RAY SHIELDING

Activity topic selected from NASA's 21st Century Explorer newsbreak "What would you hear in a weather report from Mars?"

Educator Section

Grade Level: 3-5

Connections to Curriculum: Science

Basic Science Process Skills: observing, predicting, measuring, inferring, classifying, number relationships (American Association for the Advancement of Science)

Teacher Preparation Time: 30 minutes

Lesson Duration: Part 1: 60 minutes. Part 2 (optional): 60 minutes.

Prerequisite: ultraviolet radiation, space radiation, Earth's atmosphere, ozone, ozone protection

National Education Standards addressed in this activity include Science, Technology, and Mathematics. For an alignment to standards in this activity, see page 7.

Introduction
When traveling through space, the space vehicle provides protection from the micrometeoroid particles which can be seen, and space radiation which cannot be seen. One of the most difficult things to block is space radiation, and it is also the most deadly. For long space exploration missions traveling beyond low-Earth orbit, materials used to build the spacecraft will need to provide the space explorer more protection from space radiation than what is currently provided.

Lesson Objective
In this lesson, students will analyze different materials to simulate space radiation shielding on a spacecraft and select the best material to build a spacecraft.

Problem
Which of the materials provided will block the most simulated space radiation, and be the best material to build a spacecraft?

Learning Objectives
Part 1: The students will

- collect data on space radiation shielding by observing a flashlight beam as it shines through different materials.
- collect data by measuring, predicting, counting, and weighing the materials that will shield simulated space radiation.
- analyze the data and select the most protective and lightweight material for a space exploration spacecraft.
- develop a conclusion based upon the results of this activity.

Part 2: The students will

- determine properties of materials to analyze and select testing methods.
- conduct a materials analysis, collect data, and compare the properties of the given materials.
- apply findings from the radiation shielding and material analysis to select the best material for a space exploration spacecraft.
- develop a conclusion based upon the results of this activity.

Materials Required

construction paper

card stock paper

copy paper

tissue paper

flashlights

balance or scale

gram weights or small paper clips

metric rulers

eye protection

NASA's 21st Century Explorer 30-second newsbreak – "What would you hear in a weather report from Mars?"

Materials

- NASA's 21st Century Explorer 30-second newsbreak, "What would you hear in a weather report from Mars?" (Download the newsbreak at http://education.jsc.nasa.gov/explorers/p11.html)
- gram weights or small paper clips
  - There are 3 sizes of trombone paper clips, small, medium and large. All three weigh differently. One small trombone paper clip weighs close to a gram. Do not use butterfly, plastic coated or double prong paper clips.
- balance or scale to weigh material (accessible to all groups)
  - Kitchen/cooking scale works best. Parcel post scale can also be used. If these are available, there is no need to use the gram weights or paper clips.

Per group

- 1 flashlight
- 1 metric ruler
- materials to test (all paper materials should be cut to the same size and be of the same color, white preferred)
  - unlined copy paper (at least 25 pieces)
  - tissue paper (at least 75 pieces)
  - construction paper (at least 10 pieces)
  - card stock paper (at least 10 pieces)

Per student

- eye protection (required for Part 2)
- Ray Shielding Student Section

Safety

Remind students about the importance of classroom and lab safety. Students should not look directly into the beam of the flashlights. Students should wear eye protection when needed, during this activity.

Pre-lesson Instructions

- Students should work in groups of 3 or 4.
- Cut all paper materials to the same size. Make sure the pieces are large enough to cover the beam end of the flashlight.
- Calibrate the scales.

Lesson Development

To prepare for this activity, the following background information is recommended:

- Read NASA's 21st Century Explorer Web Text Explanation titled "What would you hear in a weather report from Mars?" at http://education.jsc.nasa.gov/explorers/p11.html .
- Read the following text taken from the Observation Section of the Ray Shielding Student Section.

Observation

Space radiation comes from the Sun and from other stars from other galaxies. This radiation can have devastating effects on materials and the human body.

On Earth, the atmosphere contains a layer of ozone that prevents most of the ultraviolet rays from reaching us. We can use sunscreen on our skin to keep more of the ultraviolet rays from harming our skin. However, when astronauts live and work in space, away from Earth's protective atmosphere, they are exposed not only to ultraviolet rays but also to space radiation. Current spacecraft materials cannot block all of the radiation, so astronauts in space are exposed to more than the average person on Earth.

For longer missions, especially those taking astronauts far away from low-Earth orbit, more protection from space radiation will be needed. NASA is already working on how to make the spaceship safer by using different materials to provide protection.

