Philadelphia Museum of Art

Physics at the Art Museum: Torque and Calder's Mobiles

In order to create his mobiles, Alexander Calder needed to use his understanding of torque and rotational equilibrium. In this lesson, students will use the Physics at the Art Museum app as a starting point to explore these physics concepts—as well as build an understanding how they allowed Calder to create his balanced mobiles. In addition, students will create a diagram of a mobile with three horizontal arms, and will explain why the design will achieve rotational equilibrium.

Grade Level

Grades 6–9

Common Core Mathematics Standards

- CCSS.Math.Content.4.MD.A.1

Pennsylvania Academic Standards

- 9.1.8.A.1. (Art)
- 9.2.8.A. (Art)
- 3.2.8.A1 (Science)
- 3.2.7.B1 (Science)

Art Images Required

The Philadelphia Museum of Art website includes several images of the Calder mobile installed in the Great Stair Hall. Click on the title below to view high-resolution photographs on the Museum website. Images that are also available in the Artstor Digital Library are indicated by an ID number or search phrase.

- *Ghost*, 1964, made by Alexander Calder
  Artstor: Ghost and Diana

Ghost, 1964
Alexander Calder (American, 1898–1976)
Metal rods, painted sheet metal
Length: 34 feet (1036.3 cm)
Weight: 225lb. (102.06 kg)
Purchased with the New Members Fund, 1965 1965-47-1

Lesson Objectives/Essential Questions

1. What is torque?
2. How are the concepts of torque and rotational equilibrium demonstrated by Calder's mobile?

Suggested Vocabulary

torque	kinetic
gravity	equilibrium

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Materials

iPad with Physics at the Art Museum app
meter sticks, rulers, or wooden dowels
scale or balance (suggested)
small weights or clay
strings and/or clips to suspend ruler so that it can rotate freely

Lesson Process (before exploring the app)

1. Have students examine images of Calder's mobile *Ghost*. (Be sure students can see that the white discs are attached to crossbars and have students note the positions of these.) Discuss how the pieces are arranged. What do you notice about the size of the pieces and their positions?
2. Ask a student to volunteer: give them a ruler or yardstick that is suspended from a string at its center and hanging horizontally. Place a small piece of clay or weight on one end of the ruler and observe. What happened to the ruler after the clay was added? Why?
3. Explain that the ruler is initially balanced because the force of gravity is pulling down on each end equally. The ruler does not rotate downward at either end, and therefore shows **rotational equilibrium**. The addition of clay to one end increases the pull of gravity on that end and the ruler rotates downward. This tendency of a force to rotate an object is called is called **torque**.
4. Have another student come forward and apply a larger piece (twice the size) of clay to the other end. Is the ruler once again horizontal? Adjust the distance of the clay from the center string so that the ruler is one again balanced. Note how size and distance from the center of mass can affect equilibrium.
5. Break the class into small groups (3 or 4 students each). Distribute rulers, string, and clay. Have students experiment with different sizes of clay and distances and take notes (or sketch) their findings. (If possible, use the scale or balance so that students can add precision to their discoveries.) NOTE: You may want to print copies of the *Rulers and Clay Student Organizer* appendix to this lesson plan.
6. Come back to Calder's mobile. Discuss how the students' discoveries about torque and rotational equilibrium are related to the construction of his mobile. (Each crossbar becomes its own balance, with its own center of mass. The balanced sections of crossbars are then assembled to more central crossbars—maintaining rotational equilibrium.) Be sure students can isolate and distinguish each of these crossbar sections.
7. Have students open the Physics at the Art Museum app. Direct them to the section on Torque and Calder's *Ghost*. They should follow through the steps in the app, responding to questions as they go.

Assessment

1. Basic: Draw a horizontal line on a piece of graph paper. Consider this the center rod of your mobile. Now indicate where you could place all of the following pieces so that the rod retains rotational equilibrium: two pieces with a mass of *X*, two pieces with a mass of *2X*, one piece with a mass of *3X*.
2. Advanced: Design your own mobile, using three or four crossbars and weights of your own choosing. Sketch and label the weights and their distances from the center of mass on each of their crossbars.

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Rulers and Clay Student Organizer

	Clay piece #1 Mass (weight)	Clay piece #1 Distance from the center of mass	Clay piece #2 Mass (weight)	Clay piece #2 Distance from the center of mass	Describe the balance of the ruler
Trial 1					
Trial 2					
Trial 3					
Trial 4					