

Energy and Color

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Mission Scenario: All Scenarios

Application to Mission Preparation: Current and future spacecraft must use light as an energy source. Students will gain an understanding of how the amount of energy available is affected by light color.

Whole Group/Small Group/Individual: A whole group working in small teams; small group

Team (if applicable): All teams/Life Support

Summary: Through the use of a prism, students will discover that "white" light is a combination of all the colors in the visible light spectrum. Using this knowledge, students will investigate the energy characteristics of these colors using colored acetate filters and solar collection cells that are attached to a small motor. Their experiment will allow them to determine the different energy capacities of colored light.

LESSON AT A GLANCE

Subject(s): Science

Grade/Level: 5-8

Objective:

- Students will discover that "white" light is a combination of the colors of the visible light spectrum.
- Students will follow directions to set up a light-energy experiment.
- Students will work as a team to construct a functional solar-collection unit.
- Students will observe, record and analyze experimental data to determine what color wavelength provides the greatest/least amount of energy.

Standards:

USA- National Science Education Standards

- **Chapter Chapter 6:** Science Content Standards
 - **Grade Level :** 5-8
 - **Content Standard A:** Science as Inquiry: As a result of activities in grades 5-8, all students should develop
 - **Ability/ Concept :** Abilities necessary to do scientific inquiry

■ **Detail** : USE APPROPRIATE TOOLS AND TECHNIQUES TO GATHER, ANALYZE, AND INTERPRET DATA. The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.

■ **Detail** : DEVELOP DESCRIPTIONS, EXPLANATIONS, PREDICTIONS, AND MODELS USING EVIDENCE. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description--providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.

■ **Detail** : THINK CRITICALLY AND LOGICALLY TO MAKE THE RELATIONSHIPS BETWEEN EVIDENCE AND EXPLANATIONS. Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables.

■ **Detail** : USE MATHEMATICS IN ALL ASPECTS OF SCIENTIFIC INQUIRY. Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations.

• **Content Standard B:** Physical Science: As a result of their activities in grades 5-8, all students should develop an understanding of

• **Ability/ Concept** : Transfer of energy

■ **Detail** : Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

■ **Detail** : The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation

• **Content Standard A:** Science as Inquiry: As a result of activities in grades 5-8, all students should develop

• **Ability/ Concept** : Abilities necessary to do scientific inquiry

■ **Detail** : RECOGNIZE AND ANALYZE ALTERNATIVE EXPLANATIONS AND PREDICTIONS. Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.

■ **Detail** : COMMUNICATE SCIENTIFIC PROCEDURES AND EXPLANATIONS. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations

Time Required: 2 class periods. 40 Min. per class.

Essential Question: What light color of the spectrum provides the most energy?

Lesson Overview: Students will conduct an experiment that will allow them to investigate the energy properties of colored light.

TEACHER PREPARATION

Subject Matter Overview: Characteristics of light and light energy will be addressed in this investigation.

Materials: Attached you will find the student directions and worksheet.

Attachments:

1. [Energy and Color](#)

Preparation:

1. Gather experiment equipment and organize in an area where students can access it.
2. Copy student pages (1 per student)

Differentiated Instruction: This experiment is a "hands-on" experiment. Students of all types will be successful in the experimental set-up. Teacher demonstration of the set-up procedures before students begin their set-up will assist students who have reading difficulties. Students should be grouped by the teacher for optimum learning conditions. (Pair lower functioning students with those that are normal to high functioning.)

Advanced learners can expand their understanding of light by researching the "Why" question: Why do certain colors of light have a greater energy capacity? Using resource materials, they can research this question and then present their findings to the entire group.

Presenting those advanced learners that are more "hands-on" with the challenge of arranging the solar collection cells in a circuit, attached to one motor, will exercise their problem solving abilities. This set-up will also provide the students with a more "dramatic" set of data of work with at the conclusion of the experiment.

TEACHING THE LESSON

Lesson Management: The teacher demonstration of breaking white light into its component colors should be conducted using an overhead. The student experiment should be completed using natural Sunlight. If Sunlight is unavailable, a 75-100 watt bulb can be used.

The colored acetate filters should be placed directly over the solar collection cell. This will eliminate "contamination" by "white" light.

Teaching Tips: Begin this investigation by asking students what source(s) of energy is/are used by astronauts on the space station. (Having a picture of the space station available may aid the students.) After the students have concluded that light energy from the Sun is collected by the space station solar arrays and used by the astronauts, tell them that they are going to conduct an experiment with light.

