MESA Day Lab Book 2021

ENGINEERING LAB BOOK REQUIREMENT TEMPLATE

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School: Fairfax Senior High School

Center: UCLA MESA Center

MESA Project: Civil Structures

Level: 9/10th grade

1. Identify the Problem

What is the challenge being worked on?

The challenge is to create a bridge made out of balsa wood that can withstand the most pressure while made out of weak materials and remaining light-weight at the same time. The objective of this project is to create a strong engineering design that is able to achieve the largest strength-to weight ratio.

What are the limits/constraints?

The constraints placed upon us are the material prohibitions of stronger and better quality wood and glue as well as the limits for measurement, angle, weight, and gluing limits of the bridge.

- ➢ Measurement
  - Maximum width= 10 cm
  - Maximum length= 40 cm
  - Maximum height= 21 cm
  - Minimum span= 25 cm
  - Minimum clearance= 10 cm
- ➢ Weight
  - Maximum weight= 95 grams
- ➢ Angles
  - Minimum of 30 degrees
- ➢ Gluing
  - Maximum of glue 3mm away from joint
  - Joints must be at or within ¼ inches of the members

How do you think you can solve it?

The problem can be solved by creating a strong design for the weak materials while staying within all the constraints. Testing different prototypes and designs would allow for the creation of a well built bridge. A strong center of mass would also allow the bridge to withstand greater weight as well.

2. Explore

Find out what others have done (research). Clearly list at least 5 sources using MLA citation format (web pages, articles, books, etc.).

Identify (cite) and describe each source with one or more sentences.

Source 1

Citation: Types of Bridges

Stratosphere, Home. *18 Different Types of Bridges*, 15 Sept. 2020, www.homestratosphere.com/types-of-bridges/.

Description: This source explains many types of bridge designs and how each one can be used. This source moderately helped our group to create our own unique bridge design. Our bridge looks analogous to a single story construction, trust, or cantilever bridge.

Source 2

Citation: Why is a Triangle a Strong Shape?

Science, Let's Talk. *Why Is a Triangle a Strong Shape?*, 17 Aug. 2020, letstalkscience.ca/educational-resources/backgrounders/why-a-triangle-a-strong-shape.

Description: This site explains the strength of triangles for bridges, how they are used, and how the triangles are affected in different various bridges. This gives us the basis on which to begin our project and inspiration of such triangles.

Source 3

Citation: [Geometric Concepts Found in Bridges]

Elrod, Jennifer. *Geometric Concepts Found in Bridges*, 2 Mar. 2019, sciencing.com/geometric-concepts-found-bridges-8711435.html.

Description: The website goes in depth of the geometric concept found in bridges such as triangles, symmetry, connector plates, etc. This further explains the use and necessity of triangles in bridges.

Source 4

Citation: [Which Kind of Bridge Is Stronger]

Kroll, Jess. *Which Kind of Bridge Is Stronger: Arch or Beam?*, 2 Mar. 2019, sciencing.com/kind-bridge-stronger-arch-beam-8430815.html.

Description: The website compares strength, weight distribution, advantages, and disadvantages between arch and beam bridges. This source helped our group get a headstart to know what to consider when it comes to building bridges as superior and strong as possible.

Source 5

Citation: How Bridges Work

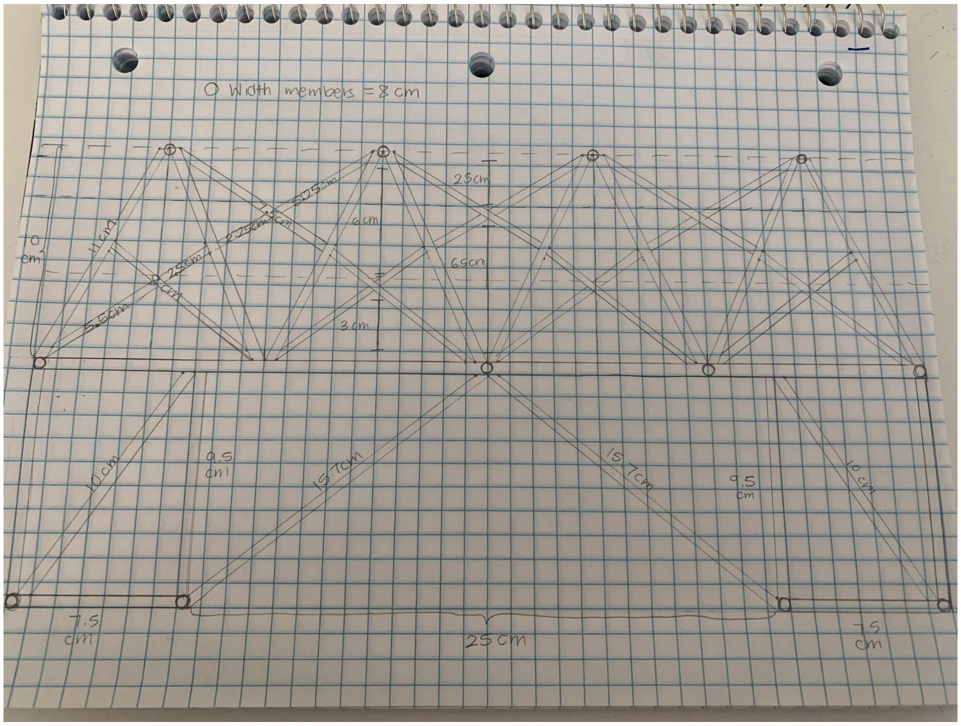
Woodford, Chris. *How Bridges Work*, 16 Oct. 2020, www.explainthatstuff.com/bridges.html#:~:text=They%20do%20it%20by%20carefully,at%20either%20side)%20and%20piers%20(.

