



RAY SHIELDING

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

Educator Section

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 activity, you 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

- gather data on space radiation shielding by observing a flashlight beam as it shines through different material.
- gather 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, gather 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.

Grade Level: 3-5

Connections to Curriculum: Science

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

Teacher Preparation Time: 30 minutes

Lesson Duration: Part 1: 50 minutes.
Part 2 (optional): 45 minutes.

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

National Education Standards

addressed in this activity include Science (NSES), International Technology Education Standards (ITEA) and Mathematics (NCTM). For an alignment to standards in this activity, see page 7.

Materials Required

construction paper
card stock paper
unlined copy paper
tissue paper
flashlights
balance or scale
gram weights or small paper clips
metric rulers
safety glasses

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

Materials

- NASA's KSNN™ 21st Century Explorer 30-second newsbreak, "What would you hear in a weather report from Mars?" (Download the newsbreak at <http://ksnn.larc.nasa.gov>.)
- 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 for this experiment.
- 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

- 1 pair of safety glasses (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.

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 KSNN™ 21st Century Explorer Web Text Explanation titled "What would you hear in a weather report from Mars?" at <http://ksnn.larc.nasa.gov>.
- 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. Materials like aluminum (absorbs about half the radiation) and polyethylene (absorbs 20 percent more than aluminum) can be used for main hull construction and can be supplemented with plastic sections and liquid hydrogen tanks on the outside of the space ship to improve the radiation-blocking ability.

- 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

Throughout this lesson, emphasize the steps involved in the scientific method. These steps are identified in ***bold italic*** print throughout the Instructional Procedure Section.

1. Show NASA's KSNM™ 21st Century Explorer newsbreak "What would you hear in a weather report from Mars?" to engage students and increase student knowledge about this topic.
2. Remind students about solar radiation, spacecraft construction, and Earth's protective atmosphere.
3. 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?
4. Have the students read the ***Observation*** Section in the Ray Shielding Student Section and discuss in their groups.
5. 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.”

6. 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.
7. Students will ***test*** their hypothesis following this procedure.
(The following steps are taken from the Student Section. Educator specific comments are in italics.)

PART 1:

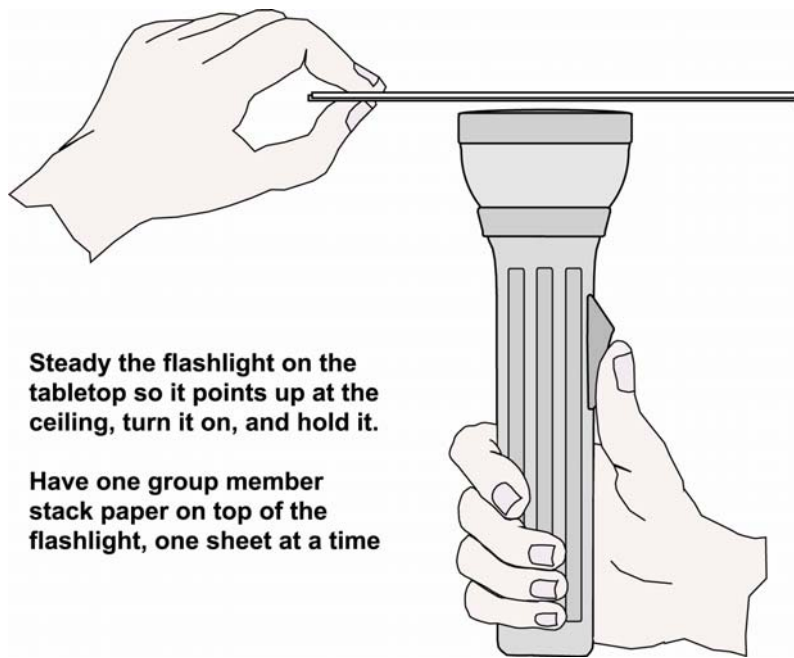
Part 1 of the activity can be conducted as its own activity. Part 2 can be conducted during the next class period if desired.

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.



Steady the flashlight on the tabletop so it points up at the ceiling, turn it on, and hold it.

Have one group member stack paper on top of the flashlight, one sheet at a time

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.
10. After taking all measurements, **study the data** and **draw conclusions** by answering the questions following the Ray Shielding Analysis Chart.

Using this information, ask students to determine if the data supports or refutes their hypothesis.

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 safety glasses.

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.
9. After taking all measurements, **study the data** and **draw conclusions** by answering the questions following the Further Materials Analysis Chart.

Using this information, ask students to determine if the data supports or refutes their hypothesis.

Conclusion

- 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.
- 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 experiments.

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

National Science Education Standards (NSES):

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry (K-8)
- Understandings about scientific inquiry (K-8)

Content Standard B: Physical Science

- Properties of objects and materials (K-4)
- Light, heat, electricity, and magnetism (K-4)
- Transfer of energy (5-8)

Content Standard E: Science and Technology

- Abilities of technological design (K-8)
- Understanding about science and technology (K-8)

National Mathematics Education Standards (NCTM):

Algebra Standard:

- Use mathematical models to represent and understand quantitative relationships
 - model problem situations with objects and use representations such as graphs, tables, and equations to draw conclusions

Measurement Standard:

- Apply appropriate techniques, tools, and formulas to determine measurements
 - select and apply appropriate standard units and tools to measure length, area, volume, weight, time, temperature, and the size of angles

Data Analysis and Probability Standard:

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
 - collect data using observations, surveys, and experiments
 - represent data using tables and graphs such as line plots, bar graphs, and line graphs
- Develop and evaluate inferences and predictions that are based on data
 - propose and justify conclusions and predictions that are based on data and design studies to further investigate the conclusions and predictions

International Technology Education Association (ITEA)

Design

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

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.

International Technology Education Association (ITEA):

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

National Science Education Standards (NSES):

Content Standard E: Science and Technology

- Abilities of technological design (K-8)
- Understanding about science and technology (K-8)

Mathematics

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

National Mathematics Education Standards (NCTM) (3-5):

Data Analysis and Probability Standard:

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
 - collect data using observations, surveys, and experiments
 - represent data using tables and graphs such as line plots, bar graphs, and line graphs

Language Arts

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

National Council of Teachers of English Standards (NCTE):

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

Sources and Career Links

Thanks to subject matter experts Mark Weyland for his contributions to KSNM™ and Noticias NASA™ on the development of this education material.

Find out more about Mark Weyland and the work that he does with the Space Radiation Analysis Group at the NASA Johnson Space Center at http://haco.jsc.nasa.gov/projects/space_radiation.cfm.

This activity was adapted from existing NASA educational products.

Lesson development by the NASA Johnson Space Center Human Health and Performance Education Outreach team.

Scientific Investigation Rubric

Experiment: 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 experiment 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