tight and hang it over the tops of the standing books, with some string hanging loosely between them.
7. Put the other end of the string securely under another stack of books, a few inches away from the standing book.
8. Now try pressing again on the string in the center. What happens this time?

What's Happening?

When the string was tied around the tops of the books, there was nothing to support the books when weight was applied to the loose string. When you changed the design by putting the ends of the string securely under stacks of books, the books helped anchor the string and stabilize the upright books. This model is very similar to how a real suspension bridge is designed.

The books standing upright are like the towers at each end of the bridge and the string is like the cable that is anchored at each end. Depending on the size and thickness of the books you used, the books may still fall over, but they should stay up better than the first time you tried it (without the anchors). You can experiment more with different sizes of books, different kinds of strings, and even using two strings a few inches apart from each other. Take a look at the picture to the right - can you tell where the cables are anchored at each end of the bridge?



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Fun Facts

- The longest, tallest, and most expensive suspension bridge ever built is the Akashi Kaikyo Bridge located in Japan. This bridge is designed to be able to withstand very strong winds and even large earthquakes! It is 12,828 ft long, which is four times longer than the Brooklyn Bridge in New York.
- The Clifton Suspension Bridge in England was built in the 1860's for traffic carried by horses. The same bridge now supports about 4 million motorized vehicles traveling over it each year!

Silly Science

- Which animals can jump higher than the Sydney Harbor Bridge?
 - *All of them, because bridges can't jump!*

Way Cool Websites

- Build bridges to help Jerry make his way across the kitchen in this fun [Tom & Jerry game](#).
- Check out these [famous bridges](#) around the world that you can climb or walk across.
- Learn about the different types of forces that affect bridges with this [Forces Lab](#).

Teacher Tidbits

Types of Bridges

Arch bridges were one of the first types of bridge. The Romans used arches in their bridges and aqueducts as well as in their triumphal arches and other great architecture. See a picture of Constantine's Arch [here](#) and Minnesota's Stone Arch Bridge [here](#). Arches are designed with an odd number of stones, with the top, middle one being the *keystone* on which the bridge's weight rests. These stones have slanted sides so that they fit tight against each other. The downward force of the bridge's weight spreads out to the stones on either side of the keystone. Arches used in bridges also have supports at each end of the arch called *abutments*. These supports keep the stones in the arch in place even when weight is put on top of them.

Suspension bridges use a combination of strong cables and tall, solid towers to achieve a balance of forces. The roadway of a suspension bridge is suspended from the tower and held up by incredibly strong cables. Most suspension bridges today use steel wires and cables, because steel is very strong. A steel wire only 1/10th of an inch thick can hold more than 1,000 pounds of weight without breaking! To make the cables used in bridges, thousands of strong steel wires are twisted and bound together to make them even stronger. The Brooklyn Bridge in New York is one of the most famous bridges, now not so much for its size as its beauty. Built in 1883, it was the first great suspension bridge and a feat of engineering. At the time, it was the longest suspension bridge ever built (though several larger ones have been built since). The stone and steel that Brooklyn Bridge was built with combined to make it both solid and graceful. See a picture of it [here](#).

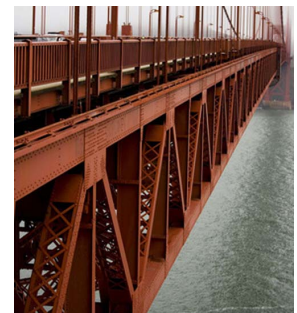
Learn more about another famous suspension bridge, the [Golden Gate Bridge](#), located in California.



Beam bridges are the simplest kind of bridge. A beam bridge is usually supported by a "pier" at each end, with a beam stretching across them. The weight of the beam pushes down on the piers, and the weight of cars or anything that will cross the bridge pushes down on the beam. Both the beam and the piers must be strong enough to support the weight that will be put on them. Beam bridges are often built over highways, rivers, and valleys. However, they cannot stretch across very long distances, since they are only supported by the piers at

the ends of the beam, with nothing supporting the center. To make longer bridges, lots of beam bridges can be linked together in a row; each beam is still supported by a pier at each end.

Truss bridges utilize the strength of triangles to spread out force. A web system of sturdy beams between two girders forms a zigzagging triangle pattern, stiffening the bridge and spreading out weight so that no one section bears all the weight at that spot. Trusses are also used to support other types of bridges, like beam or suspension bridges.



To learn more about different types of bridges, check out this [site](#).

Architects & Engineers

In general, bridges are designed by two different types of people. Architects are responsible for how a bridge looks while engineers are responsible for how the bridge works and is supported. There are a lot of things to consider when designing a bridge. Physics is a field of science that studies matter, energy, forces, and more. People who design bridges need to understand some important physics concepts in order to make a bridge that will be strong, stable, and secure over time.

Some physics concepts that are considered when bridges are designed are *compression* and *tension*. These are both forces that happen every day on bridges and can act differently on different materials. Compression presses down or shortens an object. Try putting a marshmallow on the counter and pressing down on it with the palm of your hand. The force from your hand compressed the marshmallow! Tension stretches out or lengthens an object. When you stretch a rubber band, a toy slinky, or pull two ends of a string tight, that's tension.

In addition to being able to support lots of weight, a bridge must also be able to stand up to lots of different types of weather, like high winds and sometimes even earthquakes!

Sometimes architects and engineers design special bridges that combine two or more types of bridges together to make the best possible bridge for a location. They have to be very careful to make sure the bridge design will still be stable and strong enough. Bridge designs must be tested quite well before a bridge is ever built.

Printable Worksheet

Use [this](#) worksheet to help kids review types of bridges. It also includes two simple activities.

Types of Bridges

Fill in the blanks with these words:

truss suspension arch beam

The next time you're riding in the car, count all the bridges you see.
See if you can figure out which kind each one is from the pictures on this sheet!

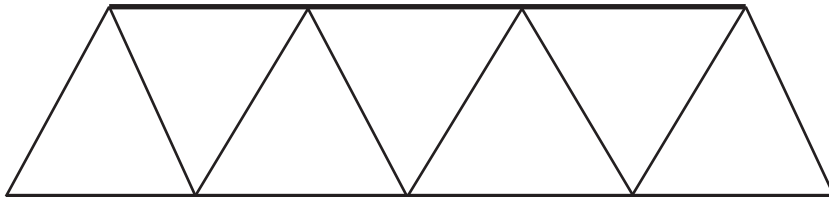


This is an

bridge.

This is a

bridge.

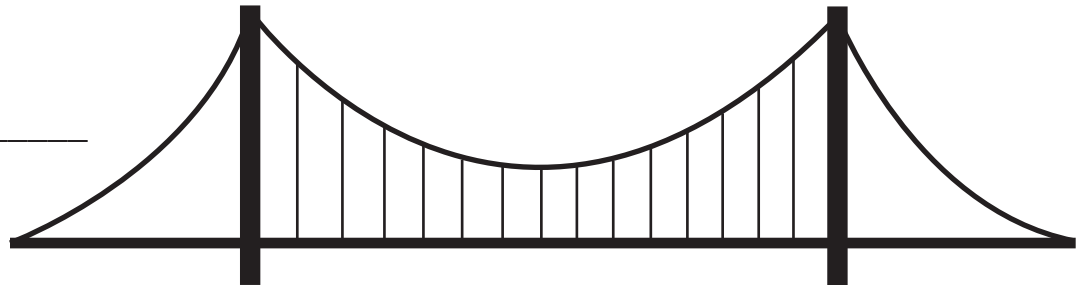


This is a

bridge.

This is a

bridge.



Draw your own bridge below by combining two different types of bridges together!