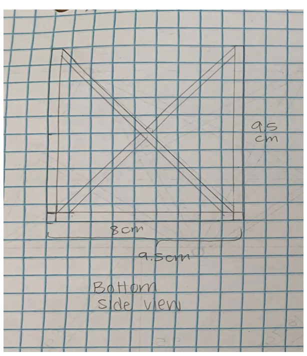
Description: This source explains the fundamentals of bridges. It stresses the wonder of bridges, how bridges balance forces, bridges through history, types of bridges, how to design bridges, bridges in harmony, and why bridges collapse.

3. Design

Brainstorm ideas (at least 3) and record them. Write 2-3 sentences describing your idea. Make sure to Include a sketch or drawing for each.

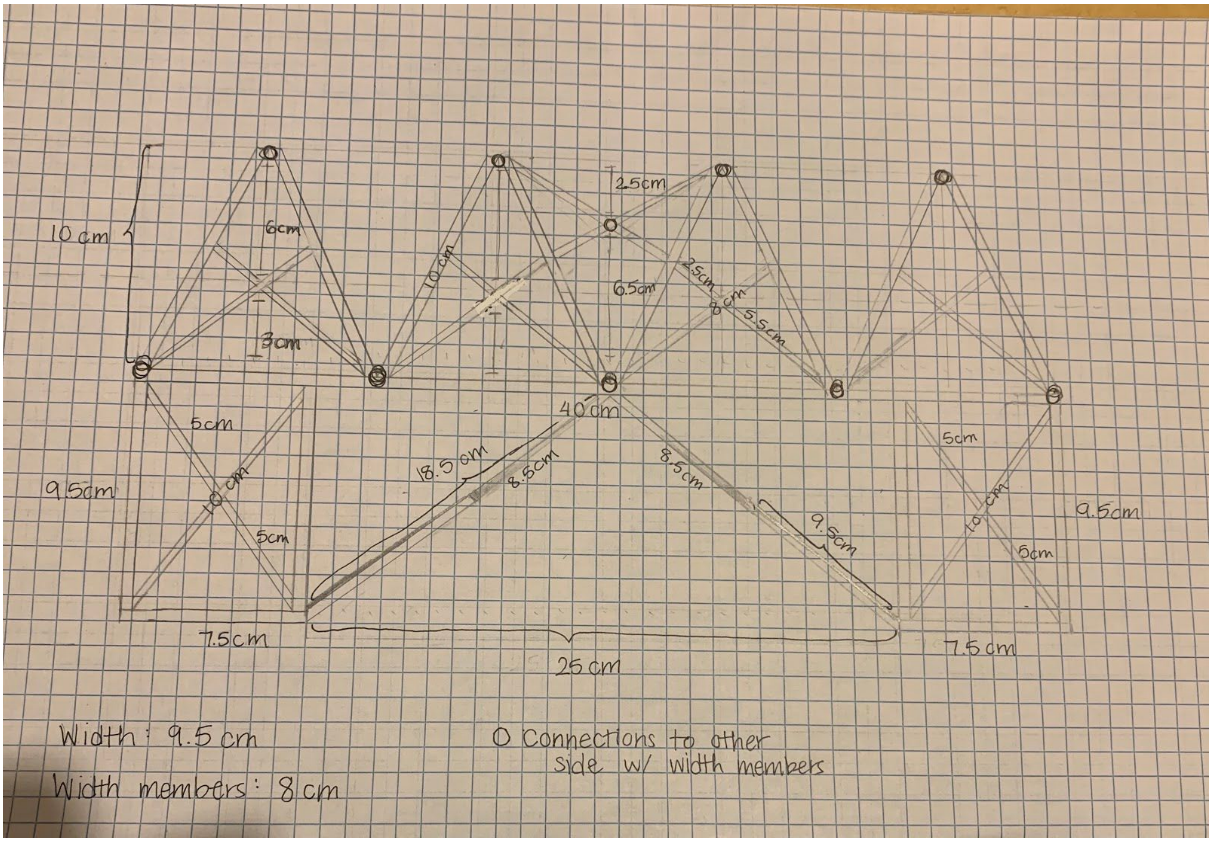
Idea #1

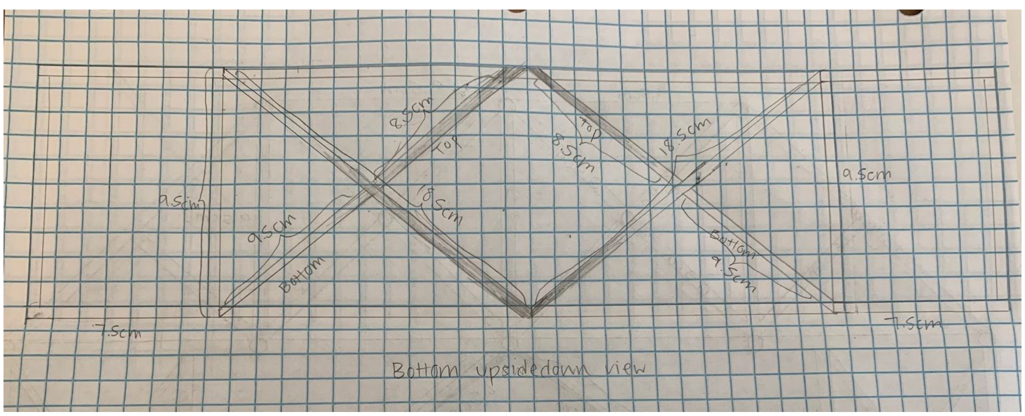


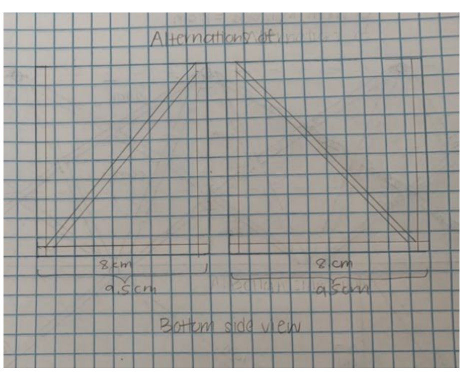


This design focuses on a stronger top half while the bottom design is more simple. This design would be ideal for a hydraulic press testing with the usage of strong triangular figures in this design. The circles represent the areas where the two identical faces would be glued together with 8 cm members of balsa wood. The side view of the bottom is given to show the four perpendicular balsa wood X's that would create greater support for the side to keep the stronger and heavier top half stable.

