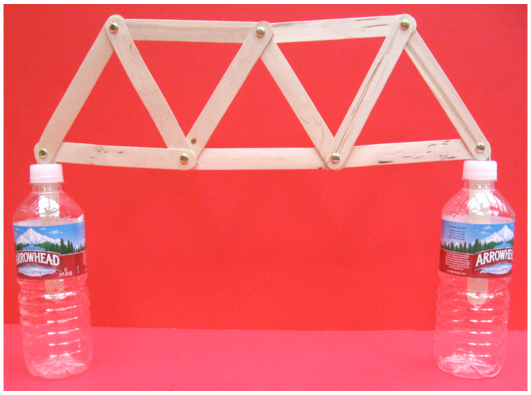
Truss Model

Compression and Tension: Push and Pull in a Truss



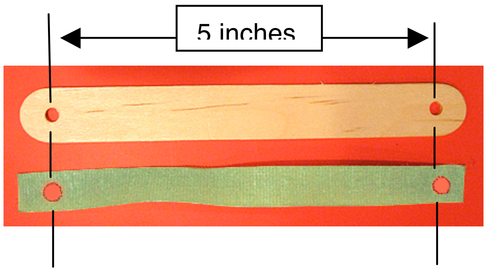
In this activity you will build a truss model with rigid wooden members, and then test it to see that it works. You will then replace wooden members of your choice with members made from flexible material (e.g. velcro garden strapping, or strips of manila file folder material), and again test the truss to see if it still works.

Materials

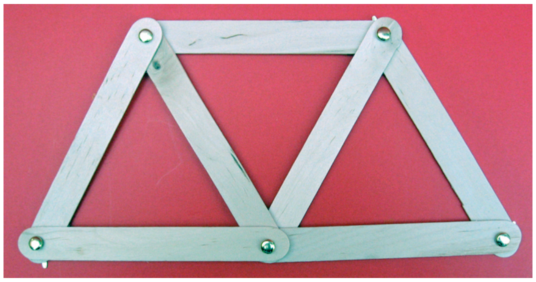
• 11` wood craft sticks, jumbo (tongue-depressor size, not popsicle-stick size) -- you only need 11 if you aren't going to build the bottle supports
• 6 pieces of flexible material 6 inches long and 1/2-3/4 inches wide -- velcro plant tie strapping will be used in this activity -- strips cut from a manila file folder also will work
• 3/16 inch drill bit
• 7 brass fasteners, 3/4 inch
• 2 plastic cups, 7 ounce (other items can be used to improvise supports, e.g., 500 mL plastic water bottles with caps, books, etc.)
• (optional) 2 plastic water bottles, 500 mL and 2 additional craft sticks
• (optional) utility knife

Assembly

1. Drill two 3/16 inch holes in each wooden stick, as shown in Figure 1. (The craft sticks shown are 5 7/8 inches long, and the holes are drilled 5 inches apart (center-to-center) -- adjust as necessary if you have different size craft sticks so that the holes are near the ends, as shown.) All sticks should be drilled as much alike as possible.



2. Use a single hole paper punch to punch holes in the velcro straps, 5 inches apart. Again, see Figure 1.



3. Use 7 sticks and 5 brass fasteners to build the truss model shown in Figure 2.

Figure 2

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To Do and Notice

1. Test the truss as shown in Figure 3a, by pulling lightly down on the bottom middle joint. NOTE: Rest the **ends** of the truss near the **edges** of the cups, so that the end **joints** of the truss are being supported rather than the truss members themselves. Do **NOT** have the supports under the middle of the members as shown in Figure 3b.

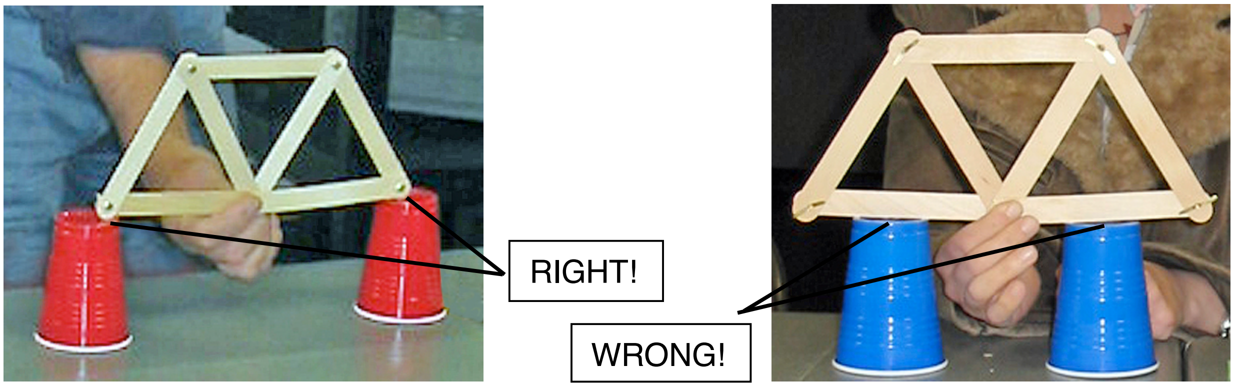


Figure 3a **Figure 3b**

3. Lay the truss model flat on the table, and replace as many of the rigid wooden members with flexible members as you think will still allow the truss to bridge the span, rather than collapsing.

