Lab Project #3: Truss Bridge Challenge

The CHALLENGE: Design and build a truss bridge with the greatest strength-to-weight ratio using the materials outlined below.

BEHIND THE CHALLENGE: Students will need to think about the best way to hold the most weight without using a ton of materials to do it, because the more materials you use, the lower your ratio is. The best way to accomplish this is by not only relying on the strength of the materials, but to think about the geometry of the design so their bridge will be strong in the right direction.

The strength-to-weight ratio is a measure of how efficient a material or structure is at performing what it was designed to do. In this lab, we'll be calculating this number by building a bridge and testing it by loading it (this is the strength of our bridge) and then dividing it by the mass of the bridge. The muscles in your body have a strength to weight ratio: if a man weighs 200 pounds and can lift 250, his strength-to-weight ratio is 250/200 = 1.25.

MATERIALS:

- Popsicle sticks 4 ½ x ⅜" (get a box of about 300), not tongue-depressor size
- Hot glue (low temperature, kid-friendly) with glue sticks
- Bucket (1 or 5 gallon) for loading bridge with weight (we'll use water)
- Kitchen scale (measuring in grams)
- Bathroom scale (for measuring in pounds or kg)
  or use known weights (like a 10 lb bag of flour or 12 lb dumbbell weights…)

CONDITIONS:

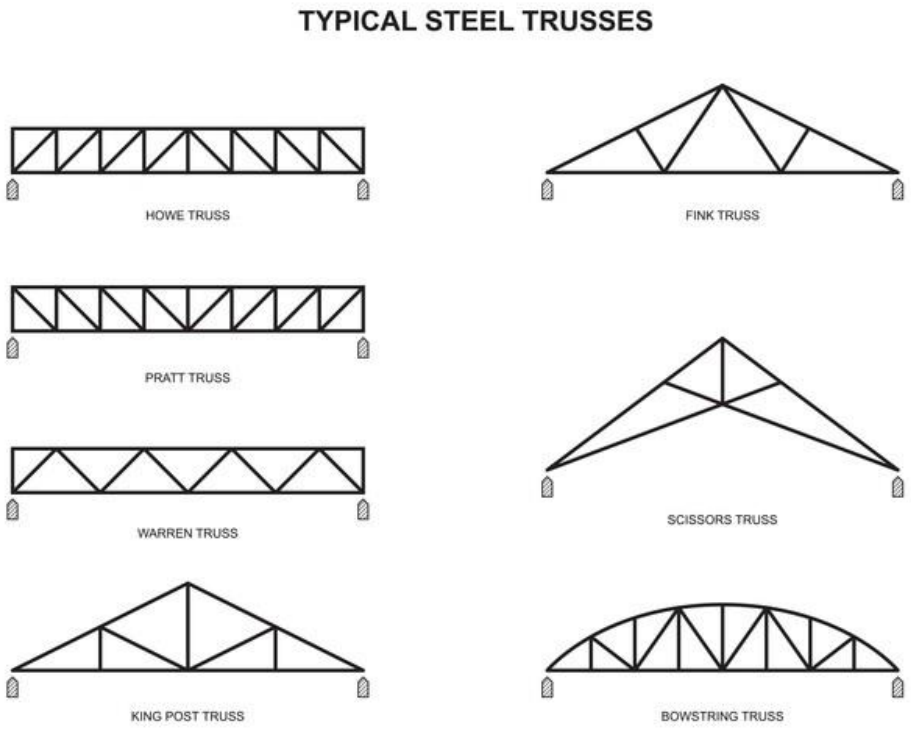
- Bridge must span at least a 17" gap between two flat surfaces
- Bridge must contain a continuous roadway capable of allowing a *Hot Wheels* or *Matchbox* size car to roll across completely without falling through
- Bridge may not be attached to the flat surface in any way
- Bridge may only be supported at the endpoints of the bridge (no additional supports may be added)
- You may only use the materials outlined above (no tape, no string…)
- Sticks can be cut, sanded, trimmed or colored

The winner of the ASCE 2022 Popsicle Stick Bridge Competition (bridges spanned 24" gap) had a bridge weight of 287 grams and a load of 222.6 lbs! (Note: the main difference between this competition and our lab project is two things: we are spanning smaller 17" gap, and we are using hot glue instead of white glue so you can build the bridge faster.)