Ask students what colors are in white light. They may be confused by the question. ("Isn't white light just white?") After a short discussion, allowing students to voice their ideas, use a prism to demonstrate that white light can be broken into the colors that make it up: the colors of the visible light spectrum; red, orange, yellow, green, blue, indigo and violet (Roy G. Biv) Using an overhead that has been covered with black construction paper except for a small area in the middle of the overhead glass center, will create a good light source to use to break the light up without causing stress on the eyes or "washing" the spectrum out because there is too much light.

Following the teacher demonstration, tell students that they can investigate the energy properties of colored light using a solar collection cell and colored acetate filters.

Using a list prepared in advance, group students into investigation teams. (Groups of 3-4 students work best.) Demonstrate the set-up of this experiment. Have students read the directions to you as you complete the steps with the equipment.

As students are working, circulate through the room, providing assistance as needed. Ask "curiosity questions" such as "Why do you think the motor turned more when the _____ filter was in place than when the _____ filter was in place?"

If colored acetate filters are unavailable, you can create your own. Cut a sheet of transparency film into six squares. Using a dry or wet-erase marker, color the square of transparency film so that the entire surface is colored. (Some permanent markers will also work.) Allow the transparency film to dry before handling. The colors needed for this investigation are red, yellow, green and blue.

Student Instructions: The student instructions can be found under the Materials section. These instructions are written at a middle school comprehension level. Each student should be given their own set of instructions. (This makes them responsible for their learning.)

Student Worksheets: The student worksheets can also be found under the Materials section. Each student should be given their own set of instructions.

Materials and resources:

Solar collection cells, Red acetate filter, Yellow acetate filter, Green acetate filter, Blue acetate filter, small motor, Tape, Coated wire with clips, Stopwatch

ASSESSMENT AND EXTENSIONS

Assessment/Rubrics:

1. [What Light Color provides the Most Energy?](#)

Extension Activities: Once students has finished using the red, yellow, green and blue acetate filters, they could create their own filters (as described in Teaching Tips) to investigate other colors of the spectrum. They could then compare the energy amounts and create a visual display of their data, in the form of a chart or graph.

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What Light Color provides the Most Energy?

Background:

The Life Support team has a crucial mission; making sure the astronauts' environment is safe and stable. Solar cells collect light energy from the Sun so that this energy can be used by the astronauts for mission work and maintaining a constant "Shuttle-internal" environment. This activity will allow you to work with solar collection cells and colored acetate filters so that you can investigate the different amounts of energy found in colored light.

Objectives:

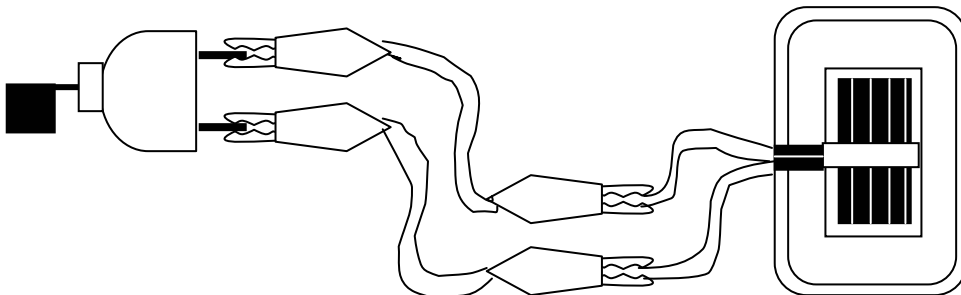
- *Student teams will work together to construct a functional solar-collection unit.
- *Student teams will assess the amount of energy received by the solar collection unit under varied colors of light.
- *Student teams will decide which color of light allows for the maximum collection of energy.

Materials:

Solar-collection cell	small motor	coated wire with clips (2)
Red plastic filter	Yellow plastic filter	Green plastic filter
Blue plastic filter	Tape	Stopwatch

Procedure:

1. Create a hypothesis for this experiment by answering this question on your data log: **What color of light do you think will provide the most energy (as evidenced by the number of motor rotations)?**
2. Obtain materials from your teacher. Using a small piece of tape, make a flag for the motor post by folding the tape over on itself with the center wrapping around the motor post.
3. Following the diagram below, assemble the solar-collection cell by attaching lead wires from the solar-cell to the motor with coated wire.



