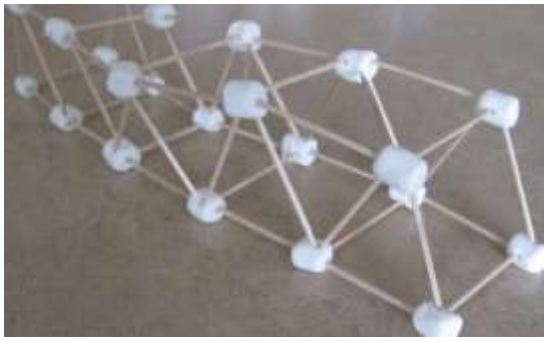
STEAM Subject: Engineering
Lab: Marshmallow and Toothpick Bridge

Grades: 5-8

Learning Objective:
Students will practice engineering concepts about bridges construction.



Engage:
Ask students the following questions:

- What is the purpose of a bridge? *To connect two places so that people (on foot, car, or any other transportation) can travel a shorter distance in a shorter amount of time*
- What are the important considerations that engineers must have when designing bridges? *What will be crossing the bridge - people, trucks, cars, etc., the type of bridge that is needed for the project - suspension, beam, etc. (these will be discussed later), other outside forces such as wind and other natural phenomena*
- Do you know of any bridges that have failed? How has that affected society? *Here's a video that shows 10 different bridge failures:* *https://www.youtube.com/watch?v=KRtefycRGdE*

Explore:
Activity Engineer your own bridge!
Students will build bridges using marshmallows and toothpicks and then test how strong their bridges are.
Materials (per student):

- Mini Marshmallows (30 max)
- Toothpicks (30 max)
- A lightweight cup (ex. Styrofoam)

- 2 chairs/tables/textbooks
- Paper and pencil
- Small coins (pennies and dimes)

Here is an example of a bridge that students built and tested (they use textbooks as their load but it's the same idea): https://www.youtube.com/watch?v=qGOssUKQXls

Procedure:

1. First, draw a design for your bridge on paper. After you have drawn a few designs, choose the design that you think will be the strongest and will hold the most force.
2. Using the marshmallows and toothpicks, construct a bridge about one foot long. You may only use up to 30 marshmallows and 60 toothpicks.
3. Allow your bridge time to set once you are done. While you wait, take a guess for how many coins you think your bridge will hold until it starts breaking.
4. Place the two chairs/tables/textbooks a little less than one foot apart. These objects represent the shorelines that your bridge must span. Place the bridge across the span.
5. Put the cup on top of the bridge in the middle. Add one coin at a time until your bridge begins to buckle. Then count the number of coins that are in your cup. That is your load limit!

Improve your design:

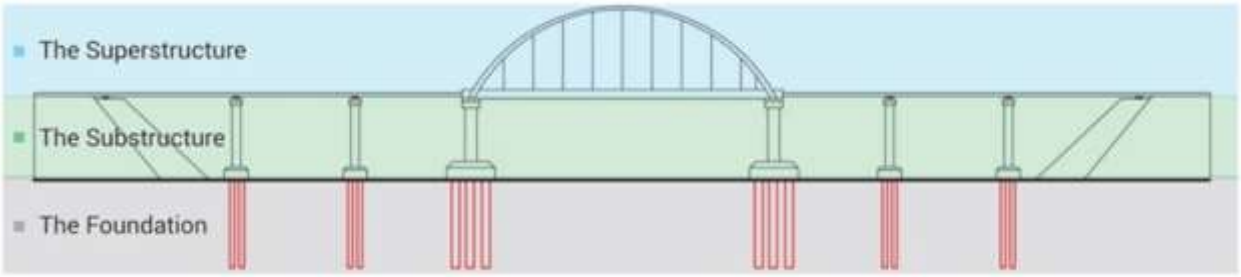
- What are some of the shapes that you see in your bridge design?
- What changes can you make to your bridge to make it sturdier?
- Did your final design look like your initial design? If not, what changes did you make and why?

You can make this a competition! Have a friend or a family member build another bridge and see which bridge can hold the most weight (the higher number of coins). Share a picture with EIS on Facebook and Instagram!

Explain:

- What are the main components of a bridge? The main components of a bridge are the foundation, sub-structure, and the super-structure. When building a bridge, the construction starts with laying the foundation. Then the sub-structure

is made to give support for the heavy super-structure above it, which is actually used as the road or walkway.