In Part 1 of this activity, you will test the ability of different materials to shield simulated space radiation. The light from a flashlight will represent space radiation. Due to weight restrictions, the ship material will need to be as lightweight as possible but thick enough to keep the radiation at a minimum.

In Part 2 of this activity, you will conduct a materials analysis to gather more information on properties of each material. You will observe and record your materials analysis findings and choose the best material for design of a new spacecraft.

- Additional NASA information on materials and space radiation:

  NASA limits the number of flights and time in space per astronaut because of the dangers of space radiation. For now, limiting flights in low-Earth orbit and the amount of time astronauts are exposed to space radiation can protect them. Current materials used to construct spacecrafts cannot block all of the radiation, so astronauts in space are exposed to more than the average person on Earth.

  NASA is already working on how to make the spacecraft safer. Replacing the most widely utilized spacecraft structural material, which is aluminum, with new materials and structures that block some types of space radiations much more efficiently can be used for both main hull and crew compartment construction. Food, water, and clothing for the mission can also be positioned around the crew cabin to provide better shielding. However, some of the most dangerous kinds of space radiation are difficult to block with reasonable amounts of shielding material and NASA has long term studies in progress to keep astronauts safe on longer missions. Examples include the use of liquid hydrogen shielding systems, active shielding with very powerful magnetic fields, and high speed nuclear electric spacecraft to reduce astronaut exposure times. It is likely that NASA's continued space biomedical research program will produce the biggest improvements in astronaut protection from the effects of space radiation via improved post flight health monitoring and development of recently discovered radiation protection pharmaceuticals.

- If needed, additional research can be done on the following science topics:
  - solar radiation
  - cosmic radiation
  - Earth's atmosphere
  - ozone
  - ozone protection
  - spacecraft materials and construction

Instructional Procedure

1. Throughout this lesson, emphasize the steps involved in the scientific method. These steps are identified in ***bold italic*** print throughout the Instructional Procedure Section and in **bold** print throughout the Ray Shielding Student Section.
2. Preview the Scientific Investigation Rubric with the students, highlighting each Performance Indicator.

3. Show NASA's 21st Century Explorer newsbreak "What would you hear in a weather report from Mars?" to engage students and increase student knowledge about this topic.
4. Remind students about solar radiation, spacecraft construction, and Earth's protective atmosphere.
5. Review the problem with the students.
   Problem: Which of the materials provided will block the most simulated space radiation, and be the best material to build a spacecraft?
6. Have the students read the ***Observation*** Section in the Ray Shielding Student Section and discuss in their groups.
7. Encourage your students to discuss and make ***observations*** about this topic by completing the first two columns in the KWL (KNOW/WANT TO KNOW/LEARNED) chart on the Ray Shielding Student Section. Use the KWL chart to help students organize prior knowledge, identify interests, and make real-world connections. As students suggest information for the "KNOW" column, ask them to share how they have come to know this information.
8. Ask your students if they have predictions relating to this activity and the "problem question". Help them refine their predictions into a ***hypothesis***. In their Student Section, they should restate the "problem question" as a statement based upon their observations and predictions. Encourage students to share their hypothesis with their group.
9. Students will ***test*** their hypothesis following this procedure.
   (The following steps are taken from the Student Section. Educator specific comments are in italics.)

Test

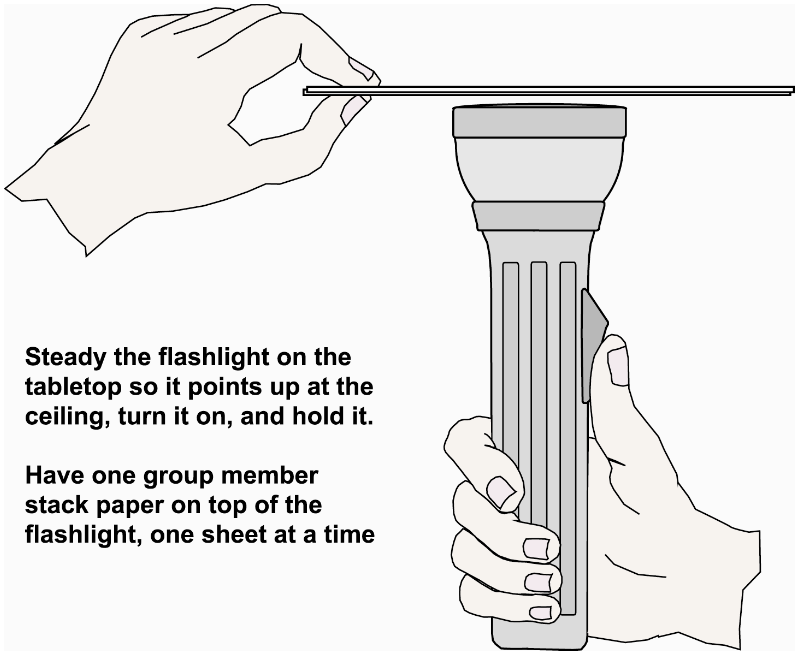
PART 1:

Part 1 of the activity can be conducted as its own activity. Part 2 can be conducted during the next class period if desired.

