CLEAN ENERGY BRIGHT FUTURES
A Program of BEF

Solar Mobile Design Challenge

Lessons 3: Exploring Center of Gravity

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DESCRIPTION
Since the concept Center of Gravity (mass) is a key factor in a mobile, students will participate in some activities to help them experience and understand this principle so it can be applied to their final Solar Mobile design. This lesson starts with a teacher demonstration of the discrepant event of a bird that can balance on its beak. Then students will explore center of mass with a meter stick and balls of clay giving them some hands-on experiences. In addition, students can work with various irregular shapes cut out of file folders and find the center of mass of an irregular shape. They can follow the same process as in Center of Irregular Things and find the initial center of mass for their aircraft.

GRADE LEVEL(S)
6, 7, 8

SUBJECT AREA(S)
Center of Gravity, Mass, Balanced Forces, Stability

ACTIVITY LENGTH
1-2 class period(s) (~55 minute class period) depending how in depth you would like your students to explore this topic.

LEARNING GOAL(S)

1. Students will observe a discrepant event and write down questions about what they observed.
2. Students will participate in a variety of activities using a meter stick in order to experience and learn about center of gravity.
3. Students will find the center of gravity of an irregular shaped paper object by using a plumb line.
4. Students will apply the concept of Center of Gravity and find the center of their solar aircraft that is to be used on their solar mobile.

CONTENT BACKGROUND

STUDENT BACKGROUND

Student background knowledge is not required for these activities.

EDUCATOR BACKGROUND

Educators should be familiar with

- Center of Gravity (Mass)

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Student Engineering Notebooks
- Lesson 4: Exploring Center of Gravity

CLASSROOM MATERIALS

- Balancing bird for Center of Gravity activity- https://www.teachersource.com/product/balancing-bird-demo/physics-
- 1 box of modeling clay divided into walnut size balls.
- Hand held hole punches (1 per table group)

ACTIVITY SUPPLIES (PER STUDENT)

- A meter stick for each student
- A small ball of clay
- File folder
- 50 cm of string
- Small dowel (10 cm) for string
- 2 washers (to be tied onto the end of the plump line string)
- Hand held hole punch (shared with table group
- Cut 20” X 30” foam board in half (Optional activity if you want to introduce the aircraft at this point- or this may be done with the final unit)

LESSON PROGRESSION

PLANNING AND PREP

- Prior to this lesson you will need to acquire a "balancing bird" for the initial discrepant event. https://www.teachersource.com/product/balancing-bird-demo/physics- is one source. There are many others to be found from other sources as well.
- Before going on to the hands-on activities, divide clay into equal pieces so that each student has a small ball to work with.
- Acquire as many meter sticks as possible so students can get a "feel" of the balancing meter stick.
- Cut file folders in half (old, used file folders work great)
- Cut string to 50 cm sections and tie to a small dowel.

LESSON SEQUENCE

PART 1 – DISCREPANT EVENT

1. **(10 min)** Engage students by showing them the "balancing bird". Ask them to write down questions and ideas about how the bird is able to balance on the tip of your finger.

   A description from the Educational Innovation website states that,
   "With balancing toys, stability is built in. They are constructed so that their center of gravity always remains below the pivot point. If the toys are tipped in any direction, the center of gravity is raised. This results in gravity exerting a restoring force (actually a torque), which pulls it back towards an

upright position. As long as the center of gravity is below the pivot point, an object will remain in stable equilibrium, even when pushed "off-center."

Source:(https://s3.amazonaws.com/cdn.teachersource.com/downloads/lesson_pdf/CTR-200-2017.pdf),

2. Have students share their questions with the classroom (can use a Think-Pair-Share method of sharing)

PART 2 – EXPERIENCING CENTER OF GRAVITY

1. **(10-15 min)** Students work to find the center of gravity of a meter stick.
   The following is based on a lesson developed by the Exploratorium and can be found online here: https://www.exploratorium.edu/snacks/center-gravity

   First, have students place each of their pointer fingers at each end of the wide side of a meter stick. With their eyes closed, students will slowly move their fingers one at a time keeping the meter stick balanced, finding the balance point (center of gravity) of the stick.

   Next, students can add the small ball of clay to a point on the meter stick and again start at the outer edges of the meter stick and move their fingers from the outside edges to balance the stick.

The center of gravity is where the fingers meet. Have students test different places on the meter stick and locate new points of center of gravity.

For an additional experience, students can close their eyes as they test.

2. **(5-10 min)** Have students record findings in their engineering notebook. Include drawings with detailed labels.

   This online article can also be used for concept reinforcement,

   http://www.explainthatstuff.com/center-of-gravity.html

   Some more advanced methods to use if you would like students to have precise measurements is using an balance hangar and stand on a meter stick such as this one from a science supply company. https://www.flinnsci.com/clamp-with-hanger-lever/ap4672/#variantDetails see extensions section.

PART 3 – CENTER OF GRAVITY OF IRREGULAR SHAPES

1. **(20 min.)** Students draw a large outline drawing of an irregular shape "star" on one side of an old file folder that has been cut in half on the fold.
2. Next, taking a hole punch, students punch out a hole at each point.

3. Insert the dowel through one of the holes in the star points. Let the star hang freely.
4. Hang the loop of the string on the dowel so that the washers dangle below.
5. While keeping the star and string still, draw a straight pencil line across the star right next to the string. Having students work in partner groups to draw the line would be helpful.
6. Repeat steps 3-6 for the other start points. Discuss what happened to all the lines that were drawn.
7. Have students locate the center of gravity for the star and explain why they think it is in this location.
8. Have students draw the irregular shape and label the center of gravity in their engineering notebook.

PART 4 – FINDING THE CENTR OF GRAVITY OF AN AIRCRAFT

Day 2- (Designed for a full 50 minute class period, adapt as needed)

Students conduct internet research to find an aircraft blueprint. Project the design onto a wall and have students trace their design/shape onto a ½ sheet of foam board. Use this drawing to find each aircraft's unique center of gravity.

Adding the aircraft at this point in the lesson builds excitement for the final engineering design challenge.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

Students should record questions and findings in an engineering notebook.

SUMMATIVE ASSESSMENT

N/A, the final Solar Mobile Engineering Design Challenge incorporates the optimum circuit that was developed in this lesson although it may change as students work on designing and redesigning their final mobile.