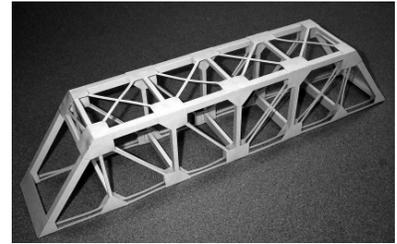


MANILA FOLDER BRIDGE

CAPITOL CENTER
ELEMENTARY MESA DAY

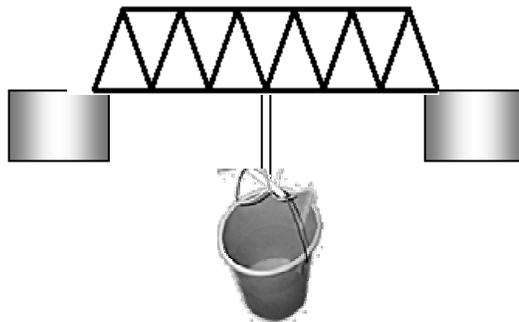


GRADE LEVEL:	K-6
TYPE OF COMPETITION:	TEAM (PREPARED)
COMPOSITION OF TEAM:	1-2
MAXIMUM NUMBER OF ENTRIES:	UNLIMITED

The Contest:

- ❖ Build a single-span truss bridge capable of spanning an 11" gap.
- ❖ No part of the bridge shall extend below the support surface.
- ❖ The width of the bridge cannot exceed 4".
- ❖ The length of the bridge cannot exceed 14".
- ❖ The height of the bridge cannot exceed 6".
- ❖ You can only use up to two manila folders to build your whole bridge, so use them carefully.
- ❖ The total weight of your bridge cannot exceed 2 ounces. Use any type of glue to assemble the bridge members. Rubber cement works well, but your teacher may not want you around the fumes.
- ❖ The load will be applied from the top of the bridge. The bridge therefore will not need a roadbed, since the test load will be placed on top of the bridge.
- ❖ The bridge must have a 1½" x ½" opening in the top and bottom, near the middle of the bridge to permit the passage of the load hook attached to the bucket

A 4"X4" thrust plate will apply force to the top of your bridge as close to the center as possible. A bucket will hang from a hook attached to the thrust plate and beans will be poured into the bucket until it fails. The bridge that withstands the greatest load before failure is the winner. Medals will be awarded for first, second and third place, based upon the load the bridges carried before failure.



MESA ELEMENTARY BRIDGE DESIGN



Why?

Design is the essence of engineering. The only way to truly appreciate the challenges and rewards of engineering is to actively engage in the creative process of design.

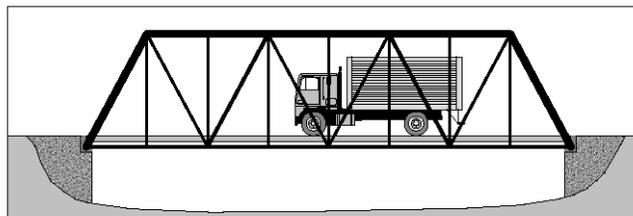
This bridge activity should allow MESA students to:

- ❖ Learn many key concepts about trusses and structural behavior that you'll use when you design your own bridge.
- ❖ Familiarize with the engineering characteristics of a rather unique building material—cardboard from a manila file folder.
- ❖ Learn some special construction techniques appropriate for this material.
- ❖ Learn about the challenges faced by real-world construction contractors, who are often required to build structures that have been designed by someone else.

Component Parts of a Truss

What is a Truss?

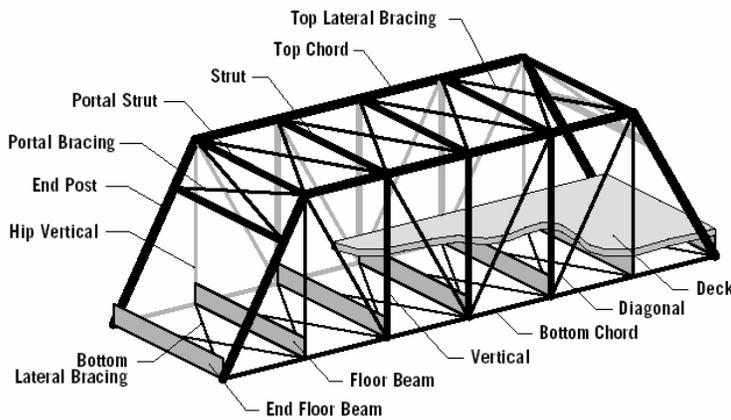
A truss is a structure composed of members connected together to form a framework. Members are the load-components of a structure. In most members are arranged in interconnected triangles, as shown on the next page. Because of this configuration, truss members carry load primarily in tension and compression. (We'll discuss these terms in detail below.) Because trusses are very strong for their weight, they are often used to span long distances.



A typical truss bridge. Note that the structure is composed entirely of interconnected triangles.

Bridge

a rigid carrying trusses,



Component parts of a typical truss bridge - Isometric View ¹

The three-dimensional bridge structure has two main load-carrying trusses. Each truss is composed of a top chord, a bottom chord, and several verticals and diagonals. The two trusses are connected together by a series of transverse members—struts, lateral bracing, and floor beams. In early truss bridges, all of these members would have been made of wood or iron. Today they are usually made of steel. Modern steel truss members are manufactured in a wide variety of shapes and sizes. A few common examples are shown below.

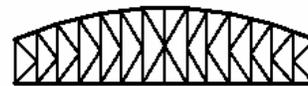
Your bridge should be composed of hollow tubes for the large members and flat strips for the narrow members of your truss.



Pratt



Parker



K-Truss



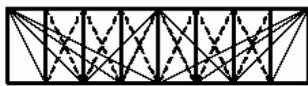
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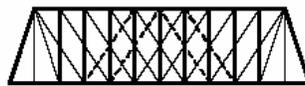
Camelback



Warren



Fink



Double Intersection Pratt



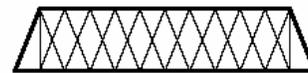
Warren (with Verticals)



Bowstring



Baltimore



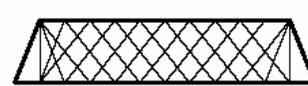
Double Intersection Warren



Waddell "A" Truss



Pennsylvania



Lattice

Common truss configurations.³

How a Structure Carries Load

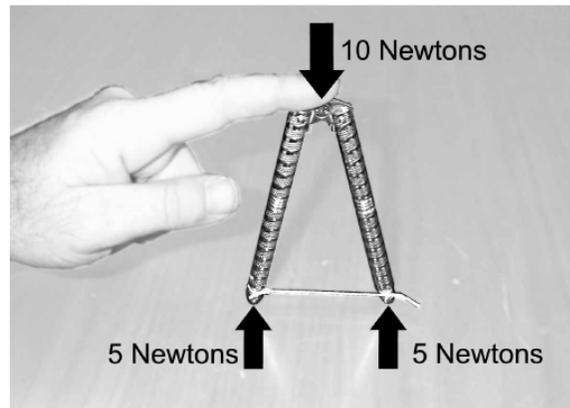
One of the most important learning objectives of this project is to understand how a truss bridge carries load. But what exactly is a "load," and what does it

mean for a structure to "carry a load?" To answer these questions, we will need to introduce some basic concepts from physics.

Forces

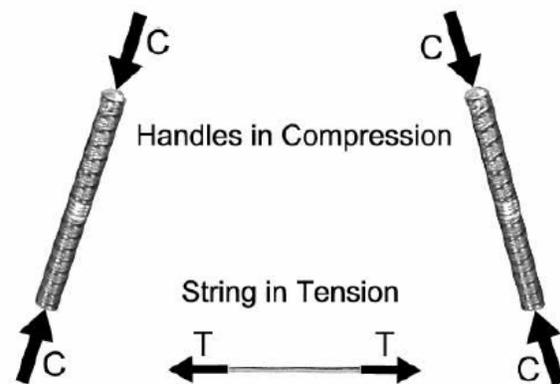
Much of structural engineering deals, in some way, with the concept of *force*. A force is simply a push or a pull applied to an object. A force always has *magnitude* and *direction*. When a truck crosses a bridge, it exerts a force on the bridge. The magnitude of the force is the weight of the truck, the direction of the force is downward. Bridges designed to transfer these downward forces to supported ends of the bridge.

A nutcracker can be used as a model of a bridge. If a string is tied across the legs, the nutcracker can transmit a downward force applied in at the top. This force is transmitted to the tabletop as compression as it travels through the handles of the nutcracker. Some of the force is also transmitted as tension through the string tied between the legs. This keeps the handles from moving apart when a force is applied from the top.

