

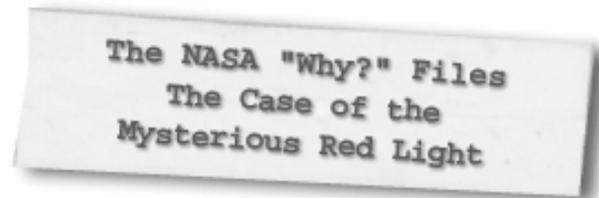


National Aeronautics and
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Langley Research Center
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Educational Product	
Educators	Grades 3-5

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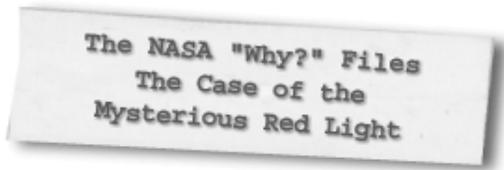


**A Lesson Guide with Activities in
Mathematics, Science, and Technology**



The Case of the Mysterious Red Light lesson guide is available in electronic format through NASA Spacelink - one of NASA's electronic resources specifically developed for the educational community. This publication and other educational products may be accessed at the following address: **<http://spacelink.nasa.gov/products>**

A PDF version of the lesson guide for NASA "Why?" Files can be found at the NASA "Why?" Files web site: **<http://whyfiles.larc.nasa.gov>**



A Lesson Guide with Activities in Mathematics, Science, and Technology

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Registered users of the NASA "Why?" Files may request an American Institute of Aeronautics and Astronautics' (AIAA) classroom mentor. For more information or to request a mentor, e-mail nasawhyfiles@aiaa.org.



Program Overview

Each day, for no apparent reason, the morning and evening sky blazes with a brilliant deep red color. In *The Case of the Mysterious Red Light*, the tree house detectives are determined to solve this mystery, but are puzzled as to what phenomena could be causing the bright red sunrises and sunsets.

As the tree house detectives set out to solve this case, they decide to learn more about light. They visit the Boston Science Museum where they learn what light is and how it travels. NASA researchers and other community experts help the tree house

detectives understand the properties of light, including frequency, amplitude, reflection, refraction, and much more.

The tree house detectives get a little help from the famous magician, Franz Harary, who makes a NASA plane disappear before their very eyes. Once the detectives understand that "seeing is not always believing," they are hot on the trail of the possible cause for the brilliant sunrises and sunsets. As they "dust off" their thinking caps, they realize that this case may "erupt" before their very eyes.

National Geography Standards (grades 3-5)

Standard	Segment			
	1	2	3	4
The geographically informed person knows and understands				
The World in Spatial Terms				
How to use maps and other graphic representations, tools, and technologies to acquire, process, and report information from a spatial perspective			x	x
Places and Regions				
The physical and human characteristics of places		x		
Physical Systems				
The physical processes that shape the patterns of the Earth's surface			x	
Environment and Society				
How physical systems affect human systems			x	
Uses of Geography				
How to apply geography to interpret the past			x	



National Science Standards (Grades K – 4)

Standard	Segment			
	1	2	3	4
Unifying Concepts and Processes				
Systems, orders, and organization	X	X	X	X
Evidence, models, and explanations	X	X	X	X
Change, constancy, and measurement	X	X	X	X
Evolution and equilibrium			X	
Form and function			X	
Science and Inquiry (Content Standard A)				
Abilities necessary to do scientific inquiry	X	X	X	X
Understandings about scientific inquiry	X	X	X	X
Physical Science (Content Standard B)				
Properties of objects and materials	X	X	X	X
Position and motion of objects			X	
Light, heat, electricity, and magnetism	X	X	X	X
Earth and Space Science (Content Standard D)				
Properties of earth materials			X	X
Objects in the sky	X		X	X
Changes in earth and sky	X	X	X	X
Science and Technology (Content Standard E)				
Abilities of technological design	X	X	X	X
Understanding about science and technology	X	X	X	X
Science in Personal and Social Perspective (Content Standard F)				
Personal health		X		
Changes in environment	X	X	X	X
History and Nature of Science (Content Standard G)				
Science as a human endeavor	X	X	X	X

National Science Standards (Grades 5 - 8)