4. Place the truss on the supports and test it as was done previously. Did the truss work? Determine the maximum number of wooden members which can be replaced with flexible members, and which members these are. This can be done by continuing your own experiments, or by combining your results with those obtained by others, and drawing a conclusion. If the group results are still not conclusive, and you think further testing is warranted, you can continue to experiment until you feel confident in your final conclusion.

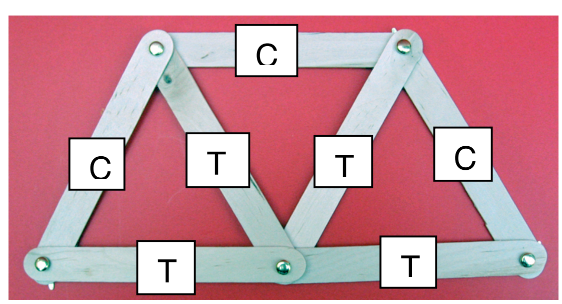
What's Going On ?

When the ends of a member are being pushed toward each other, the member is in compression. When the ends are being pulled away from each other, the member is in tension. Rigid wooden members can act in either compression or tension. You can either push or pull on the ends of a wooden stick, and it will successfully resist the forces without collapsing. Flexible members can act in tension, but will collapse under compression. You can pull on the ends of a flexible member and it will resist the forces, but when you push the ends together, it collapses very easily.

Some of the members in a truss are in compression and some are in tension. Those that are in tension can be made from flexible material. In a real truss, this might correspond to using a steel cable rather than a steel beam. One reason why this might be desirable is that the cable might be much lighter in weight than a suitable beam, and this could be an advantage in design and economic considerations.

Figure 4 shows which of the members are in tension and which in compression for the truss tested above (assuming that the load is applied straight down at the bottom middle joint).

Figure 4



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Going Further

• Use 4 additional sticks and 2 additional brass fasteners to expand the existing 7-member truss to the 11-member truss shown in Figure 4. Repeat steps 1-4 in the To Do and Notice section, except this time apply the load at joint A, as shown by the arrow in Figure 5.

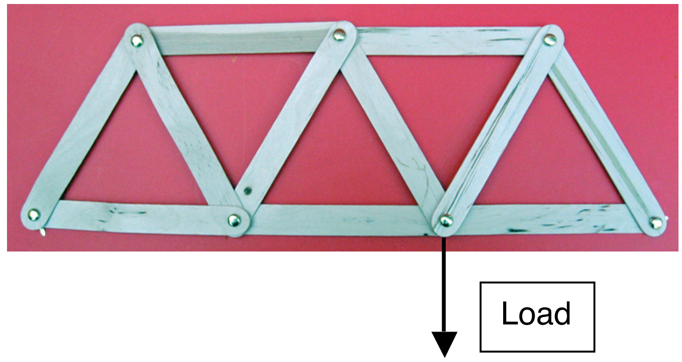

Figure 5

• Check your results with both the trusses you have made by using **Bridge Designer**, located at **www.jhu.edu/~virtlab/bridge/truss.htm** . This is a website that allows you to very easily create a truss on screen, apply a load, and calculate the forces in the members, including determining whether the members are in compression or tension. Very simple to use.

• If you would like to support the truss model for testing or display without having to hold it, you can make stands from 500 mL plastic water bottles as shown in Figures 6a-6f. Use a utility knife to cut the slits in the cap. For more stable supports, fill the bottles partly full of water.

Figure 6a

Figure 6b

Figure 6c

Figure 6d

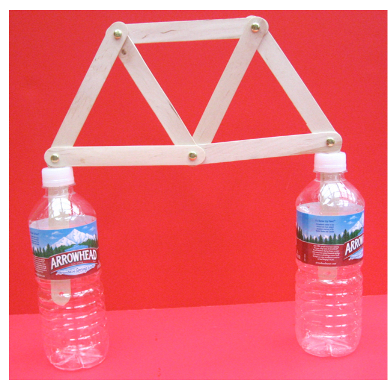

Figure 6e

References

The Art of Construction, Mario Salvadori, Chicago Review Press, 1990. Chapter 12 of this book is titled Strings and Sticks, and uses tongue depressors and brass fasteners to investigate truss models in a way similar to what you have done in this activity. See also **www.salvadori.org/aoc/** . Also see other books by Salvadori and several co-authors (e.g., Why Buildings Stand Up, Why Buildings Fall Down, etc.).

Physics Texts. Many first-year college physics texts have sections or examples dealing with mathematical truss analysis as an application of force vectors in static equilibrium. See, for example, Serway & Beichner, **Physics for Scientists and Engineers**, 5th Edition, Saunders College Publishing, 2000, p.371, Application: Analysis of a Truss. (Truss analysis examples can also be found on the web.)

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