Volcanoes of Io

Overview:

In this activity, students learn how rotational forces keep planets in their orbits, as well as what happens when multiple gravitational forces act simultaneously on a planetary body. Jupiter's moon Io is an example of such a body. Tidal heating from the tug of Jupiter and other moons keep Io hot—hot enough to be the most volcanically active body in our solar system.

Objectives:

The student will:

- observe that orbits result from the conflicting forces of forward velocity and gravitational pull;
- investigate how forces applied to an object can cause it to heat up; and
- explain how multiple forces on a planetary body cause internal heating.

Materials:

- Tennis ball
- String
- Foam squeeze balls
- Thermometers
- Scissors
- Transparency: "Jupiter and its Moons"
- Student Worksheet: "Volcanoes of Io"

Answers to Student Worksheet:

Hypothesis, Data, Analysis of Data, and Conclusions will vary.

Further Questions:

1. A control was used to make sure the temperature of the ball rose in response to the squeezing, rather than some other variable in the environment.
2. Answers will vary. In general, the ball responded to squeezing by heating up because pressure, or friction, warmed the ball.
3. Answers will vary. In general, Io heats up in response to the nearby bodies because they are pulling it in different directions, causing internal heating.
4. pressure from hands (or friction created by this pressure)
5. gravitational force

Volcanoes of Io

Activity Preparation:

Tie a long string around a tennis ball. Make another loop around the ball perpendicular to the first loop. Make sure the ball is very securely attached to the string.

Activity Procedure:

1. Ask students why planets stay in their orbits, given that gravity attracts the sun and the planets to each other. Why don't the planets crash into the sun? Write ideas on the board. If necessary, explain that planets naturally want to travel forward in a straight line, but that they are constrained by gravitational pull from the sun.
2. Demonstrate this concept with the tennis ball on the string. Explain that the ball is Earth or some other planet, while the teacher represents the sun. Make sure there is plenty of room!
3. Throw the ball with one hand while holding the string with the other. As the ball reaches the end of the string, start spinning the ball around in a circle. Explain that the ball wants to travel forward but is pulled towards the sun by gravity, causing it to travel in a circular pathway.
4. Explain that moons travel around planets for the same reason.
5. Ask students what might happen if there were multiple moons traveling around a planet, each with their own gravitational pull.
6. Tell students that Io is an example of this situation. Display the Transparency: "Jupiter and its Moons," showing the forces that pull on Io. Explain that these forces pull Io in multiple directions.
7. Remind students that the pull of gravity on a body causes it to elongate a little bit, or get "squeezed." The pulling of multiple gravitational forces on Io from different directions causes it to get flexed back and forth, which in turn causes the interior to heat up.
8. Tell students that they will model this "tidal heating" with squeeze balls. Distribute the Student Worksheet: "Volcanoes of Io" and ask students to complete it.

Note: The interior of the squeeze ball heats about 6 ˚C over four minutes when squeezed rapidly with the fingertips. If students suspect that the heating occurs simply from holding the ball rather than from the squeezing, encourage them to measure the temperature of a second "control" ball that is held only with the fingertips for the same length of time.

Name:______________________________________ **Student Worksheet**

Volcanoes of Io

Testable Question:

How will squeezing affect the temperature of a ball? ________________________________

Background Information:

Jupiter's moon, Io, is the hottest and most volcanically active body in our solar system. How does Io stay so hot? The gravitational tug of Jupiter from one side, and the moons Europa, Ganymede, and Callisto from the other, "squeeze" Io in different directions, keeping it hot. This is called "tidal heating." Today's activity uses a squeeze ball to model how tidal heating works.

Hypothesis:

If a ball is squeezed repeatedly, then the temperature of the ball will:

a. rise b. fall c. stay the same

Materials:

- 2 Thermometers
- 2 Foam squeeze balls
- Scissors
- Marker

Procedure:

1. Using scissors, poke a hole into the center of two squeeze balls. The holes should be just wide enough to hold the thermometer. The holes should be at least one inch deep.
2. Label the balls "A" and "B" with a marker.
3. Insert a thermometer into both balls. Record the starting temperature of each ball in the Data chart below. Be sure to wait until the temperature is steady before taking a reading. Record all temperatures in the same units, either °C or °F.
4. Remove the thermometers from both balls.
5. Using the fingertips of both hands, squeeze ball B rapidly for 2 minutes.
6. Insert the same thermometer back into each ball, and record the temperature of both balls in the "Data" section.
7. Remove the thermometers again. Squeeze ball B rapidly for 2 more minutes (4 total minutes of squeezing).
8. Insert the same thermometer back into each ball, and record the temperature of both balls in the "Data" section.

Data:

	Starting Temperature	Temperature at two minutes	Temperature at four minutes
Ball A			
Ball B			

Name:______________________________________ **Student Worksheet**

Volcanoes of Io

Analysis of Data:

The final temperature change of ball A is the temperature at four minutes minus the starting temperature.

The final temperature of ball A is _________ - ___________ = _____________

The final temperature change of ball B is the temperature at four minutes minus the starting temperature.

The final temperature of ball B is _________ - ___________ = _____________

Conclusion:

Was your hypothesis proved or disproved? Use a complete sentence.

____

____

Explain what evidence supports your conclusion. Use complete sentences.

____

____

Further Questions:

1. Ball A served as a “control” in this experiment. Explain why a control was used.

   ____

2. Explain, in your own words, why the ball responded to squeezing in the way that it did.

   ____

   ____

3. Explain, in your own words, why Io responds to the pull of nearby bodies as it does.

   ____

   ____

4. What force was used to squeeze the ball in this experiment? _______________________________

5. What force is used in the tidal heating of Io? ____