Standard	Segment			
	1	2	3	4
Unifying Concepts and Processes				
Systems, order, and organization	X	X	X	X
Evidence, models, and explanations	X	X	X	X
Change, constancy, and measurement	X	X	X	X
Evolution and equilibrium			X	
Form and function			X	
Science as Inquiry (Content Standard A)				
Abilities necessary to do scientific inquiry	X	X	X	X
Understanding about scientific inquiry	X	X	X	X
Physical Science (Content Standard B)				
Motion and forces	X	X	X	X
Transfer of energy	X	X	X	X
Earth and Space Science (Content Standard D)				
Structure of the earth system			X	X
Earth's history			X	
Earth in the solar system			X	X
Science and Technology (Content Standard E)				
Abilities of technological design	X	X	X	X
Understanding about science and technology	X	X	X	X
Science in Personal and Social Perspectives (Content Standard F)				
Personal health		X		
Science and technology in society	X	X	X	X
History and Nature of Science (Content Standard G)				
Science as a human endeavor	X	X	X	X
Nature of science	X	X	X	X



National Mathematics Standards (Grades 3 - 5)

Standard	Segment			
	1	2	3	4
Number and Operations				
Understand meanings of operations and how they relate to one another.			X	X
Compute fluently and make reasonable estimates.			X	X
Algebra				
Understand patterns, relations, and functions.				X
Use mathematical models to represent and understand quantitative relationships.			X	X
Analyze change in various contexts.				X
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement.	X	X	X	X
Apply appropriate techniques, tools, and formulas to determine measurements.	X	X	X	X
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.	X	X	X	X
Select and use appropriate statistical methods to analyze data.				X
Develop and evaluate inferences and predictions that are based on data.				X
Understand and apply basic concepts of probability.	X	X	X	X
Problem Solving				
Build new mathematical knowledge through problem solving.	X	X	X	X
Solve problems that arise in mathematics and in other contexts.	X	X	X	X
Apply and adapt a variety of appropriate strategies to solve problems.	X	X	X	X
Monitor and reflect on the process of mathematical problem solving.	X	X	X	X
Communication				
Organize and consolidate their mathematical thinking through communication.			X	X
Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.			X	X
Analyze and evaluate the mathematical thinking and strategies of others.			X	X
Connections				
Recognize and use connections among mathematical ideas.			X	X
Recognize and apply mathematics in contexts outside of mathematics.				X
Representation				
Create and use representations to organize, record, and communicate mathematical ideas.			X	X
Select, apply, and translate among mathematical representations to solve problems.				X



National Technology Standards (ITEA Standards for Technology Literacy, Grades 3 – 5)

Standard	Segment			
	1	2	3	4
Nature of Technology				
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	X	X	X	X
Standard 2: Students will develop an understanding of the core concepts of technology.	X	X	X	X
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	X	X	X	X
Technology and Society				
Standard 5: Students will develop an understanding of the effects of technology on the environment.			X	X
Design				
Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	X	X	X	X
Abilities for a Technological World				
Standard 11: Students will develop the abilities to apply the design process.	X	X	X	X
Standard 12: Students will develop abilities to use and maintain technological products and systems.	X	X	X	X
Standard 13: Students will develop abilities to assess the impact of products and systems.	X	X	X	X
The Designed World				
Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.	X	X	X	X



National Technology Standards (ISTE National Educational Technology Standards, Grades 3 - 5)

Standard	Segment			
	1	2	3	4
Basic Operations and Concepts				
Use Keyboards and other common input and output devices efficiently and effectively.	X	X	X	X
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	X	X	X	X
Technology Productivity Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	X	X	X	X
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	X	X	X	X
Use telecommunication efficiently and effectively to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.	X	X	X	X
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	X	X	X	X
Technology Research Tools				
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	X	X	X	X
Use technology resources for problem solving, self-directed learning, and extended learning activities.	X	X	X	X
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	X	X	X	X
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem solving, self-directed learning, and extended learning activities.	X	X	X	X
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	X	X	X	X



The NASA "Why?" Files
The Case of the
Mysterious Red Light

Segment 1

Realizing that not even magic can make the brilliant red sunrises and sunsets disappear, the tree house detectives begin their investigation by visiting the Boston Museum of Science. There they learn the difference between natural and artificial light, what light is made of, and how light travels.

The tree house detectives feel a bit confused and decide that their next stop needs to be NASA Langley Research Center in Hampton, Virginia. There they speak with Clayton Turner aboard NASA's 757 research plane. Mr. Turner explains what a spectrometer is and clarifies how light can travel both in a straight line and in waves. He further demonstrates wavelength and frequency while explaining the parts of a wave.