4. Move solar-collection assembly to a window which the sun is shining through. (If a window is not available, the use of a light with a 75-100 watt bulb will work.)
5. Tape the solar-collection cell down to the surface so that it is not accidentally moved. (As with any experiment, there should be only one variable, in this case, that of color. Taping the collection cell down so that it will not move eliminates the possibility of the accidental movement of the cell which could affect the amount of light entering the cell.)
6. You will be using the "tape flag" to count the number of times the motor turns. Practice counting the flag as it moves in a circle. (It may help to place a pencil near, but not touching, the flag. Every time the flag goes by the pencil, a turn has been completed and should be counted.)
7. Assign "jobs" to the team members. Two members should count the number of times the motor turns. One member should use the stopwatch to keep track of time. One member can hold the colored acetate in place.
8. Begin your experiment by laying the red filter over the top of the collection cell. For 1 minute, count the number of times the motor turns. Record this number in the data table on your observation sheet.
9. Complete Step #8 two more times, each time recording the number of turns in the data table.
10. Remove the red filter from the collection cell and place the yellow filter over the collection cell. For 1 minute, count the number of times the motor turns. Record this number in the appropriate box in the data table.
11. Complete Step #10 two more times, each time recording the number of turns in the data table.
12. Repeat this process of changing filters and counting/recording motor turns for the green filter and the blue filter.

13. When you have completed investigating all four filters, disconnect the motor from the solar-collection cell and answer the questions on your data log.
14. Return all equipment to your teacher.

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Hypothesis: _____

Data Table

Filter Color	Trial #1	Trial #2	Trial #3	Average
Red				
Yellow				
Green				

Once you have completed all of the trials, average the trials for each filter and record the result in the column labeled "Average."

(To average, add the numbers of the three trials for the red filter together and divide by three. Record that number in the "Average" column. Average the numbers for the remaining filters in the same way.)

Analysis and Conclusion

1. What is the function of a solar collection cell? _____

2. In what way would solar cells be of benefit to the astronauts on the space shuttle or space station?

3. What is the purpose of obtaining three sets of data for each colored filter and using the average of that data in your analysis and conclusion?

4. Using the information in the "Averages" column of your data table, what light color turned the motor the greatest number of times?

5. Referring to your answer in question #4, what does this mean for that light color?

6. Using the information in the "Averages" column of your data table, what light color turned the motor the least number of times?

7. Referring to your answer in question #6, what does this mean for that light color?

8. Based on the information you obtained in your experiment, answer the following question: If the astronauts needed maximum energy in the space shuttle, which color filter would they want to have in place? Why?

9. Was your hypothesis correct? In not, explain why it was incorrect. _____

10. What other questions do you have about light and energy? _____

What Light Color provides the Most Energy? Rubric

Levels:

	1	2	3	4	Score
<i>Criteria:</i>					
Data and Observations	Data and observations are incorrect or missing entirely. Relevant units or labels are missing.	Data and observations are incomplete or do not include sufficient details. Relevant units or labels may be missing.	Data and observations are complete and correct.	Data and observations are complete and correct, with all relevant units and labels included. Student provides a level of detail and organization that goes above and beyond requirements.	
Conclusions and Explanations	Conclusions and explanations are missing or do not make sense given student's data and observations.	Conclusions and explanations are incomplete not supported by sufficient details. Relevant data and observations are not referenced.	Conclusions and explanations are complete and supported by student's data. Relevant data and observations and referenced where appropriate.	Conclusions and explanations are complete and supported by student's data. Student provides a level of detail and depth that goes above and beyond requirements.	
Materials and Tools	Student is unable to identify many tools and materials. Student does not use materials and tools appropriately or responsibly.	Student is able to identify nearly all tools and materials. Student does not use all tools and materials appropriately or responsibly.	Student is able to identify all tools and materials. Student usually uses tools and materials appropriately and responsibly.	Student is able to identify all tools and materials. Student uses tools and materials appropriately and responsibly.	
Procedure	Student does not	Student correctly	Student follows	Student	

	correctly follow many aspects of the procedure.	follows some aspects of procedure, but makes crucial mistakes or skips some important steps.	critical aspects or procedure, but has difficulty responding effectively to problems.	correctly follows every aspect of the procedure and supplements procedure with effective and inventive additions.
Collaboration	Student is unable to work cooperatively with lab partners to complete the activity. Requires continual intervention by teacher.	Student simply follows directions of partner(s) and makes little effort to actively contribute.	Student is able to work cooperatively with lab partners to complete the activity, but may not be receptive to partners' ideas.	Student works cooperatively with lab partners to complete the activity, emerging as an effective collaborator who supports the ideas and suggestions of his/her peers.
Use of Numerical Data	Relevant data not cited or cited erroneously. Units are not accurate and values are not consistent with general explanation.	Some data cited are inaccurate or have inappropriate units. No attention to size of values. Important omissions.	Data cited are accurate and have appropriate units. For some data the citation shows poor understanding of size of values. Minor omissions.	Data cited are always accurate and appropriate units. The citation indicates understanding of size of values.
