



Danger: Space Debris

LESSON THEME

This lesson connects a series of activities to examine the physics and dangers of natural and man-made debris traveling through space.

OBJECTIVES

Students will:

- Explore the law of conservation of momentum using colliding marbles.
- Investigate how velocity and kinetic energy affect the penetration of a speeding object into substance.
- Use gelatin to demonstrate how aerogel was utilized by the Stardust mission to capture comet material without damaging it.

NASA SUMMER OF INNOVATION

UNIT

Physical Science- Forces and Motion

GRADE LEVELS

4th - 6th

CONNECTION TO CURRICULUM

Science, Mathematics, Technology

TEACHER PREPARATION TIME

45 minutes

LESSON TIME NEEDED

4 hours

Complexity: Moderate

NATIONAL STANDARDS

National Science Education Standards (NSTA)

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science

- Properties and Changes of Properties in Matter
- Motions and forces
- Transfer of energy
- Interactions of Energy and Matter

Earth and Space Science

- Earth in the Solar System

Science in Personal and Social Perspectives

- Risks and Benefits
- Natural and Human-Induced Hazards

History and Nature of Science

- Science as human endeavor
- Nature of science
- History of science

Common Core State Standards for Mathematics (NCTM)

Operations and Algebraic Thinking

- Generate and analyze patterns

Measurement and data

- Represent and Interpret data

MANAGEMENT

The activities in this lesson should be done with cooperative groups of two to three students. Safety practices should be reviewed and observed during these activities. For the Aerogel-lo activity, be sure to prepare the gelatin before doing the activity in class. Allow enough time for the gelatin to set.

CONTENT RESEARCH

Review the background information included with each activity.

Key Concepts

- **Momentum-** The momentum of a moving object is the product of its mass and its velocity ($M = mv$)
- **Kinetic energy**—energy associated with an object in motion
- **Micrometeoroids-** Tiny particle of space debris (natural or artificial) traveling at high speed through space
- **Aerogel-** Aerogels are the world's lightest solid materials, composed of up to 99.98% air by volume.
- **Stardust Mission-** The primary objective of the Stardust mission was to capture both cometary samples and interstellar dust.

LESSON ACTIVITIES

The ***Danger: Space Debris*** activities needed for this lesson can be found at the websites next to each specific activity outlined below:

Collisions

Students will be observing colliding marbles, which demonstrate the law of conservation of momentum. The momentum of a moving object is the product of its mass and its velocity ($M = mv$). If all of the marbles are identical in mass and size, a moving marble will transfer its momentum to a stationary marble when they collide. (See page 49 of guide.)

http://er.jsc.nasa.gov/seh/amuse_park_physics.pdf

Potato Astronaut

Exploration Brief: Micrometeoroids and Space Debris

Part 1: Students will investigate the relationship between velocity and penetration depth when a potato is struck with a plastic straw. Part 2: Challenge the students to design a way to protect the potato from damage caused by impacts using just the materials they brought to the classroom.

http://www.nasa.gov/.../Suited_for_Spacewalking_Educator_Guide.html

(See page 67 of guide.)

Aerogel-lo

Technology For Studying Comets: Part 3 Aerogel

This activity offers a simple approach for “experiencing” aerogel. Aerogel is an amazing feat of technology that was used by the STARDUST spacecraft to capture high-velocity interstellar dust and particles from the coma of comet Wild 2. This demonstration uses gelatin and pellets to show how STARDUST’s aerogel collector captured comet particles. The gelatin is referred to as “aerogel-lo.” <http://solarsystem.nasa.gov/docs/Aerogello.pdf>
<http://stardust.jpl.nasa.gov/classroom/guides.html> (Aerogel fact sheet at bottom)

MATERIALS

- 2 Plastic rulers with center groove (30 centimeters long) or similar items for tracking the marbles, such as grooved wooden molding
- Eight identical marbles
- Two identical books or boards to use as ramp supports
- Plastic (milkshake-size)
- Potato
- Tissue paper, notebook paper, handkerchiefs, rubber bands, napkins, aluminum foil, wax paper, plastic wrap, etc.
- Impact Resistance Test Stand (from Teacher Tech Brief)
- 1 packet unflavored gelatin
- Hot water
- Two clear plastic cups
- A spoon
- A plastic straw
- A scrap of clean pantyhose and tape to secure it (optional)
- **Steel** pellets (available at sporting goods stores)
- Safety goggles for you and all students
- Aerogel Fact Sheet

ADDITIONAL RESOURCES

To learn more about space debris and the dangers it poses go to:

<http://orbitaldebris.jsc.nasa.gov/>

To learn more about spacesuits and why astronauts must wear them go to:

http://www.nasa.gov/audience/foreducators/spacesuits/home/clickable_suit_nf.html

To learn more about the Stardust Mission and aerogel go to:

http://cio.gsfc.nasa.gov/mission_pages/stardust/spacecraft/aerogel-index.html

Learn about the next Stardust Mission:

<http://stardust.jpl.nasa.gov/home/index.html>

DISCUSSION QUESTIONS

Each NASA activity includes discussion questions in the provided Student Data components.

Additional Questions:

- How might collisions of debris in space affect the velocity, density and distribution of asteroids, meteors and space junk that could be harmful to astronauts or satellites? *Collisions of debris in space increase and number of dangerous debris objects in space increasing the density of the objects present even though the size of each is reduced.*
- How did your results vary protecting your “Potato astronaut” as you tried different covering materials? *Student answers will vary depending on materials they used to protect their potato.*
- Which material worked the best to protect your “potato astronaut”? *Student answers will vary depending on materials they used to protect their potato.*
- Name several qualities a real space suit needs to have to protect astronauts in space (other than protection from micrometeoroids).
 - *Spacesuits must maintain a pressure environment to protect from the vacuum of space.*
 - *Temperature regulation in spacesuits is critical because of extreme temperatures of space.*
 - *Spacesuits provide some protection from cosmic radiation exposure in space.*

ASSESSMENT ACTIVITIES

Have students answer questions with each lesson to evaluate their understanding of the concepts.

- In the two Collisions activities, the conclusion sections have questions which can be used as a pre-test of students understanding and then again after they run the tests.
- Have student make predictions about which materials will work best to protect the potato astronaut before they proceed with their experiments.
- Ask students how they might redesign the protection systems developed to better protect the potato astronaut.
- Have students make predictions about how well the “gelatin” will stop the projectile shot into it.
- Discuss the reflection questions at the end of the “Aerogel” activity.

ENRICHMENT

Each activity includes extensions to allow students to continue their learning experiences.