Bottle Balancing Beam

Center of Gravity Demonstration

Introduction

A gymnast falls off a balance beam. A football player gets knocked over by a lineman. A ballerina can't complete a twirl. A painter falls off a ladder. Center of gravity can be more than just an abstract concept!

Concepts

- Center of gravity
- Stability
- Balance

Background

According to Newton's laws of gravitation, the Earth attracts every tiny particle of mass of every object and pulls them toward the center of the Earth. For any specific object, the *center of gravity* of the object is the point where all the individual gravitational forces acting on the individual particles add up and result in one net force. It is the point where we can assume all of the mass of the object is concentrated. For irregularly shaped objects or moving objects, the center of gravity at a particular moment may be critical for balance and stability. The location of the center of gravity is critical for the overall stability and balance of an object on the Earth's surface.

As an object's mass shifts, its center of gravity also changes. If the center of gravity is positioned over an object's base of support, the object will be balanced. If an object's mass shifts in such a way as to move the center of gravity beyond the base of support, the object will be unstable. The position of the center of gravity of an object is important in determining its stability. An object with a broad base and with the center of gravity fairly low is more stable than an object with a narrow base and a high center of gravity.

Materials

Balance Beam (wooden board)*
2-L bottle with screw-on cap
Food coloring (optional)
Water, 2 L

**See* Preparation *section.*

Safety Precautions

This demonstration is considered safe. Follow all normal laboratory safety rules.

Preparation

Some trial and error may be needed to make the balance beam just right. A ½″ or ⅝″ piece of plywood, approximately 9¼″ long and 3⅝″ wide should work well. Cut one end at a 45-degree angle. Cut a 1½″ diameter hole centered about 3½″ from the straight end. Test with a 2-L bottle full of water (see Figure 1) and make adjustments with the angled end if necessary.

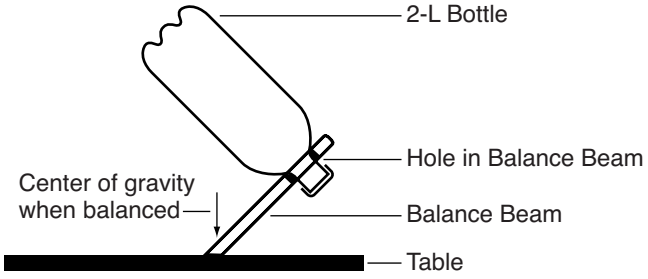

Figure 1. Bottle Balance Beam Arrangement

Procedure

1. Start by placing the empty bottle in the Balance Beam hole and trying to balance the apparatus on a flat, stable table top. When the bottle is empty, the apparatus will not balance and it will fall over.
2. Remove the empty bottle and fill it one-half full with water. *Optional:* Add a few drops of food coloring for better visibility. Replace the cap and place the bottle back in the Balance Beam hole. Try to balance it. Determine the location of the center of gravity relative to the base. *Note:* An approximation of the center of gravity may be determined by placing a fingertip under the upper end of the beam, exerting a slight upward force, and then sliding the finger as far down the

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beam as possible while maintaining balance. The lowest point where the slight upward force of the finger can just hold the apparatus in balance is the center of gravity.

3. Continue adding water to the bottle and testing it until the apparatus balances. When it balances, identify the fact that the center of gravity is directly over the foot of the base of the apparatus. Use a plumb line or other vertical item to visually line up a straight line above the base. Show that the mass is equal on both sides of the plumb line and that the resultant force is centered on the foot of the base of the apparatus.
4. When the bottle is balanced, use your hand and press down on the bottle cap. What happens to the bottle? Set the bottle back up, and this time press down on the bottom of the bottle. What happens to the bottle? Get the apparatus to fall in both directions and discuss what happens in terms of the center of gravity shift.
5. Discuss other items relative to their center of gravity. When a person is standing on two feet, where is his or her center of gravity? Where is the center of gravity when standing on one foot? What happens if the person's weight shifts and the center of gravity gets outside of his or her base? Why do football players in the line try to "stay low to the ground"?

Disposal

Dispose of water in an appropriate sink and save the apparatus for many repeat demonstrations.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter, understanding of motions and forces
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, motions and forces

Tips

- This activity is available from Flinn Scientific as a demonstration kit, Bottle Balance Beam (Catalog No. AP6376).
- The bottle should balance when it is full.
- This apparatus can also be used as an innovative density demonstration. Obtain two clean 2-L bottles. Take one bottle and fill it half full with clear water and the remaining half with blue kerosene. Tightly cap the bottle. The blue kerosene will float on top of the clear water. Next, fill the second bottle half full with water that has been dyed blue (try to match the color of the blue kerosene), and fill the remaining half with clear mineral oil. Tightly cap the bottle. The clear mineral oil will float on top of the blue water. Set up and display the Bottle Balancing Beam with one of the bottles. After a few days, replace this bottle with the second bottle. Do this when the students are not present. See how long it takes for the students to notice the color flip. This will initiate questions and discussion on density. At this point it may be beneficial to present both bottles to the students simultaneously. The bottles may be stored properly and reused for years. *Note:* Do not allow students to open the bottles—they contain flammable liquids. The caps may be glued onto the bottles to prevent opening, spilling, or tampering.

References

Thanks to Robert Farber, Central High School, Philadelphia, PA for sending this idea to Flinn Scientific.

Materials for *Bottle Balancing Beam* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP6376	Bottle Balance Beam—Demonstration Kit
V0003	Food Coloring Dyes
K0007	Kerosene, Blue
M0065	Mineral Oil

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.