1. Each group member will have a designated job:
   - One student will hold the flashlight.
   - Another student will hold and stack the paper on top of the flashlight.
   - A third student will measure and weigh the material and record the data.
   - If you are working in groups of 4, the fourth student will be the recorder.
2. Measure in centimeters, the dimensions (length and width) of the materials (pieces of paper) your group will test and record on the Ray Shielding Analysis Chart.
3. Choose one material for radiation shield testing and predict how many pieces of that material it will take to completely block the simulated space radiation. Record the predicted amount on the Ray Shielding Analysis Chart.
4. The flashlight holder should steady the flashlight on the tabletop so it points up at the ceiling, turn it on, and keep holding it. CAUTION: Do not look directly into the flashlight beam.

   Remind students about the classroom and lab safety rules and caution them not to shine the flashlight beam into their eyes or at anyone else.
5. ***Collect Data***: Have one group member stack paper on top of the flashlight, one sheet at a time, to block the simulated space radiation (flashlight beam). As each piece of paper is added, the light beam should become weak. Continue adding one sheet at a time until the simulated space radiation is completely blocked. (See diagram.)

   Results will vary from group to group depending on flashlight bulb wattage and battery strength.



6. ***Record*** the number of sheets used to block the simulated space radiation on the Ray Shielding Analysis Chart.
7. Using a balance or scale, weigh the sheets used to block the simulated space radiation and ***record*** on the Ray Shielding Analysis Chart. Use your measurement and estimation skills to determine the weight in grams.

   If you are using paperclips on a balance as a substitute for the gram weights, make sure to tell the students that each paperclip is 1 gram. If you are using a parcel post scale or a food scale, there is no need to use the gram weights or paper clips.
8. Keep this stack of paper together, and set it aside to use later in the activity (Part 2).
9. Repeat steps 3–8 with each type of material/paper. Everyone in your group should switch roles when a new material is tested, so that every group member performs each duty.

Study Data

PART 1:

After taking all measurements, students should study the data by answering the questions on the Ray Shielding Analysis Chart.

Test

PART 2:

1. Gather the materials that were tested (stacks of paper) from Part 1 of the activity. Continue with the materials analysis by classifying the tested material. If you could classify all these materials in to one category, what would it be? Write your answer at the top of the Further Materials Analysis Web.

   All the material can be classified as “paper”. Have the students write “Paper” on the top line in the Further Materials Analysis Web.
2. Brainstorm properties of these materials that your group would like to test. These properties should be important factors that will help you decide which material to use to

build your spacecraft. Some examples might be “will the material tear?” or “will the paper stretch?“. Complete the Further Materials Analysis Web with the properties your group decides to test. A few properties have already been filled in.

Suggest to the students other properties that may be investigated such as: Is it bendable? Is it breakable? Will it bounce? What is its hardness/strength? Discuss with students what properties the materials will need to possess to travel into space.

3. List the properties that you want to test in the first column of the Further Materials Analysis Chart.
4. With your group, decide how you will test each property and write a short description in the second column of the Further Materials Analysis Chart.

   Make sure the students are choosing classroom safe tests and the tests are limited to what is in the classroom.

5. Put on your eye protection.

   Stress the importance of keeping eye protection on during this portion of the lesson.

6. Conduct your tests for each property by stacking the same number of tested materials (pieces of paper) that blocked the simulated space radiation (during Part 1), and then perform your test on that material. Rank each material (stack of paper) and ***record*** your ranking in the Further Materials Analysis Chart.

   The ranking will be from 0 to 5:
   - If the material shows no sign of that property, assign it a 0.
   - If the material shows a small sign of that property, assign it a lower number.
   - If the material shows a large sign of that property, assign it a larger number.

   Caution students to be careful and to test the materials safely.

7. Once you have conducted your tests and assigned a rank to each material, add up the numbers in each column. This will be the total rankings for each material.
8. Study the data from the Ray Shielding Analysis Chart (from Part 1) and the Further Materials Analysis Chart.

