Condensed Lesson Plan (for day-of)

Engineering vocabulary:

- Structure: set of connected elements that forms a system that can support an external weight
- Freestanding: able to remain upright without additional support
- Rigidity: resistance to bending
- Strength: resistance to breaking

Time	Length	Description
3:15pm	~10-15 min	Introduction
3:30pm	~ 5 min	**Part 1: Exploring common shapes & their stability** Key tasks: 1. Start with having students build 2D shapes (i.e. square + triangle). **Questions:** What are some shapes we can build? Which shapes are more rigid? Which one has more room to build more? 2. What 3-dimensional shapes can we make from these triangles and squares? (3-sided / 4-sided pyramid, cube, tent, pentagon, etc). Students can get creative here, there's a ton of shapes! **Questions:** Which ones are more rigid? Which ones are more stable? Finish with giving them 1-2 minutes to brainstorm their design
3:35pm-ish	15 min	**Part 2: The challenge! (I'll send a message out to the groups)** With the material that they have, try and build the tallest, **freestanding** tower! Students have 15 minutes to build. Feel free to help them throughout.
3:50pm-ish	15 min	**Part 3: Reassess + continue building** Have students share their towers. **Questions:** What worked? What did not? Some ideas that have worked for me: ● Multiple toothpicks per connection ● Creating internal triangles ● Having a wide base for your tower Give students additional 10 minutes to incorporate changes into their towers
4:05pm-ish	5 min	Part 4: Adding external weight Now, with a flattened roof, place the cardboard piece on top of their towers and slowly add pennies to the top (see how many they can withstand & hold)
4:10pm	5 min	Return to main room, have students share designs / strategies

Marshmallow challenge
(lesson adapted from https://www.crscience.org/pdf/Marshmallow_toothpick_challenge.pdf)

The goal of this lesson is for students to design and build the tallest tower possible with limited materials (and learn design/engineering principles along the way!)

Materials:

- Toothpicks (x 80) [can also do spaghetti noodles]
- Marshmallows (x 80) [can also do gum drops]
- External weight (x 50 pennies)
- NOTE: in the future, include some spaghetti to make reinforcing easier

Lesson plan
Part 1: Intro to civil engineering (10 min)

Let's build a skyscraper!

Introduce history of skyscrapers (progressively building bigger buildings [show examples in Seattle])

Engineering vocabulary:

- Structure: set of connected elements that forms a system that can support an external load
    - Can support its own weight AND external weight
- Rigidity: resistance to bending
- Strength: resistance to breaking
- Freestanding: able to remain upright without additional support
- Stability: the ability of a structure to withstand the load of undesirable movements

Revisit the design process:
Design Process Steps

1. Define: Find the need and define the problem.
2. Brainstorm: Come up with ideas.
3. Design: Select the most promising design you've created.
4. Create: Build a prototype of your design. What's a prototype?? Preliminary model that can be copied or improved. Why do we use these? So we can see if they work without manufacturing 1 million defective rubber duckies (test)
5. Test: Identify if there are failure points or modifications.
6. Improve: Optimize!

Communication!

Place students in breakout rooms

Part 2: Explore + the challenge (5 min)

Have students build different shapes with toothpicks and marshmallows. Key questions:

- What shapes can you make? (square, triangle, cube, pyramid)
- Which shapes are the strongest? Weakest?

Have students attempt to build the tallest structure they can with just the marshmallows and toothpicks. This is an excellent opportunity for students to attempt to come up with solutions as they go through the process of trial and error.

Some common build strategies that I came across:

- Reinforcing individual connections with multiple toothpicks
- Creating connections across a square (to make two triangles; this was a bit tricky, since the hypotenuse was a bit longer than the toothpick, but basically I took two toothpicks and merged them together using a marshmallow or two).
- Pyramids are better than cubes, but it takes more pyramids to build vertically

Part 3: Assess, re-design (15 min)

Have students share their towers. What parts of their design worked? What parts didn't work? How could they be improved? This is the perfect opportunity for students to learn from each other and combine their thinking to design/reinforce their structures. Continue building!

Part 4: Challenge! Withstand additional external loads (if there is time!)

In each kit, there should be a piece of cardboard and 50 pennies. If we have additional time (or if students want to try on their own at home), students can test the amount of weight their towers can handle. The cardboard is intended to be placed on top of their tower and serve as a flat surface for them to accrue pennies.

- This is a great extension if you have students who are looking for additional things to do

Outro:
Bring students back from breakout rooms and have them show their designs. In non-virtual years, it'd be great to have a group competition at the end, but for this year we can ask them some of the same questions as in Part 3 if there's time, and share one thing each group learned with the class.

https://www.youtube.com/watch?v=5SwpkT1khHc