The tree house detectives are excited as they formulate a hypothesis. They are sure that they are on the right "frequency" to solve this mystery

Objectives

The student will

- understand the difference between natural and artificial light.
- learn that light is composed of photons.
- learn that light travels in a straight line.
- learn that light travels in waves.
- learn the parts of a wave.
- understand wavelength and frequency.

Vocabulary

amplitude - in a wave, one half the distance from the bottom of the trough to the top of the crest

artificial light - man-made light produced from artificial sources such as electricity

atom - the smallest part of an element

crest - high point of a wave

frequency - number of complete waves that pass a fixed point in a given unit of time

light - a form of energy called radiant energy that travels freely through space

natural light - light that comes from natural sources such as the Sun, lightning, and fire

photons - a tiny packet or bundle of energy belonging to a particular wavelength that is released when an electron loses its extra energy. Light is a stream of photons.

ray - a straight line that represents the motion of light in one direction

spectrometer - an instrument that separates light into its respective frequencies or waves and has a scale for measuring the frequency or wavelength

trough - lowest point of a wave

wave - disturbance that transfers energy through matter or space

wavelength - distance between any two corresponding points on successive waves, usually crest-to-crest or trough-to-trough

Video Component

Implementation Strategy

The NASA "Why?" Files is designed to enhance and enrich the existing curriculum. Two to three days of class time is suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 1 of *The Case of the Mysterious Red Light*, read the program overview (p. 5) to the students. List and discuss questions and preconceptions that students may have about light.
2. Record a list of issues and questions that the

students want answered in the program. Determine why it is important to define the problem before beginning. From this list, guide students to create a class or team list of three issues and four questions that will help them to better understand the problem. The following tools are available on the web site to assist in the process.

Problem Board - printable form to create student or class K-W-L chart

PBL Questions - questions for students to use while conducting research

Problem Log - printable log for students with the stages of the problem-solving process



2001 – 2002 NASA “Why?” Files Programs

The Scientific Method - chart that describes the scientific method process

3. **Focus Questions** - questions at the beginning of each segment help students focus on a reason for viewing the videotape and can be printed from the web site so that students can write them in their science journals. Encourage students to take notes during the show to answer the questions.

View Segment 1 of the Video

For optimal educational benefit, view *The Case of the Mysterious Red Light* in 15-minute segments and not in its entirety.

After Viewing

1. Have students reflect on the “What’s Up?” questions asked at the end of each segment.
2. Have students work in groups or as a class either to develop a hypothesis or to determine if the tree house detectives’ hypothesis is correct. Guide students to determine if their choices are possible solutions, facts, or pure speculations. Extend this discussion by having them rank their choices. Investigate the top two choices.

Validation Station - printable form to help students validate their hypothesis

3. Choose activities from the educator’s guide and web site to reinforce concepts discussed in the segment. The variety of activities is designed to enrich and enhance your curriculum. They also help students “solve” the problem along with the tree house detectives. Ask students, “Why is it important for the tree house detectives to know these concepts?” For example: Why would they need to know the difference between natural and artificial light? After completing the activity, “Natural or Artificial” (p. 15), the students should be able to understand that the bright red sky is not coming from an artificial source and therefore rule out possibilities such as bright streetlights.
4. Have the students work individually, in pairs, or in small groups on the problem-based learning activity on the NASA “Why?” Files web site.

To begin the PBL activity, read the scenario to the students.

Read and discuss the various roles involved in the investigation. Have each student choose his/her role.

Print the criteria for the investigation and distribute.

Have students use the Research Rack located on the web site and the online tools that are available.

5. Having students reflect in their journals what they have learned from this segment and from their own experimentation and research is one way to assess their understanding. In the beginning, students may have difficulty reflecting. To help students, give them specific questions related to the concepts to reflect upon.
6. The NASA “Why?” Files web site provides checklists and rubrics that may assist teachers in assessment. Other tools found on the web that can be useful in assessing students’ learning are the Problem Log and the Validation Station.

Careers

museum curator
magician
engineer
professor



Resources (additional resources located on web site)

Books

Burnie, David: *Eyewitness: Light*. DK Publishing Inc., 1999, ISBN: 0789448858

Cobb, Vicki; Josh Cobb; Theo Cobb (illustrator); and Joshua Cobb. *Light Action! Amazing Experiments with Optics*. Harper Collins Children Books, 1993, ISBN: 0060214376

Web Sites

Physics with David Harris

A great resource for your physics questions. Includes an online dictionary, articles covering various subjects, and links to over 700 sites.
<http://physics.about.com/mbody.htm>

Boston Museum of Science

Check out the Boston Museum of Science. Visit the great online exhibits and educators' resources.
<http://www.mos.org/home.html>