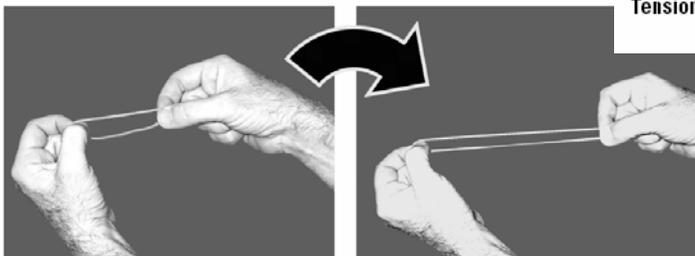


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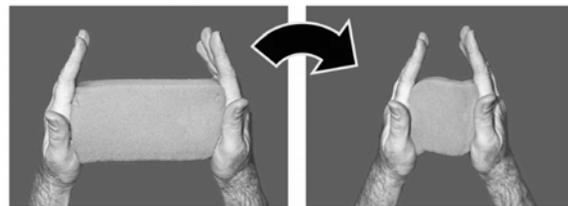


Tension and compression in the nutcracker truss.



Here is an example of a rubber band in tension.

Here is an example of an sponge in compression. (Note the effects of compression on materials)

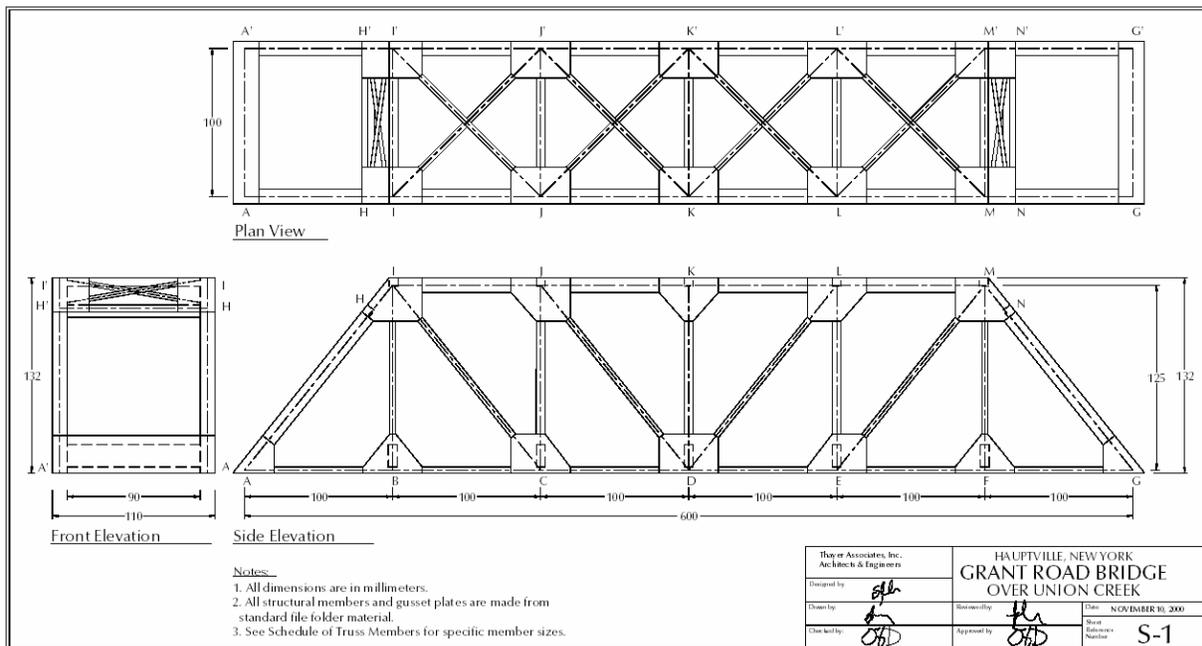


Designing Your Bridge

Since you are building your bridge out of manila file folder cardboard, you need to know that cardboard can carry tremendous amounts of tensional forces, but limited amounts of compression. File folder cardboard must be shaped into tubes in order to adequately carry compressional forces. Strips of cardboard are more than adequate to carry tension.

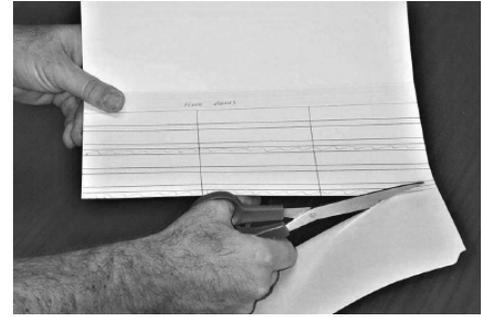
Download the computer-aided design program at: <http://bridgecontest.usma.edu>.