Here is a video of real engineers in their process of designing bridges: https://www.youtube.com/watch?v=-yLZYETYlmM

- Review the Engineering Design Process and answer the questions in the gears about bridge design:

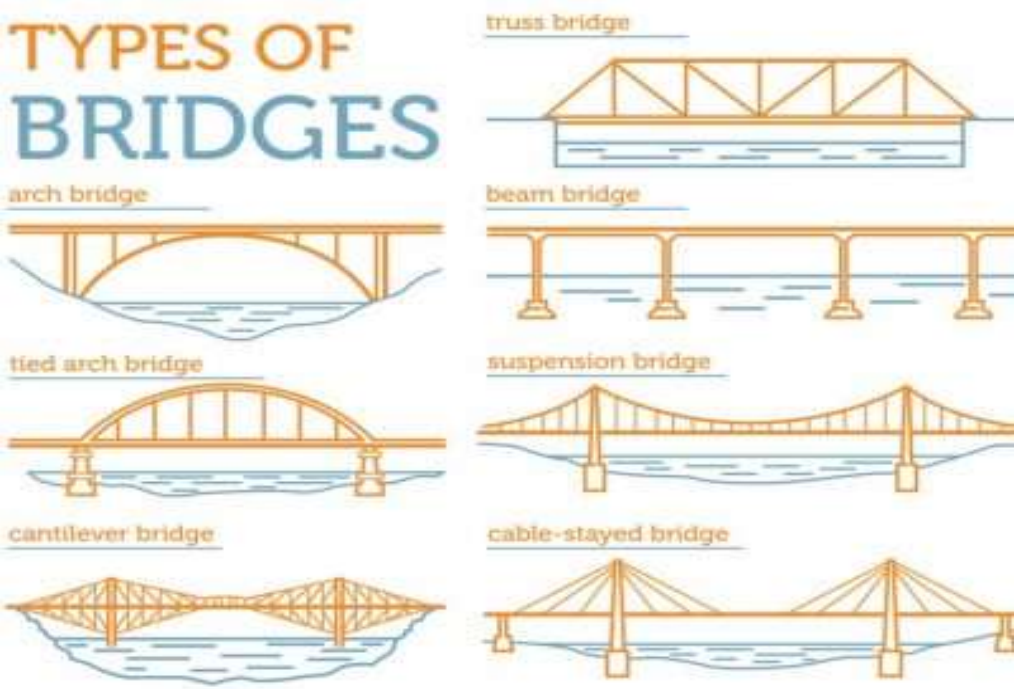
<u>Engineers Consider for Bridge Design:</u>

a. Where is this bridge being built?
b. What is around this area that would affect this bridge?
c. What will the bridge be used for? (people, cars, trucks, etc.)
d. What type of bridge is best for the specific needs? (arch, beam, etc.)
e. What material should be used?
f. Will there be any natural phenomena that need to be considered?
g. What forces and loads will be exerted on the bridge? (use mathematical equations)

- What makes a bridge strong?

Watch video: https://www.youtube.com/watch?v=oVOnRPefcno

- What are the 3 basic designs of bridges?
    - **Arch:** distributes the load across the arch
    - **Beam:** simplest kind to build, its load is distributed across numerous posts underneath the deck
    - **Suspension:** carries the load of the deck from above, using towers and cables



Review Engineering Vocabulary:

- **Civil engineer:** an engineer who designs and maintains roads, bridges, dams, and similar structures
- **Force:** any action applied to an object which would cause the object to move, change the way it is currently moving, or change its shape
- **Load:** the weight or force on a joint, connection, beam, column, etc.; the biggest engineering factor when designing any structural element
- **Tension:** a force that pulls materials apart, this occurs on the bottom of the bridge
- **Compression:** a force that squeezes materials together, this occurs on the top of the bridge

- **Buckling:** occurs when the compressive forces overcome an object's ability to endure compression
- **Snapping:** occurs when the tensile force surpasses an object's ability to handle tension

Elaborate:

Learn fun facts about bridges!

- World's Longest Bridge: Danyang-Kunshan Grand Bridge in China (over 100 miles long)
- World's Tallest Bridge: Millau Viaduct in France (343 meters high)
- World's Oldest Bridge: Slab-stone bridge in Turkey (850 BC)

Evaluate:

Think about the bridges that we have here in San Diego. Not just the famous ones but maybe smaller ones that are not so familiar. Imagine you are a civil engineer for the day. What kind of bridge would you create and where would it go in San Diego? Draw it on a piece of paper! Share your ideas and your marshmallow bridges with EIS!