How Stuff Works: Light

This site looks at light from many different angles. It helps people understand "How Light Works!"
<http://www.howstuffworks.com/light.htm>

The Center for Science Education at the Space Sciences Lab: Light Tour

This site addresses the behavior of light, measuring a light wavelength and properties of a wave.
<http://cse.ssl.berkeley.edu/light/measure.html>

ThinkQuest: Discovering Light

This web site provides background on the physics of light, light in nature, and light in technology, a great background resource that covers a wide range of content areas within the topic of light.
<http://library.thinkquest.org/27356/index.htm>

The Sun

This site has a collection of facts and images of the Sun.
<http://seds.lpl.arizona.edu/nineplanets/nineplanets/sol.html>

NASA Sun-Earth Day

Visit this site to learn about common misconceptions held about the Sun-Earth relationship.
http://sunearth.gsfc.nasa.gov/SECEF_SunEarthDay/Ten.htm

Activities and Worksheets

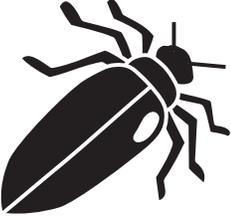
In the Guide	<p>Natural or Artificial Learn the difference between natural and artificial light.15</p> <p>Photons Learn how photons travel from the Sun to the Earth.16</p> <p>Traveling the Straight and Narrow Explore how light travels in a straight line.17</p> <p>Roping the Wave Demonstrate light traveling in waves.18</p> <p>Wave Upon Wave Understand wave frequency.19</p> <p>Roll Out the Frequency Learn how frequency and wavelength are related.20</p>
On the Web	<p>The Incredible Edible Wave Learn the parts of the wave and then enjoy it!</p>



Natural or Artificial

Almost all the natural light the Earth receives comes from the Sun. The Sun is a star that creates its own light. People control some sources of light called artificial light. Look at the pictures below and determine if they are sources of natural or artificial light.

Lightning Bug



1. _____

TV



2. _____

Stars



3. _____

Lamp



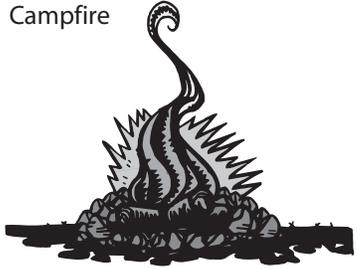
4. _____

Flashlight



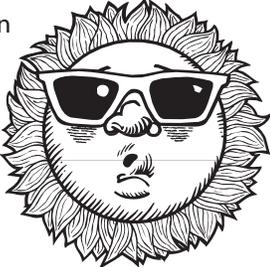
5. _____

Campfire



6. _____

Sun



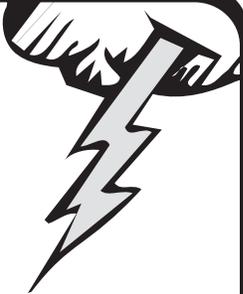
7. _____

Volcano



8. _____

Lightning



9. _____

List two more sources of natural light. _____

Explain the difference between natural light and artificial light. _____

(optional) To learn more about the types of light, research these terms and give an example of each:

Direct light: incandescent light

Indirect light: fluorescent light

Reflected light: neon light

Photons

Purpose

To simulate photons in light.

Procedure

1. Prior to the simulation, the teacher should outline an area on the ground approximately 3m x 3m to represent the Earth.
2. To represent the Sun, outline another area as a large circle approximately 5-8 m in diameter and 15-20 m from the Earth.
3. Discuss with the class the definition of a simulation.
4. Place students in the center of the Sun.
5. Have one student stand on the edge of the circle facing the Earth and grasp one end of the rope. He/she will be the first photon.
6. Stretch the rope in a straight path toward the Earth.
7. Explain that the students in the Sun represent photons emerging from the Sun.
8. To begin the simulation, choose one of the photons to leave the Sun and tag the first photon at the edge of the circle.
9. Never letting go of the rope, the "tagged" photon will then move up the rope to the next mark on the rope.
10. Meanwhile, other photons should leave the Sun in an orderly fashion, tagging the last photon on the edge of the circle and repeating the above to create a "chain reaction" that simulates a flow of photons (light) from the Sun.
11. Continue until all photons have left the Sun.
12. Discuss the simulation with the students.