Idea #2



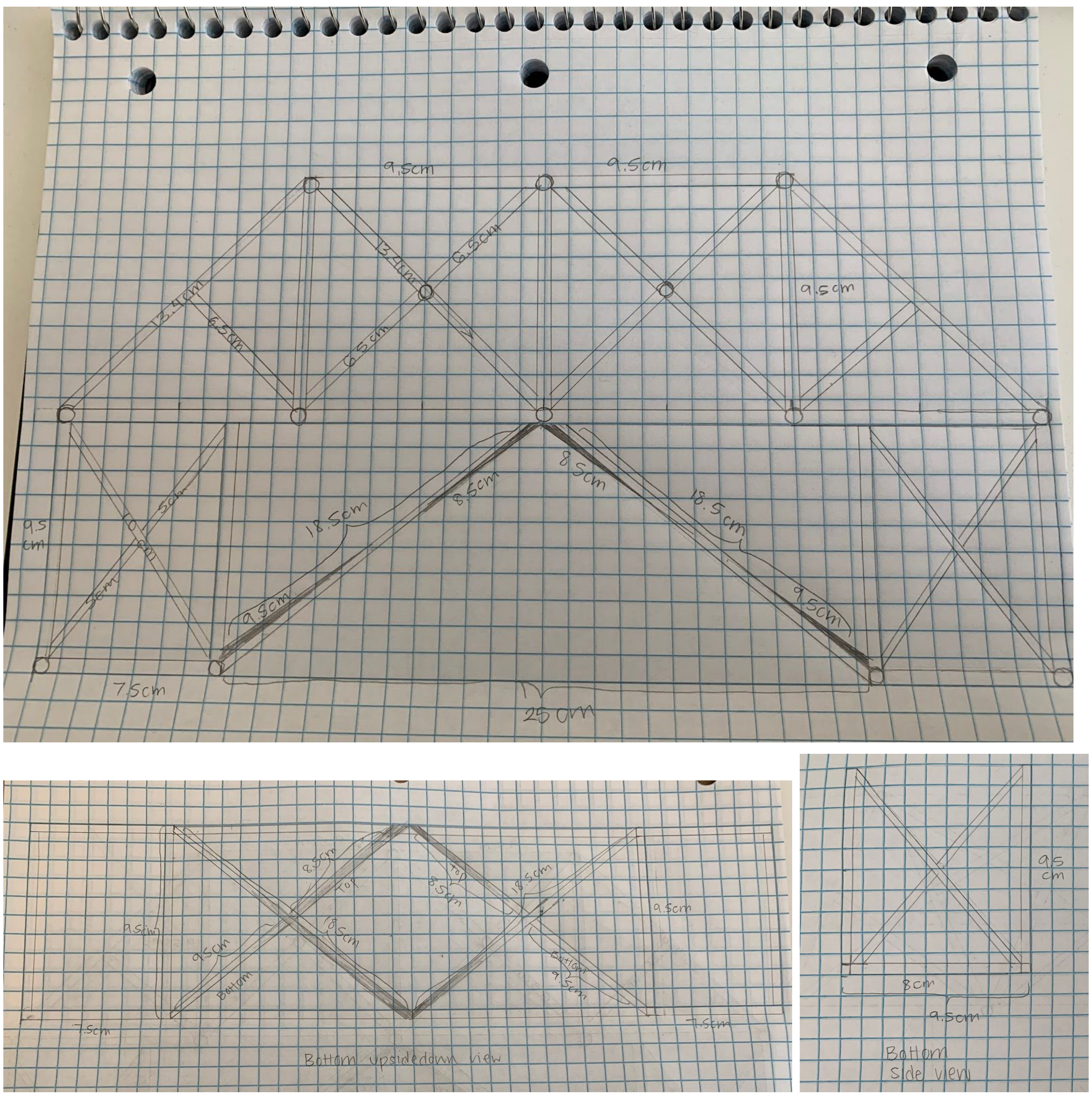




Idea 2 consists of a simpler top of Idea 1 but with the difference of the bottom members from 0cm to 9.5cm. The X figures in the rectangles of the far left and right differ from the ones in the first idea. The middle supports in the 25 cm span also differ since they give a three-dimensional support

instead of the two dimensional supports in the first Idea. The circles show approximately where the bridge would be connected with the other identical side of it.
Note: There are also 4 more width members not shown in the sketch at the bottom

Idea #3



This idea is based on a simpler bridge that would make it more lightweight than the others and relatively strong. The design still remains similar to the others except that the top is made with right triangles instead. This allows for a more weight distributed bridge allowing the bottom more support.

Select one of the 3 ideas above and describe a plan for building it (at least 5 sentences).

We selected to build Idea #2. A pencil will be used to indicate the measured pieces of balsa wood and cut angles. To build it, we will use small blades to cut up the wood at the appropriate angles. All alike pieces will be held together and evened out after they are all cut. The graph paper will serve as a template to make sure all triangles are as alike as possible. The ruler and protractor will make sure the project stays in competition constraints at all times. During the gluing stage, tape will be used as support to hold members together until they fully glue, then the tape can be discarded. The bridge will be built from the top down with the main triangles cut and glued first. The two faces of the bridge will then be glued together, the bottom supports will then follow. The vertical bottom members will be glued one by one horizontally on the table to the base to make sure they all hold a 90 degree angle and correctly match the top part of the bridge. The 6 angled middle supports will be added last.

Generate a list of materials for the prototype.

- ¼ by ¼ inch balsa wood sticks
- Bottle of elmer's glue
- Blades
- Tape

- ❖ Graph paper
- ❖ Pencil
- ❖ Ruler
- ❖ Protractor

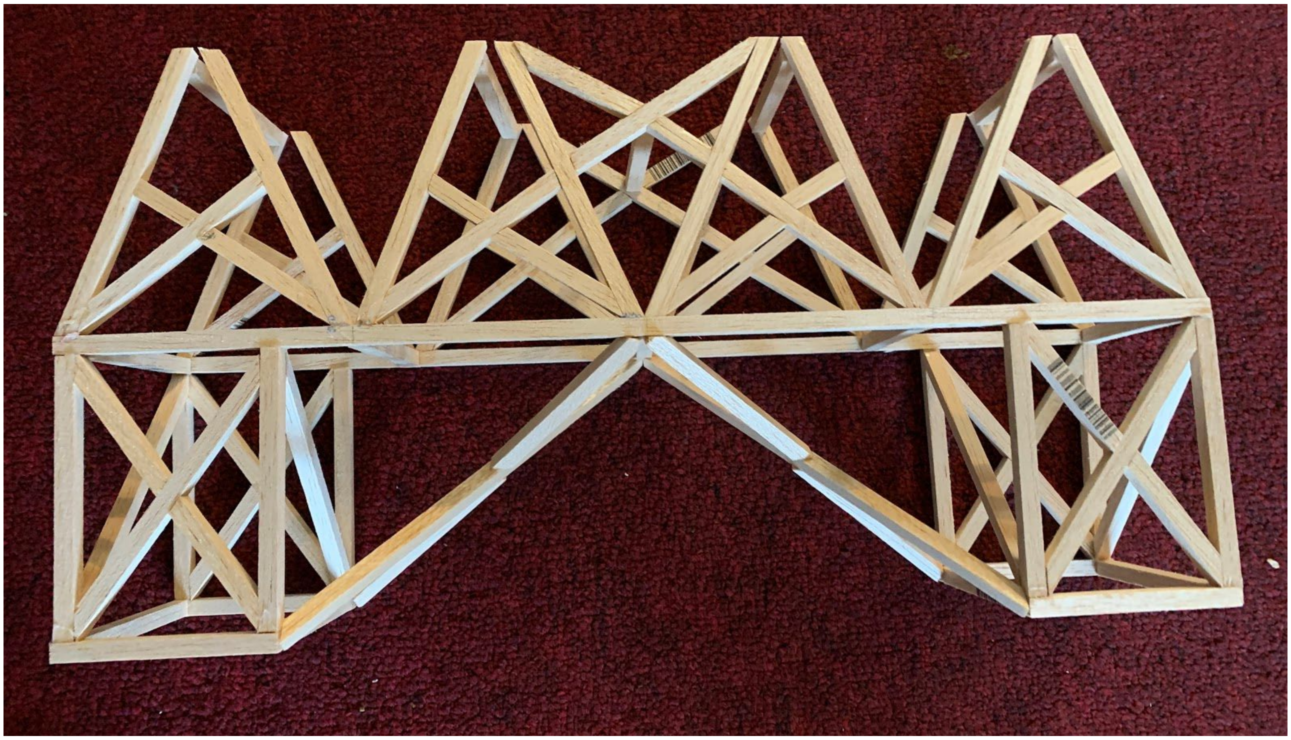
4. Create