Study Data

PART 2:

After taking all measurements, students should study the data by answering the questions following the Further Materials Analysis Chart. And, they should study the data from the Ray Shielding Analysis Chart (from Part 1).

Conclusion

PART 1 and PART 2:

- Discuss the answers to the Ray Shielding Student Section questions (Part 1 and/or Part 2, as appropriate).
- Have the students update the LEARNED column in their KWL chart.
- Have students write a conclusion by restating their hypothesis and explaining how the results do, or do not, support their hypothesis.
- Ask students to compare their individual data from both analyses to the class data. What patterns can be found?
- Discuss ways to apply the students’ findings to select a material for providing radiation shielding when building a spacecraft to protect the astronauts.

- Ask students what they wonder now. Encourage students to design their own activities.

Assessment

- Assess student knowledge through questioning.
- Observe and assess student performance throughout the activity using the attached Scientific Investigation Rubric.

Activity Alignment to National Education Standards

Next Generation Science Standards (NGSS)
Science and Engineering Practices

- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Physical Science

- PS1.A Structure of matter
- PS4.B Electromagnetic radiation

Engineering, Technology, and Applications of Science

- ETS1: Engineering Design
- ETS2: Links Among Engineering, technology, Science, and society

Common Core State Standards - Mathematics (CCSS-M)
Measurement &Data

- Describe and compare measurable attributes
- Represent and interpret data
- Measure and estimate lengths in standard units

Statistics & Probability

- Summarize and describe distributions

International Technological and Engineering Educators Association (ITEEA)
The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.

Design

- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 11: Students will apply the design process.

Curriculum Explorations

To extend the concepts in this activity, the following explorations can be conducted:

Engineering and Design

Student can apply their findings from both materials analysis to build a spacecraft with the best material. As a group, the students should determine design requirements for the spacecraft. You may require students to:

- consider using different types of materials for different parts of the spacecraft (for example, the living and working areas of the spacecraft may need higher radiation shielding than other areas of the spacecraft).
- consider weight restrictions
- allow the addition of their own requirements to their design as desired
- add other requirements (such as a window)

Student should compare the final spacecraft designs and explain the choices made. Discuss the similarities and differences in design. Analyze the data, looking for patterns and trends.

ITEEA Technology Standards

The Nature of Technology
- Standard 1: Students will develop an understanding of the characteristics and scope of technology.

Design
- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem

Abilities for a Technological World
- Standard 11: Students will apply the design process.

Mathematics

Compare all the graphic organizers that were created. Which type of organizer was the best display for this data?

Common Core State Standards - Mathematics

Measurement & Data
- Describe and compare measurable attributes
- Represent and interpret data
- Measure and estimate lengths in standard units

Language Arts

Ask students to explain the activity. How might students improve this activity? Where might there have been mistakes made? How might these mistakes have affected the results?

Common Core State Standards - English Language Arts

Literacy in History/Social Studies, Science, & Technical Subjects
- Integration of Knowledge and Ideas

Sources and Career Links

Thanks to subject matter experts Mark Weyland and Steven Koontz for their contributions to the development of this education material.

Find out more about the Space Radiation Analysis Group at the NASA Johnson Space Center at http://srag.jsc.nasa.gov/Index.cfm and the work they do with protecting astronauts here http://srag.jsc.nasa.gov/SpaceRadiation/How/How.cfm

To find out more about the International Space Station
http://www.nasa.gov/mission_pages/station/research/index.html

To learn about space radiation and humans in space from the Human Research Program
http://www.nasa.gov/exploration/humanresearch/elements/research_info_element-srpe.html

This activity was adapted from existing NASA educational products.

Lesson development by the NASA Johnson Space Center Human Research Program Education Outreach team.

Scientific Investigation Rubric

Activity: RAY SHIELDING

Student Name ___________________________________ Date ___________________

Performance Indicator	**0**	**1**	**2**	**3**	**4**
The student developed a clear and complete hypothesis.					
The student followed all lab safety rules and directions.					
The student followed the scientific method.					
The student recorded all data on the data sheet and drew a conclusion based on the data.					
The student asked engaging questions related to the study.					
The student analyzed their findings from this activity and selected the best material for a space exploration spacecraft from this analysis.					
Point Total					

Point total from above: ________ **/ (24 possible)**

Grade for this investigation __________________

Grading Scale:

A = 22 - 24 points

B = 19 - 21 points

C = 16 - 18 points

D = 13 - 15 points

F = 0 - 12 points