Materials

large open area such as a playground or field
chalk or duct tape to outline areas
15-20 m of thick rope knotted on each end and sectioned off in 1 m increments (use marker or tape)

Extension

After discussing reflection, refraction, and scattering, use this simulation to enhance student understanding of what happens to light as it enters the atmosphere and strikes the Earth. Some of the photons could scatter before reaching the Earth, some could strike "clouds" and reflect, or some could strike the surface of the Earth and reflect, absorb, or refract.

Conclusion

1. How do the photons represent a beam of light? _____

2. What would happen if the photons stopped coming? _____

3. Draw a diagram that represents the simulation.



Traveling the Straight and Narrow

Purpose To learn that light travels in a straight line

- Procedure**
1. Lay the white paper on a flat surface.
 2. Determine the lengthwise center of the paper and use the ruler to draw a straight line from one end to the other.
 3. From one end of the paper, mark points on the line at 6 cm, 12 cm, 18 cm, and 24 cm.
 4. Place a small amount of clay at each point.
 5. On one of the index cards, mark point 3.5 cm from the bottom of the card and 2 cm from the left of the card. See diagram 1.
 6. Lay this card on top of the other two cards and make sure they are correctly aligned.
 7. Use the hole puncher to punch a hole over the mark through all three cards.
 8. Place a card in the first three mounds of clay and line up the holes. See diagram 2. Place the card without the hole in the last mound of clay.
 9. Darken the room and shine the flashlight directly through the hole on the first card.
 10. Observe the path of light and the size of the beam on each card. Record your observations in your journal.
 11. Move the light at a 45° angle and shine it through the hole of the first card.
 12. Observe the path of light and record your observations.

Materials

- 30 cm of white paper (shelf paper works great)
- 4 index cards
- hole puncher
- metric ruler
- pencil
- small amount of clay
- small flashlight or penlight
- science journal

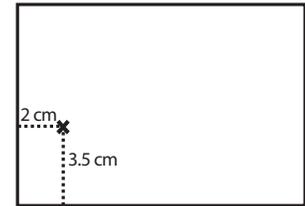


Diagram 1

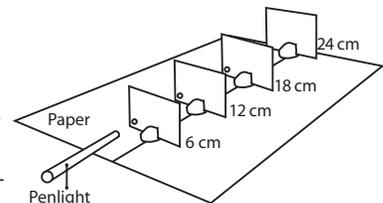


Diagram 2

Conclusion 1. How did the size of the light beam change on each card?

2. What happened when you changed the angle of the light?

3. Does light travel in a straight line? Explain how you know. _____

4. Why would the tree house detectives need to know that light travels in a straight line? _____

Extension

Make 4 additional index cards with larger holes. Place them in a straight line and darken the room. Shine the flashlight through the holes and observe. To make this experiment really visible, clap two chalk erasers or spray water mist in the air. Experiment by repositioning the various cards.

Roping the Wave

Purpose

To demonstrate light traveling in waves

Procedure

1. This activity can be performed as a teacher demonstration or by students in small groups.
2. Have one student hold one end of the rope and a second student hold the other end.
3. Have one of the students slowly move the rope up and down while the other student holds his/her end still.
4. Observe the waves.
5. Move the rope more quickly and observe.
6. Stretch a slinky on the floor between two students about 6-10 m apart.
7. Repeat Steps 2-4 with the slinky.
8. In your science journal, explain the differences you observed in the waves.

Materials

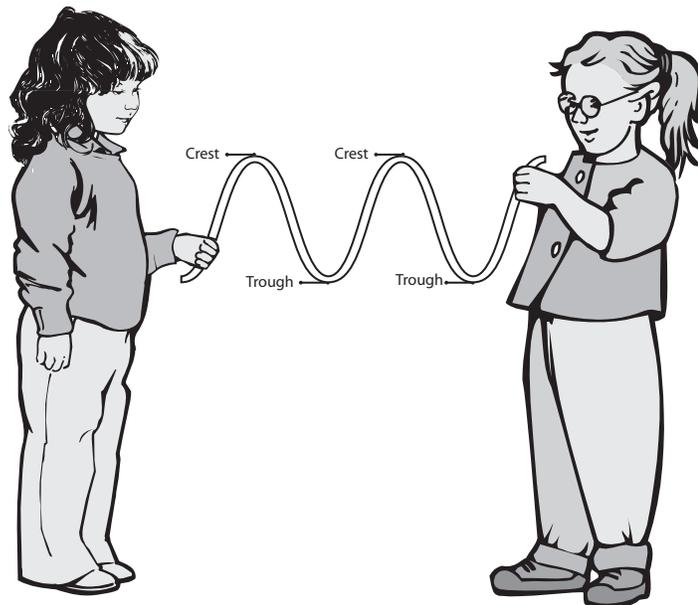
4-5 m of rope
slinky
science journal

Conclusion

1. How did the length of the wave change when you changed the amount of force you applied to the rope and slinky? _____
2. What does this tell you about the energy source of a wave? _____

