Scaling Models
2024 NHERI Center for Geotechnical Modeling
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Summary-
Students will learn about the importance of the centrifuge when it comes to scaling smaller models to behave like larger real-world structures. They will model how the centrifuge scales up smaller objects using a cup and string and simulating how the spins occur with water.

Engineering Connection-
Centrifuge modeling is very important in engineering due to the fact that its costs less, has no human loss of life or injury, and has much more precise data acquisition than do on-site testing.

Audience-
Middle School (6-8)

Lesson Objectives-
Students will learn to design a rudimentary centrifuge that will allow them to learn about the scaling up that the centrifuge does to model real world structures. They will learn about the G's added to the model and how as the model spins, gravity stops being the only force applied to it.

Educational Standards-
MS.Forces and Interactions and MS.Engineering Design

Material List-
String, clear plastic cup, hole punch, food dye, a device that's capable of recording slow motion, water

Introduction-
Centrifuge testing is an alternative to on-site modeling for a multitude of reasons and gives precise data that is applicable to real world structures. This is done by increasing the gravity that the model feels during spinning, which as a result makes a smaller model scale "upwards in size" and feels the same stress that a much larger structure would feel in the real world. The smaller model behaves in the centrifuge the same as a much larger model, which makes the centrifuge modeling work for acquiring data.

Procedure-

- Explain how the centrifuge scales up the gravity, and scales down the necessary length the model must be. As a result, this makes the stress the model feel in the centrifuge to be the exact same as the stress felt by a larger structure in the real world. This is done thanks to centripetal force applied during spinning in the centrifuge, which behaves like increasing gravity, but this increased force is perpendicular to how the gravity is acting. A model can be shown with a person next to it and students can be asked how large this model is at 70gs. Field questions and then reveal in the next slide that it is the size of the football field.
- Have the students partner up and hole punch three evenly spaced holes around the cup, and have them feed one string into each hole, and tie each individual ring around its respective hole. Then bring all three strings that are tied on and tie them together in the middle, in a basket-like shape, with the strings carrying the cup. Then have water poured into the cup at around 1/3 of the height and put a drop of food dye into the cup.
- Have the students go outside, then have one student recording in slow motion. Have the other student begin spinning slowly, and gradually spin quicker and quicker. Make sure the student spins perpendicular to themselves, or parallel with the ground in a flat spin. Have the student start spinning slowly and gradually spin faster and faster until the spin is parallel with the ground or is 90 degrees from its original position. Once the student has reached the speed, have them slow it down again until they reach 0 m/s. Have the students switch and repeat.
- Have the students look over the video and see how the water and cup move around during the spin up and slow down

Assessment-
Ask them questions pertaining to what they felt when they were spinning up the cup, and if the cup began to be more difficult to hold on to. Ask them when they were looking at the video, what did they notice the direction the water went as the cup span up. Why did the water not pour out of the cup? Hint that centripetal force is what kept the water from falling out.

Wrap-up-
Have the students write some short questions about their experience and what they learned, ask them how they think this modeling could be helpful in the real world and any ideas they could have of different structures that could be modeled in the centrifuge.