PROCEDURE:

Before you start building your bridge, you might want to create smaller "test bridge" sections so you can try out your design. By creating sections intended for loading (until they break), you can study how they broke and how the bridge's geometry changed just before the break.

As you create your bridge design, think about different geometric shapes, and which is strong in the direction you need it to be. Here are a few samples used by engineers when designing roof supports and structures from steel:



What geometry do you think will increase your bridge's strength when a load is applied? Where do you think your bridge will be the weakest under load, and what can you do to improve the design? Sketch out and write your ideas here:

STEPS:

1. Design and create your truss bride to span a 17" gap.
2. Make sure your bridge is not attached to any surfaces. I should be able to pick it up and move it easily to a new position.

3. Weight your bridge (in grams):_____

4. Figure out the best way to apply a load to your bridge. Pay attention to where you will be applying your load and make sure it's where you want the forces applied.

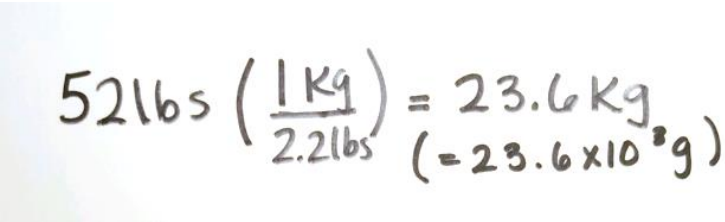
   FOR THE BUCKET WEIGHING METHOD:

   a. You can hang an empty 5-gallon bucket around your bridge. An empty paint bucket usually weighs 1-2 pounds.

   b. When ready, start loading your bridge. If using the bucket method, slowly start to fill the bucket with water. When the bridge starts to lean, creak or buckle, stop the water and weigh the bucket. This is your *load weight.* A full bucket (to the brim) is just about 50 pounds.

THE MATH:

If you measured your load weight in pounds, you'll need to convert your number to kilograms (kg) using this conversion: 1 lb = 2.2 kg. Here's an example calculation:



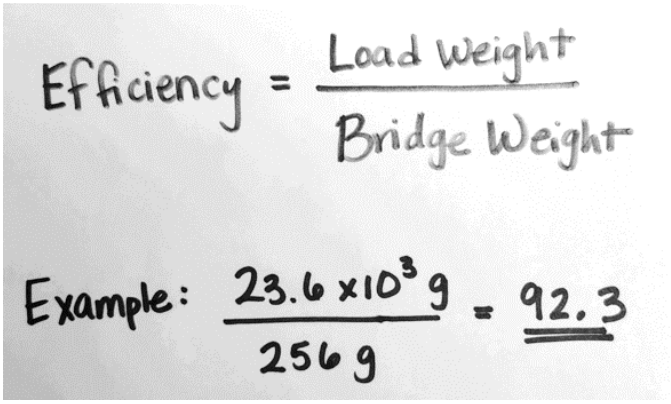
How many kg does your bridge hold?

Now let's calculate the strength-to-weight ratio for your bridge.

This is a measure of how efficient your bridge is at performing what it was designed to do.

In this lab, we'll be calculating this number by building a bridge and testing it by loading it (this is the strength of our bridge) and then dividing it by the mass of the bridge.

Let's do this now:



What is your bridge efficiency?

Use the graph paper below (or your own if you prefer) and construct a drawing of your bridge before you tested it. You can use graph paper or the blank space below.

FINAL THOUGHTS: If you have more time to spend on this project, what are two recommendations that you would seriously consider as design improvements in order to double the strength-to-weight ratio / efficiency?

Write and sketch your ideas below: