Title: Watch Out! *(Adapted from a NASAexplores lesson)*

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Subject(s): Science

Topic(s): Meteoroids, Space Science, Meteorites, Meteors

Grade/Level: 5-6

Objective:
By the end of this lesson, students will be able to:

- construct meteoroid models to impact predetermined surface areas.
- analyze the effects of meteorite impacts on different surfaces.
- explain how impacts in space are a concern for NASA missions.

Summary of Lesson:
In this lesson, students craft a meteor impact to demonstrate the possible change in surface area and resulting spray of the meteor. The resulting model provides explanation and understanding of meteor impacts in space. The process of setting up and conducting experiments provides students with application of scientific inquiry.

Time Allotment: 45 minutes

Procedures/Instructions:

1. Prior to the activity, gather colored aquarium rocks, metal baking sheets, cardboard boxes, tops to large plastic tubs, sheets of cellophane, and rolls of aluminum foil.
2. Have materials assembled in a central location.
3. Have the students fill the water balloons with water and pebbles. This will help students model the distribution of materials after a meteorite impact. The pebbles represent the meteorite fragments. Using the model, the students will analyze the meteorite impact on different surfaces.
4. Read orally the 5-8 NASAexplores article, "Caution: Falling Debris." Discuss the article with students.

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5. Explain that meteorite debris bombards any orbiting spacecraft. In many cases, meteorites break apart into many fragments as they pass through the Earth's atmosphere. These smaller fragments are harder to track than one large meteorite.
6. Hand out Student Sheets, and read over the directions as a class.
7. Remind groups that although each student launches (throws) a balloon, students should work as a group to choose which surface they will target, to record observations, and to draw conclusions.
8. Remind students to wear protective eyewear and to stand as far from the impact site as possible.

Instructional Materials:

- 4-5 round balloons
- 40-100 small pebbles (colored aquarium rocks work well)
- pencils
- safety goggles
- water faucet
- funnel
- measuring cup
- thin stick or skewer
- section of a cardboard box
- metal baking sheet
- large plastic tub
- dirt area
- sand pit
- sheets of cellophane paper
- rolls of aluminum foil
- tape (used to tape cellophane paper over plastic tube)
- Student Worksheet
- NASAexplores article, "Caution: Falling Debris"

National Science or Mathematics Standards:

Science

Unifying Concepts and Processes
CONTENT STANDARD: K-12
As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes

- Evidence, models, and explanation

Science as Inquiry
CONTENT STANDARD A:
As a result of activities in grades 5-8, all students should develop

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

Physical Science
CONTENT STANDARD B:
As a result of activities in grades 5-8, all students should develop and understanding of

- Properties and changes of properties in matter; Motions and forces

Assessment Plan:
5 Points

- Scatter patterns were found for at least 3 of the balloon launches.
- At least 3 comparisons were made between the balloon impact and meteor impacts in space.
- Observations accurately describe the results.
- Writing is clear and understandable.

4 Points

- Scatter patterns were found for at least 2 of the balloon launches.
- At least 2 comparisons were made between the balloon impact and meteor impacts in space.
- Observations describe the results.
- Writing is clear and understandable.

3 Points

- Scatter patterns were found for at least 2 of the balloon launches.
- At least 2 comparisons were made between the balloon impact and meteor impacts in space.
- Observations describe the results.
- Writing is understandable.

2 Points

- Scatter patterns were found for at least 1 of the balloon launches.
- At least 1 comparison was made between the balloon impact and meteor impacts.
- Observations attempt to describe the result.
- Writing is difficult to understand.

1 Point

- Scatter patterns were found for at least 1 of the balloon launches.

- An attempt to compare was made between the balloon impact and meteor impacts.
- Observations do not describe the results.
- Writing is not understandable.

0 Points

- No work completed.

Caution: Falling Debris
A 5-8 NASAexplores Article

With all the objects and debris flying around in space, you'd think NASA would be worried about a **cataclysmic** collision that would blow the International Space Station (ISS) to smithereens. The big objects are easily tracked and avoided. However, the small objects cause the concern. It's impossible to move out of the way of a speck moving at orbital speeds of 27,535 kilometers per hour (17,000 miles per hour).

There are two categories of objects orbiting the Earth. Orbital debris is the man-made fragments of rocket bodies, stray nuts or bolts lost on a space walk, paint chips, and other leftovers from human activity. Meteoroids are naturally forming substances like bits of comets and asteroids that remain in space. Both have a probability of colliding with the ISS, the Space Shuttle, a satellite, or other spacecraft.

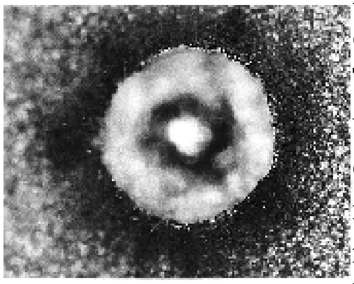
There are approximately 9,000 items larger than a softball orbiting the Earth. They are all tracked and monitored. If one should be headed on a collision course with a spacecraft, the crew takes **evasive** action. However, the smaller bits won't show up on radar. It's anybody's guess when one might hit a craft.