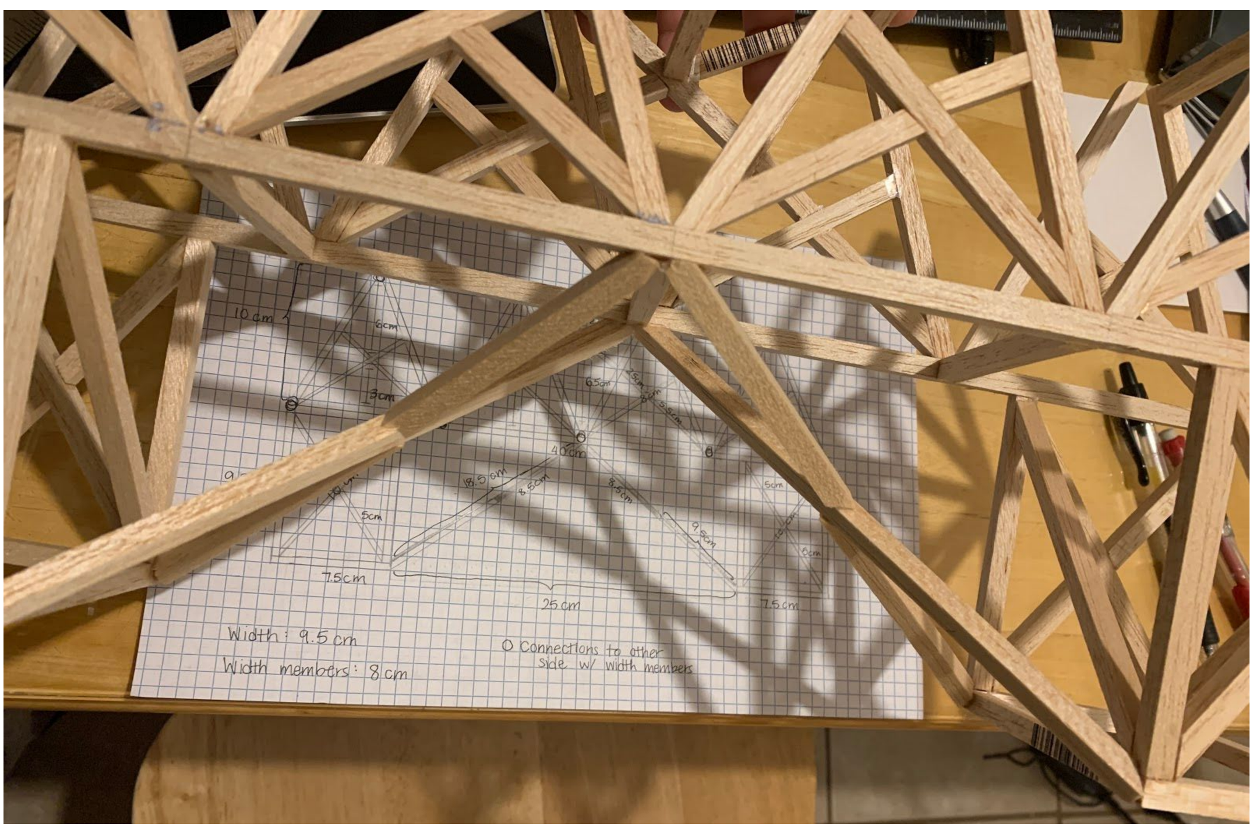
Using your plan, build your prototype. Describe how the prototype was built in at least 5 sentences. Include a picture of the actual project prototype built.

