ACTIVITIES

Feel the Impact

"Comet on a Stick" Teacher Guide

Background

This activity is adapted for visually-impaired students from "Deep Impact Comet on a Stick", created for the Deep Impact Mission, A NASA Discovery Mission, by Maura Rountree-Brown and Art Hammon. See the original activity at:
http://deepimpact.jpl.nasa.gov/educ/CometStick.cfm

The Deep Impact mission was launched in 2004 and encountered Comet Tempel 1 on July 4th of 2005. The Stardust mission collected cometary particles from Comet Wild (pronounced Vilt) 2. Before these missions were launched, scientists and engineers used modeling to research and test some of their theories about comets. They also used modeling to find solutions to some of their mission challenges. Modeling takes place throughout the life of a mission as challenges arise.

You can try modeling by making a "Comet on a Stick". Use it to test the influence of the Sun on these small bodies. Discuss as a class some theories about comets. Then try to communicate them with the stick comet. This is a good model for some of the attributes of a comet. For others, it is not. The challenge is to design a model to communicate what you know or need to know if you are going to develop a mission to a comet.

If learn more about comets and about the Deep Impact Stardust missions , visit http://deepimpact.jpl.nasa.gov and http://stardust.jpl.nasa.gov.

National Science Education Standards Addressed
Grades 5-8

Science as Inquiry
- Understands about inquiry

Physical Science
- Properties and changes in properties of matter
- Transfer of energy

Science and Technology
- Understands about science and technology

History and Nature of Science
- Nature of science and scientific knowledge
- History of science and historical perspective
- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

Grades 9-12
Science as Inquiry
- Understands about inquiry

Earth and Space Science
- The origin and evolution of the universe

Physical Science
- Motions and forces
- Interactions of energy and matter

Science and Technology
- Understands about science and technology

History and Nature of Science
- Nature of science and scientific knowledge
- History of science and historical perspective

View a full text of the National Science Education Standards
http://newton.nap.edu/html/nses/6a.html

Purpose:
The purpose of this activity is to develop a model of a comet and use the same thought processes as a science and engineering team do to design and build missions. Use it to test your theories about comets and then evaluate the strengths and weaknesses of your comet model. The importance of this activity is not the initial model, but the model you improve or design and your evaluation of the initial model. After you have made your model, determine the strengths and weaknesses of the model? Can you improve the stick comet model?

Before you start:
As a class, discuss what you know about comets. Build one list. Add to that list the things you wonder about comets or don't know. Now you want to build a model to study one question: If you have to send a spacecraft to a comet, what will you need to consider about the way the Sun affects a comet? Now, build your "Comet on a Stick".

Materials per group:

- One 2" Styrofoam or other ball
- Four 1 – 2 ft lengths of Mylar™ gift strips or thin ribbon
- Two 5" strip of tape
- One wooden skewer (shish kabob type)
- An electric hairdryer/electrical power available
- Small amount of modeling clay
- Three inch piece of pipe cleaner

Directions for construction of model:

1. Make a tiny hole in the ball so it can be mounted on the skewer (the fit of the skewer should be tight). Mount the ball on the skewer.
2. Place the Mylar™ or ribbon strips on top of the ball so the pieces cross each other and the lengths of all sides of the strips hang down evenly. You can also use light ribbon in place of the Mylar™ strips.
3. Attach the strips to the ball with the 5" strips of tape or narrow masking tape wrapped over the strips and around the circumference of the ball.
4. Press a small amount of modeling clay onto the Styrofoam ball to assign a "front" for your comet representing the head. Taking the three inch piece of pipe cleaner, bend it in half and push the two ends into the Styrofoam ball opposite the side from the clay. This will represent the tail of your comet.

> Have a Comet on a Stick model available for students to feel the correct placement of the mylar strips on the Styrofoam ball.

Procedure:
Use a hairdryer to simulate a portion of the Sun's solar energy (the solar wind) as it meets the comet. Have someone be the "Sun" and stand in place with the hairdryer. The "Sun" should aim the hairdryer at the comet as it approaches and as it moves away. The "Sun" will have to turn in place to keep the "solar wind" flowing to the comet.

Have student(s) observe what happens to the Mylar™ strips as one student holds the comet by the stick and walks in an elliptical orbit around the Sun.

In this model, the hairdryer simulates the solar wind causing the comet tail (Mylar or ribbon strips) to form and trail behind the comet.

The heat from the Sun causes gas, ice, particles and rocky debris of various sizes to burst from the comet and form the coma. The solar wind causes these substances to form a “tail” behind the comet.

As the comet gets closer to the Sun, the solar heating and solar wind affects the comet so that the tail forms and so that it stays in opposition to the Sun. As it travels away, the lost solar heating of the Sun causes the tail to diminish.

Help students determine the strengths and weaknesses for this model by answering the following questions:

Questions:
1. How does this model succeed in showing the influence of the Sun on a comet?
2. How is this model unsuccessful at showing the proper influence of the Sun?
3. What other elements of a comet can be seen using this model?
4. Which elements of a comet are not well shown by this model?
5. The Stardust mission takes a comet sample by flying near the front of Comet Wild 2 instead of the trailing tail. Why? Can your model show the reason for this decision? Why or why not?
6. The Deep Impact mission made a crater in the nucleus of Comet Tempel 1 with a copper projectile. A sister spacecraft nearby took optical and spectrometer data during the encounter and for 14 minutes after impact. What did the engineers and scientists need to consider about a comet in order to successfully gather their data?

Now to Improve:
Can you design your own model to communicate what you know or need to know if you are going to design a mission to a comet?
Have students use the extra materials you have gathered to improve or build a new model by:
1. Forming new teams and choosing three facts about comets you would like to show through modeling.
2. Making a new model or improve the Styrofoam comet to illustrate these comet facts.
3. Evaluating your new model. Did it successfully demonstrate these facts? Why or why not?

Tips for the Teacher:
1. A hairdryer only sends “wind” from one side while the Sun would be sending out solar wind from all sides.
2. Other household or art supplies may be gathered to use to design different comet models. Use the materials you gathered to have students improve or build new models.
3. This model does form a tail with the solar wind but it fails to show that the material that outgases from the comet mostly shoots forward. This is why we see the front of the comet glow but do not directly see the nucleus of the comet which is hidden further back inside the comet’s coma.
4. The Stardust mission did not take its sample from the tail behind the comet because there is a much higher concentration (density) of material on the sunward side where it originates. By the time it blows back into the tail, it is very spread out. Similarly, the Deep Impact observing spacecraft maintained a path beneath the comet, which passes overhead. This helps the spacecraft to avoid coma debris from the comet tail and safely transfer its images and other data to Earth through the Deep Space Network antennas.

5. This model does not show that the tail of a comet appears curved because in space we see a “history of the tail”. At any point in time, particles move directly away from the Sun (as in this model). Over time, as the comet curves around the Sun on its orbit path, the particles leave a tail that is curved (not shown in this model).
6. As the comet moves away from the Sun, the model tail droops. In space, the particles and debris continue to be swept away from the nucleus, but the production rate of debris decreases.
7. Comets are not white since the rock and debris being outgassed clings to the surface of the comet in a crust that is blacker than toner for a copy machine. Comets also appear in different irregular shapes and are not round “balls”. They are shaped more like potatoes. Scientists are not sure how rough or smooth the surface of a comet might be and will get that information from the missions currently planned by NASA.
8. Comets have three tails: the largest is the dust tail produced by radiation light pressure from the Sun; the ion tail, produced by solar wind and a neutral sodium tail produced by solar wind.