Install the software on a pc and design a single-span truss bridge. (Design #1 of the sample bridges). Run the test program on the design and observe the color of the bridge members. Red members are in compression and must be constructed as tubes of cardboard. Blue members are in tension and can be crafted as simple cut strips of cardboard. Print out your design and then redraw it in a scaled up version that is more than 11" in length. Another way to generate a 1:1 scale diagram of your bridge truss is to photocopy it using the enlarge feature on the copier. Your bridge design must be longer than a sheet of paper, so copy it on two papers and tape them together. (11")

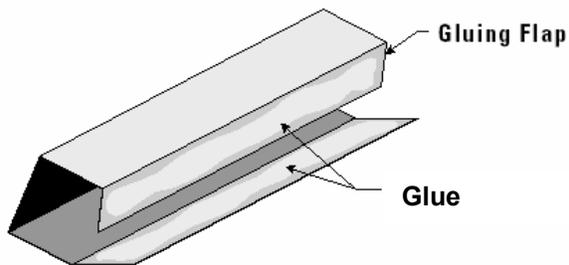


Tube Members

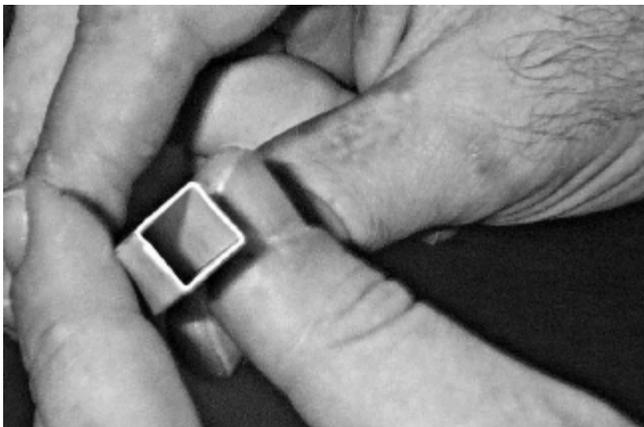
Tubes are made from a manila file folder by cutting it into rectangles. Using a pencil, divide the rectangles into 5 parts, 4 for each side of the tube and 1 for a glue flap.



Crease the cardboard with a ruler and fold the cardboard along your pencil lines. Glue the last two flaps together to complete the tube.

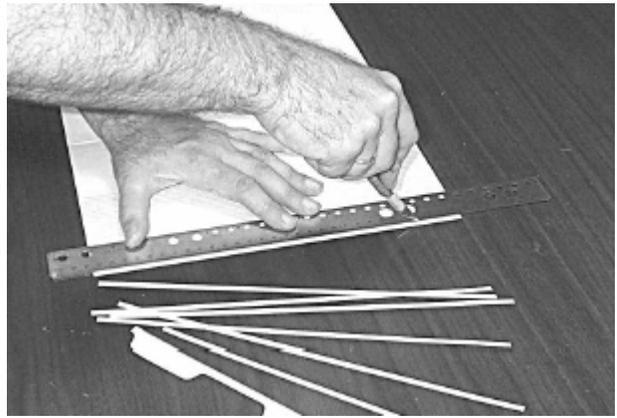


After folding and gluing the cardboard into a tube, be sure to flatten it while the glue is still wet. Press it so that the glue flap side is up as show in the picture on the right. This process insures that the tubes are straight and not curved in shape. After the glue sets up a bit, open the tube back into its hollow shape as shown below.



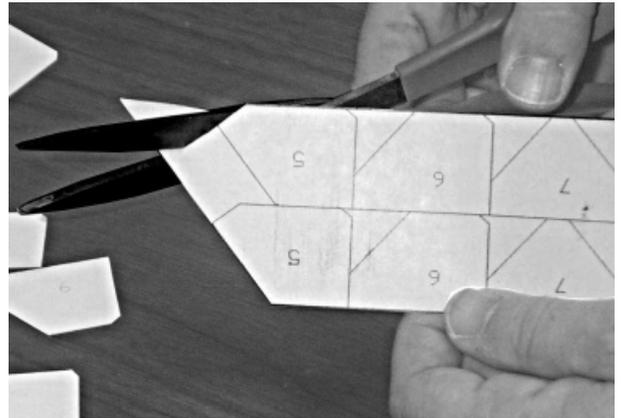
Tension Bars

Bridge members in tension are easily constructed from narrow strips of file folder. (about 1/4" wide)



Gussets

The bridge elements need to be joined to something that insures a strong joint. Gussets provide enough gluing surface to make the joints stronger than the bridge members themselves. Gussets can be simple rectangular strips about 1"x 3/4".



Construction Tips

It helps if you make a scale drawing of your bridge. Cover the drawing with waxed paper, then layout the gussets over the joints. The bridge members are then glued directly to the gussets. You can cut the bridge members to length by simply using scissors.

