TOWER CHALLENGE: CENTER OF GRAVITY AND BALANCE

OBJECTIVE: Students will learn about the center of gravity and analyze how it helps to make structures stable.

TIME: 45 minutes

MATERIALS: "Tower Challenge" student activity worksheet, electric fan, 10–15 small books, set of building materials for each group: 20 drinking straws, 4 paint stirrers, 10 Popsicle sticks, 4 paper-towel tubes, 2 sheets of cardboard, 10 rubber bands, masking tape

STANDARDS FOCUS:

Science (NGSS)

Science and Engineering Practices: Asking Questions and Defining Problems, Planning and Carrying Out Investigations, Constructing Explanations and Designing Solutions
PS2.A: Forces and Motion
PS2.B: Types of Interactions
ETS1.B: Developing Possible Solutions

Language Arts (CCSS)

SL1: Participate in collaborative discussions

Art (National Core Arts Standards)

VA—Cr1: Generate and conceptualize artistic ideas and work

Math (CCSS)

MP1: Make sense of problems and persevere in solving them

LESSON PLAN

1. **Classroom Demonstration:** Ask for one or two volunteers to come to the front of the class and stand with his or her feet shoulder-width apart. One at a time, place a lightweight chair roughly 6 inches in front of each volunteer. Ask them to try to pick up the chair. Instruct the rest of the class to observe the students' posture and movement. What, if anything, did the class notice about the students' bodies as they picked up the chairs? (They may notice that the students' hips pushed backward.) Ask the students: *Was it easy or difficult to pick up the chair?* (They will likely say it was easy.) Repeat the process, but this time have each student stand with his or her hips, legs, and heels flat against a sturdy wall. Ask: *What differences did they notice between the two trials?* (They will notice that it is more difficult to pick up the chair with their hips against a wall. They may feel like they are going to tip forward.)

2. **Discuss Forces:** Explain that the difference between the two trials has to do with the **center of gravity**. A person's center of gravity is located near his or her waist. If your center of gravity stays over your feet, you stay upright. But when you pick up an object in your hands, it adds weight to the front of your body—changing the location of your center of gravity. Normally, you compensate by moving your hips backward. This balances your total weight so that your center of gravity stays over your feet. When the students stood against the wall, they couldn't move their hips back to balance the weight. The center of gravity moved forward and they felt like they were going to tip over.

3. **Make Connections:** Ask students why engineers might need to consider center of gravity when building structures or other objects. (For example, buildings need to have the center of gravity located over the supporting base, a robot needs to keep its center of gravity over its support as it moves, etc.) What other factors might affect how well a building or object can stay upright? (Answers may include the strength of the materials used to build it, the size of the supporting base.)

4. **Build and Test Towers:** Hand out the "Tower Challenge" student activity worksheet. Break the class into pairs or small groups and have them use the worksheet to each build a strong tower. Prompt them to consider your classroom discussion as they plan their designs. After 5 minutes of planning time and 25 minutes of building time, test each group's designs. Discuss the results of the tests. Did each tower's center of gravity affect its stability? A tower with more weight on top (high center of gravity) will be more likely to tip over than one with a lower center of gravity. How did the tower's base size and width affect its stability? (In general, a wider base will be more stable.)

DIVE DEEPER WITH KOOV

When building with KOOV, understanding how different structures can balance is key. Several courses will guide students through learning about the structures that keep robots stable. Go to the KOOV Learning Course and open "Become a KOOV Block Artist." Complete Stage 2: "The 360 Connector and the Center of Gravity." Then move on to Stage 3: "Strengthening Boards," Stage 5: "How to Place and Balance," and Stage 6: "Objectives and Originality." Once they have completed the courses, challenge students to experiment with a changing center of gravity by adding movable parts to their creations. Can they keep their creations balanced even while they're moving or changing shape?

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TOWER CHALLENGE

Follow the steps below to design and build a tower. Your tower must be able to stay standing when wind blows on it and should be able to support a large weight.

DESIGN REQUIREMENTS:
Your goal is to build a tower that can stay standing even with powerful winds and which can hold as many books as possible. You may only use the given materials to build your tower. Your tower must be at least 40 centimeters (15 inches) tall.

BUILDING MATERIALS:
20 drinking straws, 4 paint stirrers, 10 Popsicle sticks, 4 paper-towel tubes, 2 sheets of cardboard, 10 rubber bands, masking tape

PLAN YOUR DESIGN: Spend 5 minutes planning your tower design. To the right, draw a model of your tower, labeling the building materials you will use.

BUILD YOUR DESIGN: You have 25 minutes to build your design.

TEST YOUR DESIGN: Compare your design to those of your classmates. Which do you think will stand up the longest?

WIND TEST: Place your design on the table 60 centimeters (24 inches) from the electric fan your teacher set up. Tape the base of your tower to the table. Tape only the side farthest away from the fan. Observe what happens when the fan is turned on low speed. Does the tower sway? Does it fall over? Increase the speed of the fan to medium. Observe what happens when the speed of the fan is increased to medium.

STRENGTH TEST: Place a thin book or magazine on the top level of the tower. Observe what happens. Does the tower begin to bend? One by one, add additional books or magazines until the tower begins to bend or break. How many did it hold?

EVALUATE YOUR DESIGN: How did your tower compare with those of your classmates? What features did the strongest towers have?

Think about the results of your tests. How would you change your design to improve it?