The prototype was built as described before with all the materials listed above. There were groups of members held together then cut as a group to try to get a uniform length and angle cut. Other pieces and graph paper were used as templates and traced to make the member length and angle cut more accurate. Because of the difficulty at cutting at an angle, some pieces had to be discarded and used later as smaller pieces. The two main faces of 40 cm with 10 cm length and width triangles were used as templates to match each other. Tape held down the two faces of the bridge to create an even surface. To create the bottom supports of the bridge, each member had to be glued individually while waiting for the other to dry. The most difficult part was creating the middle vertical supports since they create a three dimensional "x," severely complicating angle cutting. It took a decent time to figure out the appropriate angle and wasted material. Some pieces of the bridge had to be cut out and reglued because they either did not meet competition constraints, or were lopsided or glued incorrectly. The glue was very difficult to contain at most points since it would drip. Blades or pieces of paper were used to scrape off the excess glue. The contents of

the faces of the bridge were created first, assembled, then the two were combined with width members. After this, the two bottom supports were made, attached, and then the two middle supports were added.

Prototype Images





5. Try it Out

Test your idea/prototype. Describe at least 3 trials/attempts. Use tables/charts as needed.

Test #1

Criteria: How much weight can the bridge hold

Results: The bridge supported more than what was originally predicted therefore the first trial did not test its true limits. More books were added after this segment. The weight of these books are 17.81 pounds.

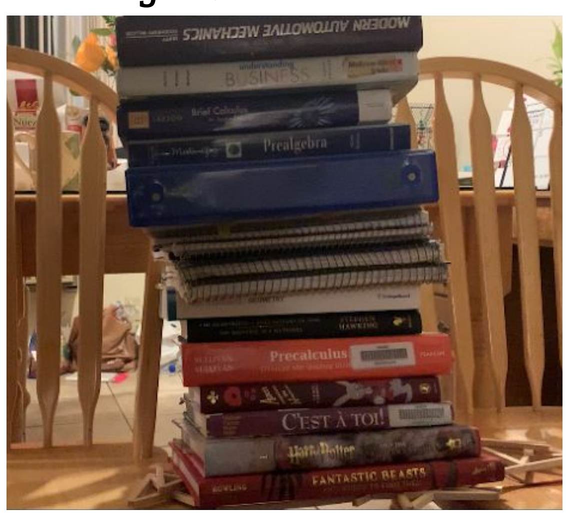
Test #2

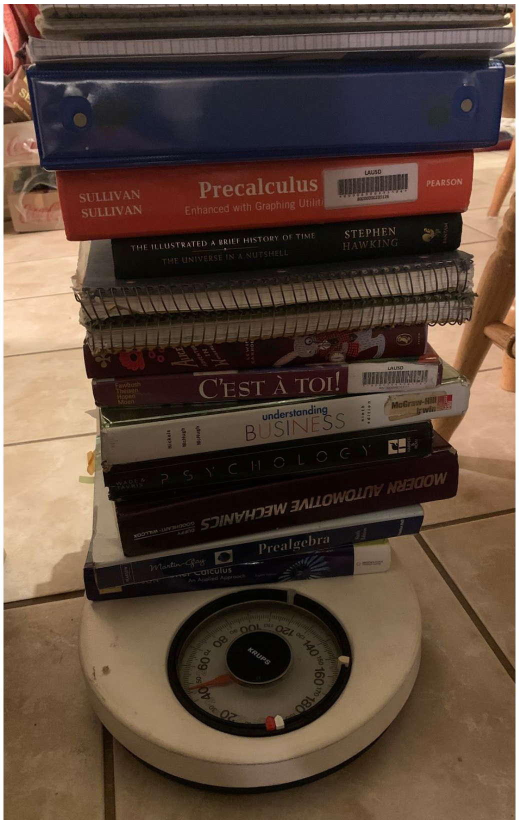
Criteria: How much weight can the bridge hold