An object 1 millimeter (.03 inch) in size could break data cables and secondary power lines. Something 4 to 5 mm (.15 inches) could damage primary power cables, tubes, and radiator panels. The crew is trained to react to damage. They can repair some problems, however, it is best to prevent the damage in the first place.

Much of the ISS is made of aluminum; the Space Shuttle is constructed of fabric panels and thin composite leading edges. All of these materials are **susceptible** to damage. How have researchers helped reduce risk?

Notes:

In space, the Shuttle flies backwards and upside down most of the time.



Positioning the Shuttle so that it faces away from most debris protects the vehicle's leading edges from damage. This greatly reduces the risk of collisions to the vulnerable cargo bay area. The objects placed in the cargo bay are situated so that if an impact should occur, it would not hit dangerous or fragile items. **Toxic** materials, batteries, and coolants, for instance, are not located near the outside edges of the bay, and neither are furnaces. If these objects were hit, they could trigger explosions and cause severe damage. They are stored in more sheltered areas of the cargo bay.

A satellite called the Long Duration Exposure Facility was up in space for 6 years. When it returned to Earth, researchers recorded 30,000 impacts on the vehicle's surface. The lab module of the Space Station, approximately the same size, could expect closer to 100,000 impacts since it should be in space for 20 years.

Of those 100,000 impacts, researchers expect to find a few craters and only a few puncture holes that would actually penetrate the outer surface. How can they expect to dodge that many bullets?

Bullet is the key word. Much of the blanket on ISS is made of Kevlar. Kevlar is used to make bulletproof vests. Kevlar provides an ultra-strong defense and is lightweight. This makes the ISS less massive. This material is also used in some of the ISS shields that keep debris from reaching fragile areas.

Notes:

There are over 200 different kinds of shields protecting the ISS from impacts. As a group, they're referred to as Whipple shields. They are named after Fred Whipple, an astronomer and comet researcher who came up with the idea of protecting spacecraft from high-speed collisions with pieces ejected from comets. The shield is a thin bumper that is placed in front of the spacecraft pressure shell. NASA has used Whipple shields successfully for years.

On a recent mission in the summer of 2001, the Space Shuttle took supplies to ISS. When it left Earth, the module was fine; when it returned to Earth several days later, there were three tiny holes on the outer shell of the module. Scientists sampled those holes and determined that a paint flake caused one, another was the result of a meteorite, and the cause of the third was undeterminable.

If debris caused a penetrating hole in a craft's system, the depressurization alarm would sound, and it would show up on a monitor. So far, the Shuttle and Space Station haven't experienced that situation. The only evidence of contact with debris has been found after the vehicle is safely on the ground.

Some damage is expected and acceptable on space missions. Calculating and evaluating the risk of collision is a complex operation using computer models describing the distribution of particle sizes, locations, and other variables. Over 10 years, the probability of penetration causing a significant hole is about 5 percent. That's when the crew would need to make repairs to prevent the mission from having to return to Earth early. Statistically speaking, those aren't bad odds!

Notes:

Watch Out!
Student Worksheet

1. Choose the type of surface that your meteorite will crash into. Make sure that every person in your group chooses a different one. See suggestions listed below:

    - Piece of cardboard
    - Sand area
    - Aluminum foil covered baking sheet
    - Dirt area
    - Cellophane paper suspended over plastic tub

2. If your teacher has prepared the water balloons, continue with step 3. If your teacher has not already prepared the water balloons:

    - Place a funnel in the neck of a balloon.
    - Add 10-20 pebbles one at a time, noting the number and color of each.
    - Fill the balloon ¾ full with water. Be sure to tie the balloon securely. This step must be done just before going outside to launch the balloons.

3. Determine the area to create the impact. Make observations of the surface: Is the surface smooth or rough? Are there any natural or man-made characteristics of the surface?
4. **Put on safety goggles prior to launching balloons, and stand as far away as possible from the impact site.**
5. Launch balloons one at a time in the predetermined area. You may throw the balloons at an angle, lob them, or throw them straight up so that they impact vertically on the impact site.
6. Sketch the scatter pattern of the fragments at each launch site, and record the number of pebbles embedded in the impact surface. Make sure to sketch the scatter pattern before entering the impact site.
7. Remember to work as a group. Record your observations at each launch site, and quickly move to the next site. Record data using the table below.
8. Clean up all balloon fragments, and leave impact areas as clean as possible.

Balloon	Distance from launch site to impact (centimeters)	Depth of impact crater (if measurable) (centimeters)	Width of impact scatter pattern (centimeters)
#1			
#2			
#3			
#4			

Answer the following questions:

1. Based on your data, which surface was the easiest for the pebbles to penetrate? Why? ____-
____

____
______

2. What kind of surface might be the best to use to prevent damage from meteorites? Why?
____

3. What does the number of pebbles embedded in the impact site tell you about the surface?

4. What does the number of pebbles deflected by the impact site tell you about the surface?

5. How might a scientist use this type of testing and information to help choose materials for spacecraft?

Sketch the scatter pattern of the fragments at each launch site, and record the number of pebbles embedded in the impact surface of each site.

Balloon #1	Balloon #2

Balloon #3	Balloon #4