Energy Transfer

STARFINDER

PROGRAM 13

Instructional Objectives

After viewing the program and participating in the accompanying activities, the student will be able to:

1. compare and contrast elastic and inelastic collisions,
2. describe the relationship of relative mass to the exchange or transfer of momentum between objects during the collision, and
3. desribe meteors as objects that collide with earth's atmosphere.

Synopsis

In "HST Data Stream," Eric Chaisson shares some of the latest information received from the Hubble Space Telescope.

Program 13 "Science Links" provides a basic lesson on the transfer of energy in elastic and inelastic collisions. Momentum is defined. Using a series of studio demonstrations with pool balls, the conservation of energy is presented. Demonstrations are shown of elastic and inelastic collisions. The effect of the differences between the masses of colliding objects is demonstrated.

This program provides an opportunity to present comets and meteors to the viewing audience. Meteors are shown as examples of natural collisions in which an object's kinetic energy is changed into heat energy. As this segment concludes, viewers will visit Canyon Diablo, a crater of gigantic proportions that provides evidence of one massive meteorite's collision with the earth.

In "The People Behind the HST", students will meet David Leckrone, the Deputy Project Scientist for the Hubble Space Telescope Project.

Vocabulary

Comet - A small ball of rock and ice which travels through the solar system in a huge elongated orbit about the sun.

Conservation of Energy - The basic physics law which states that the sum of the energy of a system must remain constant.

Deconvolution - Computer Enhancement. A mathematical technique in which computers are used to restore the true resolution of an image. The images received from the Hubble Space Telescope are being computer enhanced through this process to help make up for the distortion created by the faulty optics.

Elastic Collision - A collision in which the total kinetic energy is the same before and after the collision. In perfectly elastic collision, there is no crumpling or sticking together of the objects.

Inelastic Collision - A collision in which some kinetic energy is used up. A completely inelastic collision is one in which two colliding objects stick together after the collision.

Kinetic Energy - The energy of an object due to its motion.

Meteor - A heated glowing object streaking through earth's atmosphere, but not yet having hit the surface.

Meteorite - A meteoroid that manages to survive passage through an atmosphere to collide with the surface of a planet or moon.

Meteoroid - A boulder, generally about a yard in diameter, that travels through the solar system. Many meteoroids are thought to originate from the Asteroid Belt, a rocky region of space between Mars and Jupiter. Others are remnants of the rocks that are part of comets.

Momentum - Mass multiplied by speed.

Previewing Activities

Some people refer to elastic collisions as "bouncy" and inelastic collisions as "sticky." Discuss with the class why these terms are descriptive of elastic and inelastic collisions.

Review the concept that mass is the amount of matter in an object. Use the example of a bowling ball and a soccer ball to illustrate that mass is not determined by size.

Ask students if any of them have seen a "shooting star." Have them describe what they think a shooting star is.

Postviewing Activities

Discuss the latest findings of the Hubble Space Telescope.

Discuss the career of the Deputy Project Scientist for the Hubble Space Telescope Project.

Have students classify the following collisions as mostly elastic or inelastic, and explain why.

- a game of pool or billiards
- a skier crashing into a snowbank
- a game of croquet
- a demolition derby event
- a grand slam baseball hit
- a spectacular catch by the shortstop

Assure students that although meteor showers are fairly common, most meteors burn up as they travel through the atmosphere. It is very uncommon for a large meteor to land intact on the earth. There has only been one case in recorded history of anyone being struck by a meteor—and she only received a bruise. In fact, the odds of anybody at all being hit by a meteorite is only once in every 9300 years. The largest craters, such as those visible on the moon, were formed by impacts that took place during the early stages of the solar system.

Help students find out when they can see a meteor shower. Post a calendar of the major meteor showers in the classroom. You can reproduce the sample calendar on the Experiments/Projects page, included in this packet.

Your students can report their meteor sightings to the American Meteor Society. Observations should be made from areas as free as possible from artificial lights. They should provide the hourly counts of meteors seen by a single individual, preferably on a clear, dark, moonless night. To be useful, meteor counts need to include the date, each one hour time interval, the observer's name and mailing address, the location of the observation, and the number of meteors seen during each hour. Observations can be sent to: *Meteor News*, c/o Karl Simmons, Route 3, Box 1062, Callahan, FL 32011. Results will be published. Subscriptions to the newsletter cost $5.00 and can be ordered from the above address.

Active Involvement

Allow students to compare various factors of a group of objects. You will need a yardstick; a variety of similarly sized balls, such as a tennis ball, a croquet ball, a lacrosse ball, a baseball, a ball of clay, and a styrofoam ball; a tray of chalk dust; scales; and access to a chalkboard. Write a list of the ball types across the top of the chalkboard.

1. Have students weigh each ball and record its weight on the board. If you have an inertial balance or oscillating spring device, record the oscillations per second.
2. Mount a yardstick against a wall so that it touches the floor. Assign one student as the "spotter" and place her/him so that s/he is at the same relative height as the yardstick. Have another student drop one ball from a height of 36", directly in front of the yardstick, and have the "spotter" record the height to which the ball bounces. Repeat twice. Take an average of the three bounce heights and record on the board.
3. One at a time, dip each ball into the chalk dust. Drop each ball from shoulder height. Measure the diameter of the imprint left by the ball.
4. Ask students to draw some conclusions about the information they have recorded. Elicit responses.

Students who have access to a home video camera and a pool or billiard table can set up a series of pool or billiard shots to show to the class. When they present the video, they should pause the VCR at the moment of collision. Other students in the class can then predict the direction of movement the balls will take.

Have students research some of the facts and mysteries of meteors. Possible topics include:

—Research the connection between a possible collision of awesome proportions on the planet Mars and a group of meteorites found in Antarctica. Could these rocks be remnants of that distant planet? One source of this information is Patricia Lauber's *Meteors and Meteorites: Voyagers from Space* (see bibliography).

—Research the connection between diamonds and meteorites. One source for this information is Franklyn Branley's *Comets, Meteoroids, and Asteroids: Mavericks of the Solar System.*

—Have students report on the strange event that took place in Tunguska, Siberia. While many believe that this mysterious event was the collision of a comet or meteorite, no crater has been found. One source for this information is Baxter and Atkins' *The Fire Came By: The Riddle of the Great Siberian Explosion*

—Relay the interesting story of the Ahnighito Meteorite, brought from Greenland to the United States by Robert Peary in 1897. This 68,085 pound rock can be seen at the Hayden Planetarium in New York City. One source of information for this story is Franklyn M. Branley's *Comets, Meteoroids, and Asteroids: Mavericks of the Solar System*

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For high school readers:

Adair, Robert K. *The Physics of Baseball.* New York: Harper & Row, 1990.

Baxter, John and Thomas Atkins. *The Fire Came By: The Riddle of the Great Siberian Explosion.* Garden City: Doubleday and Company, 1976.

Gibilisco, Stan. *Comets, Meteors and Asteroids—How they Affect Earth.* Blue Ridge Summit: TAB Books, Inc. 1985.

For middle school readers:

Branley, Franklyn. *Comets, Meteoroids, and Asteroids: Mavericks of the Solar System.* New York: Thomas Y. Crowell and Co, 1974.

Froman, Robert. *Baseball-istics: The Physics of Baseball.* New York: G.P. Putnam's Sons, 1967.

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Science Career Profile

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DAVID LECKRONE
Deputy Project Scientist for HST Project
Goddard Space Flight Center
Education: B.S. Physics
M.A. Astronomy
Ph. D. Astronomy

Chief Responsibilities

As Instruments Scientist and Deputy Project Scientist for the Hubble Space Telescope, David Leckrone helped define the scientific objectives for the HST mission and worked with project managers, engineers, and other scientists to try to achieve those objectives. He played a leadership role in the selection of the scientific instruments on Hubble, helped establish their design features and watched over the development. Since launch, he has worked on assessing the results of the in-orbit testing of HST, and on planning the early scientific observations.

David is part of an HST project science group made up of five astronomers who are responsible for overseeing and understanding all aspects of the project from hardware development, to in-orbit operation, to scientific research with HST data. Using their broad knowledge and experience, these scientists give advice to managers and engineers about decisions and policies that may affect the scientific capabilities of the HST. They also help to solve problems that arise about the HST. The Project Manager often turns to these scientists for advice. The scientists in turn must look at various factors and decide what solution would be both scientifically beneficial and practical.

David is also head of the astronomy branch within the laboratory at Goddard. He is responsible for supervising about thirteen Ph.D. astronomers and a secretary. He looks after their needs, helps them find solutions to their problems, and keeps them up to date on events and requirements of their positions. They work on a variety of space projects, not just the Hubble Space Telescope.

Besides his managerial jobs, David is also a practicing research astronomer who will be making observations with the Hubble Space Telescope. Specifically, he is a spectroscopist—someone who studies the chemical make-up of stars by breaking down the light received into its component colors. The instruments on the HST are sensitive to ultraviolet light, so David will be able to study the spectra of this light. He is concentrating his first observation on a very peculiar star called Chi Lupi, a star in the constellation Lupus, the Wolf. It is known to contain large abundances of elements like mercury, platinum and manganese, and is thought to contain an unusual mixture of isotopes of elements. David wants to know if the ground-based telescopes have really received the correct information. If so, this will lead to exciting research on why stars like Chi Lupi have such a bizarre chemical make up.

Typical Day

Like so many other scientists connected with the Hubble Space Telescope Project, David begins each day by checking his electronic mail. In this way, he is able to communicate with people all over the world.

He then might spend an hour or so meeting with his research assistant. They are busy doing calculations for their HST observation. It has been important to be as prepared as possible for the Chi Lupi observation. In that way, data can be analyzed very quickly as it comes in.

David then will attend a series of meetings. He may visit the control center area for the HST. Each morning, there is a meeting between the science teams—instrument teams and observatory scientists—and the operations group. They must review what is going on, what happened the previous day, and make plans for the next several days. They deal with questions and problems. This meeting is a way for them to touch base with one another and keep informed.

David must also spend time keeping up to date on his writing and correspondence with colleagues, and taking action on items from his previous meetings by writing notes and memos, and drafting resolutions. As a member of the Scientific Editorial Board, he is currently going through the early HST data to determine if there is sufficient scientific information to present through a press conference. If so, this group will assist in the presentation of the information to the public.

David also gives many interviews, public talks, speaks with the press, and handles questions.

Finally, David gets to close his door and work on his own research. Because he is able to tie in with the computers in his laboratory over telephone lines, he often continues this research in his office at home. He does not mind working late hours on his research because it is something he loves.

Career Viewpoint

David advises that if you are really interested in something, and really want to succeed, it doesn't matter who you are or where you are from. You do not need to have been given a head start by your schools, your teachers, or your parents. You can do it yourself by being focused on what you love.

David feels that computers are powerful tools which can greatly help people in their work. It is important to learn how to use them effectively. It's amazing how much computers can extend your individuality, by allowing you to solve complex problems or to do routine things very quickly. Learning to work with computers will make a contribution to your personal and educational growth and development.

Content Consultants for STARFINDER - Program 13

Eric Chaisson
Space Telescope Science Institute
Operated by AURA for NASA

Ella-Jay Parfitt
South East Middle School
Baltimore, MD

Teacher's Guide

Writers
Barbara Bourne
Patricia Murphy

Editor
Kate Harrison

Illustrator
Robert Jones

Graphic Design
Bob Lindler
The Design Co-op

Typesetting
Blue Heron Typesetters

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11767 Bonita Avenue
Owings Mills, Maryland 21117
(301) 356-5600

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See for Yourself: Experiments/Projects

Momentum Tracks

▶ MATERIALS:

- 2 yardsticks
- tape (double faced tape would work best)
- marbles, two small, one large
- modeling clay shaped into a ball the size of the larger marble
- styrofoam ball, the size of the larger marble

▶ DIRECTIONS:

Using tape, securely attach the two yardsticks to a level table or uncarpeted floor, so that they are parallel and one half inch apart. This will be your track. You will be able to measure distances by looking at the measurements on yardsticks. Label one end of the track "left" and one end "right." You will be able to state in which direction the marbles travel by indicating left or right.

1. Place one small marble at the 18″ mark on the track. Place the other small marble 3 inches away and lightly shoot it towards the stationary marble.
   a. At what inch mark is the point of collision?
   b. In what direction and how far did the marble that was stationary travel after the collision?
   c. Record what happened to the moving marble.
   d. Which of the marbles had momentum before the collision?
   e. Record what happened to the momentum.
   f. Was this an elastic or inelastic collision?
2. Repeat step one, but this time, use your finger to hold the stationary marble in place so that it will not move when it is struck.
   a. In what direction, and how far did each marble travel?
   b. Record what you think happened to the momentum of the moving marble.
   c. Was this an elastic or inelastic collision?
3. Place one small marble on the 3″ mark and the other small marble on the 33″ mark of the track. Shoot them at each other at exactly the same time. Try to have them move with the same amount of force so that they have equal momentum. You should be able to do this by spreading your arms apart and tapping the marbles with your fingers at the same time.
   a. If they travel at the same speed, at which point on the track should they collide?

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   b. Have a friend watch closely and determine at exactly which point the marbles actually collide.
   c. Record the directions and distances each marble travels after the collision.
   d. What has happened to the momentum of each marble?
4. Place one small marble at the 18″ mark on the track. Place the large marble 3 inches away and flick towards the stationary marble.
   a. Which marble has the greater mass?
   b. In what direction, and how far did the marble that was stationary travel after the collision?
   c. Record what happened to the moving marble.
5. Switch the positions of the two marbles in step 3.
   a. Before you shoot the smaller marble at the larger one, predict what the results will be. Record the reason for your prediction.
   b. Shoot the smaller marble at the larger one. Record the direction and distance traveled by the smaller marble.
   c. Record the direction and distance traveled by the larger marble. Compare these results with those of step 3.
6. Place the large marble at the 18″ mark on the track. Place the styrofoam ball 3 inches away.
   a. Which ball has more mass?
   b. Before you shoot the styrofoam ball at the marble, predict what the results of the collision will be. State the reasons for your prediction.
   c. Shoot the styrofoam ball at the marble and record the directions and distances traveled by each. How did your predictions compare with the results?
7. Place the ball of clay at the 18″ mark on the track. Place the larger marble 3 inches away. Aim and shoot the marble towards the clay.
   a. Before you shoot the marble, predict what the results will be.
   b. Record the results of this collision.
   c. Was this an elastic or inelastic collision?
8. Using two or more of the marbles and balls, set up an experiment for another student to carry out. Write up the experiment and record the results.

Making a Celestial Rock Collection*

*Be prepared to begin this project on a rainy day

You may not be able to find a baseball sized meteorite in your backyard, but you can collect the tiniest forms of the meteorites that fall to earth—micrometeorites. These tiny remnants of comets and meteoroids are the size of a particle of dust. They are so tiny that they do not burn up as they enter earth's atmosphere, but are slowly carried to earth with the rain. Of course, they are most plentiful after a meteor shower, so check the Table of Meteor Showers on this page for the best times to carry out this project.

▶ MATERIALS:

- 2 clean pyrex pie plates
- magnet
- ziplock bag
- 1 cup distilled water
- magnifying glass
- microscope slide
- microscope
- tiny magnet or magnetized needle

▶ DIRECTIONS:

1. Thoroughly clean two pyrex pie plates. Wipe them with a clean, lint free cloth and place in a clean plastic bag until you are ready to use them. Place the magnet in a clean ziplock bag.
2. On the next rainy day, set out one pie plate to collect rain water.
3. When you have almost completed the rainwater collection, pour 1 cup of distilled water into the second clean pie plate.
4. In order to collect the micrometeorites, move the magnet (still in the ziplock bag) around the bottom of the pan with the rain water. Because the meteorites contain iron, they will be attracted to the magnet.
5. To remove the particles, swish the magnet in the distilled water to loosen and remove the micrometeorites.
6. Repeat steps 4 & 5 several times. The particles are very tiny; you may have trouble seeing them in the water.
7. Evaporate the distilled water. You can do this quickly by heating the pie plate in a microwave oven.
8. Check for larger particles with a magnifying glass.
9. Use a tiny magnet or magnetized needle to pick up the particles and transfer them to a microscope slide.
10. Repeat this process on several rainy days. Rate the best dates and compare them to the list of dates of meteor showers.

TABLE OF METEOR SHOWERS

SHOWER	DATE OF MAXIMUM ACTIVITY	MAXIMUM HOURLY RATE
Quadrantids	Jan. 3	40
Lyrids	April 21	10
Eta Aquarids	May 6	10
Perseids	Aug. 10-14	50
Orionids	Oct. 20-23	20
Taurids	Nov. 3-10	13
Leonids	Nov. 16-17	12
Geminids	Dec. 13-14	65
Ursidis	Dec. 22	13