Results: The total number of books placed in this trial cannot be seen by the camera since it yet again exceeded the expectations of the books it was able to support. The estimated weight it supported in this trial was 28.09 pounds.

Test #3

Criteria: How much weight can the bridge hold




SULLIVAN
SULLIVAN
Precalculus
PEARSON
THE ILLUSTRATED A BRIEF HISTORY OF TIME
THE UNIVERSE IN A NUTSHELL
STEPHEN HAWKING
C'EST À TOI!
understanding BUSINESS
PSYCHOLOGY
MODERN AUTOMOTIVE MECHANICS
Prealgebra


KRUPS
120
140
160
180
100
80
60
40
20


yoobi


PSYCHOLOGY
MODERN AUTOMOTIVE MECHANICS
understanding BUSINESS
Brief Calculus
Prealgebra
LARSON
Precalculus
C'EST À TOI

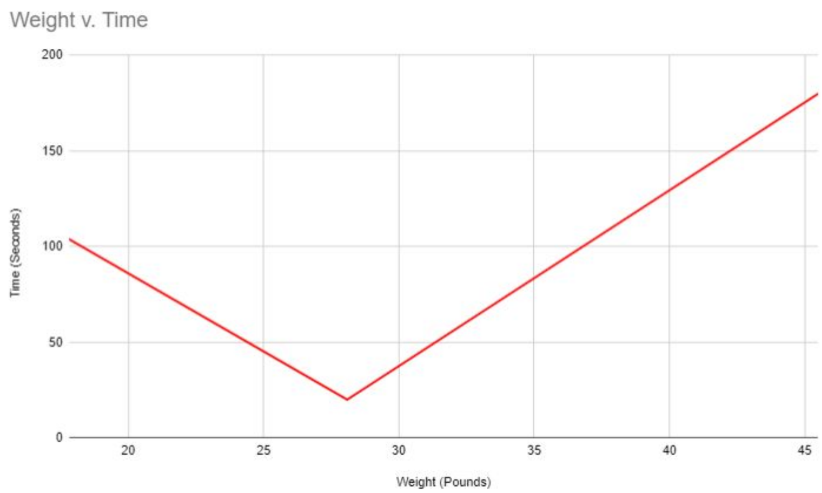
Results: This is the final trial in which the prototype completely collapsed under the weight and pressure of the books. Positioning the books strategically proved to be difficult as well as to not create too much unbalance, this resulted in the prolonged exertion of weight to the bridge, creating a dilemma in where the bridge was not able to reach its true potential as it would under competition testing. The final two images show the bridge after it broke. The last image shows in more detail which parts of the bridge broke and which ones stayed intact. The point of major failure that collapsed the entire bridge was when one of the long 40cm members snapped in half, while the majority of the Xs were able to remain intact. The pictures above also depict the scale, weight, and height of the books supported by the bridge. The bridge supported 45.5 pounds in this trial.

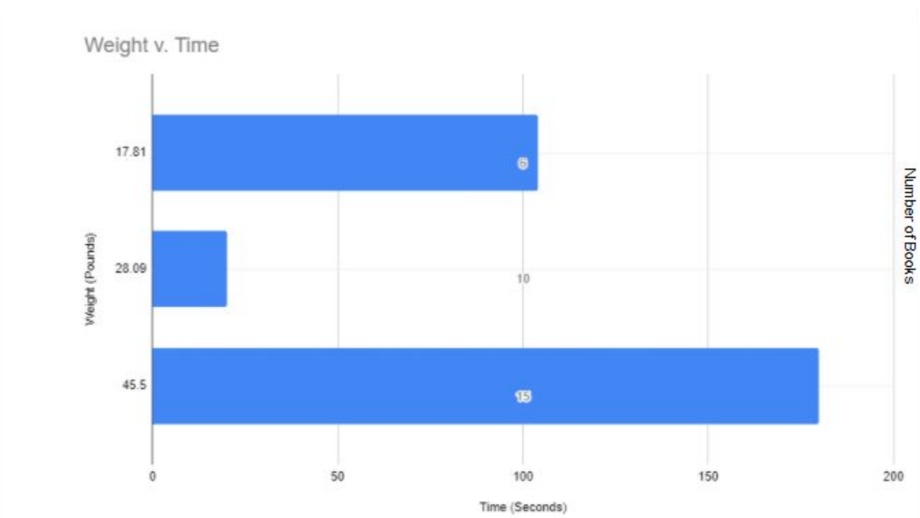
Notes:

- This is all the same prototype
- The images of the intact bridge were all taken from the same video
- The sum of the trials (first book placed until the bridge collapsed) lasted 6 minutes and 37 seconds
- Books were removed and rearranged a few times

Graphs and Tables

Place graphs and tables which provide information in your device. All graphs, charts and tables MUST be created in Microsoft Excel or Microsoft Word.





Trial	Time	Weight	Books
Test #1	1 min 44 sec	17.81 pounds	6 (hard cover)
Test #2	20 sec	28.09 pounds	10 (hard cover, notebooks, paperback)
Test #3	3 min	45.5 pounds	15 (All)

Use of mathematical concepts/equations:

Applicable math concept/equation (state concept/equation):

a^2 + b^2 = c^2 (pythagorean theorem)

How was the concept/equation used? (Demonstrate use of concept/equation as it pertained to project):

The pythagorean theorem equation was used in order to find the exact lengths of the member lengths. However, since this equation is only used for right triangles (triangles that have a 90 degree angle), it was used for the bottom portions of the bridge. A vertical and horizontal member at the bottom would be the a and b for the pythagorean theorem. This would then mean that (7.5)^2+(9.5)^2 is approximately 12.1 cm.

Note: The actual members would have to be shorter than this since the theorem does not account much for the angle the members need to be cut at.

Applicable math concept/equation (state concept/equation):

The mathematical concept we utilized are the angles of triangles. This is where all three angles add up to 180 degrees.

How was the concept/equation used? (Demonstrate use of concept/equation as it pertained to project):

Knowing the angles of the triangle can help us estimate which sides are going to be longer than the other. This concept can also help figure out if the lengths are equal. If we know that two angles of the triangles are congruent, this will mean the sides that correspond to that side will be equal to each other. This is also known as the isosceles triangle as we use it as the basis of our project. The angles also help make sure the bridge and all of its pieces are as precise as possible.

Applicable math concept/equation (state concept/equation):

Another math concept we can apply are triangle congruence postulates.

How was the concept/equation used? (Demonstrate use of concept/equation as it pertained to project):

The triangle congruence postulates are used to indicate if two triangles are congruent. There are five postulates called the SSS (Side Side Side), SAS (Side Angle Side), ASA (Angle Side Angle), AAS (Angle Angle Side), and HL (Hypotenuse Leg). All the postulates except HL can be used in any kind of triangle. Only the HL postulate works for the right triangle. If the hypotenuse is congruent to another right triangle, then the triangles are congruent. Another example using SSS, when all sides are congruent to the three sides of another triangle, the two triangles are congruent to each other. The postulates apply the same way as their corresponding postulate names. This is used in our project to check that all measurements and angles are as symmetrical and identical to the other triangles and parts of the bridge. The usage of these postulates enable less time spent measuring each individual angle.

6. Make it Better

How can you make the project better? What modifications do you plan to make (state at least 5)?

<u>Modification/Improvement #1:</u> The project can be improved by cutting the angles of the members more precisely. This would allow the members not only to fit better together but also to create a more uniform alignment, strengthening the design.

<u>Modification/Improvement #2:</u> Softer balsa wood members will be used either as the smaller pieces or be excluded from the project altogether. Though this would add to the weight slightly, it would also increase the effectiveness of the bridge and make the members slightly easier to cut.

Modification/Improvement #3: The time of the gluing stage will be increased and monitored. Instead of leaving wrongly glued lopsided pieces, they will be cut up and reglued accordingly.

Modification/Improvement #4: An increased amount of tape will be put into use to allow the accurate placement of the members even if they yet remain slightly lopsided during gluing. It will also allow for the protection of the other members if a portion of the bridge is used as a template for the other members to be glued in the same format.

Modification/Improvement #5: The width portion of the legs of the bridge is to have a slight change in the direction the members face. The two middle members are to be facing the same direction, while the outside members are facing the opposite direction of the middle two, but facing the same direction as each other. (Can be seen by comparing the prototype and finished project.)

Modification/Improvement #6: Instead of cutting alike members consecutively and putting them all together at the end, the main 10 by 10 triangle will be created and glued right after for a more uniform appearance and better fit.

Build and prepare a competition ready project. Include a picture below. Show different views of your project (top view, side view , front view etc)