3. Are long waves likely to be produced by a low-energy source or a high-energy source? Explain. _____

4. What about short waves? Explain. _____



Wave Upon Wave

Purpose

To understand wave frequency

Procedure

1. Soften the clay and roll it into a ball. Place the clay on the bottom of the pan near the end.
2. Insert the craft stick into the clay ball perpendicular to the bottom of the pan. See diagram 1.
3. Fill the pan two-thirds full of water.
4. Using the side of your hand, slowly strike the water's surface three times at the end opposite the stick.
5. Observe the waves that were created.
6. Repeat striking the water slowly three times, but this time count the number of waves that pass the stick in five seconds. Count the waves by observing either the crests (tops) or the troughs (bottoms) of the waves.
7. Record results in science journal.
8. Repeat striking the water three times, but more quickly. Count the number of waves that pass in five seconds. Record.
9. Experiment with striking the water at various speeds.
10. Experiment with timing the waves for 10 seconds and 20 seconds.

Materials

rectangular-shaped pan
clay
craft stick
water
stopwatch or clock with second hand
science journal

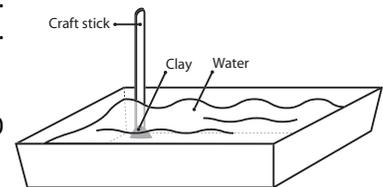


Diagram 1

Conclusion

1. Which action produced more waves? Why? _____

2. What happened when you increased the number of seconds you counted the waves? Explain why this happened. _____

3. From your observation, write your own definition of frequency. _____

Extension

The teacher may conduct this experiment by using an overhead projector and a clear rectangular glass dish. Place the glass dish on the overhead projector, insert clay and craft stick, and add water. Make sure that no water has spilled onto the projector. Turn on the projector and have students view the waves on the projection screen. Because this experiment involves water and electrical equipment, it should be done by an ADULT only.

Roll Out the Frequency

Purpose

To understand frequency and wavelength

Procedure

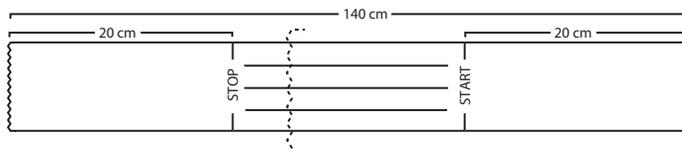


Diagram 1

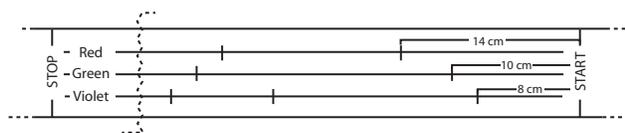


Diagram 2

Materials (per group)

140 cm adding machine tape (1.4 m)
metric ruler
pencil
colored pencils (red, green, and violet)
manila folder
scissors
tape
pencil or dowel
stopwatch or clock with second hand

1. Measure 20 cm from one end of the adding machine tape and draw a vertical line. Label this end "Start."
2. Repeat with the other end of the adding machine tape. Label this end "Stop."
3. Use a metric ruler to draw three evenly spaced horizontal lines from start to stop in the center of the adding machine tape. See diagram 1.
4. Color the top line red, the middle line green, and the bottom line violet.
5. Use a metric ruler and red pencil to measure and mark the red line every 14 cm, making dark wavelength marks that are easy to see. See diagram 2.
6. Repeat, dividing the green line with the green pencil every 10 cm and the violet line with the violet pencil every 8 cm.
7. From the left bottom edge of the manila folder, measure and mark 12.5 cm. Repeat from the right bottom edge of the folder.
8. Using the marks as guides, measure 10 cm from the bottom of the manila folder upward along the marks. Mark the spot and then draw a line from the bottom to that mark.
9. Connect the two lines at the top to form a rectangle. See diagram 3.
10. Use scissors to cut out the rectangle. Cut through both sides of folder.
11. Roll adding machine tape into coil with the "start" end visible. See diagram 4.
12. Place the "start" end of the adding machine tape inside the manila folder so that "start" shows through the cutout window with the excess sticking out the right side of the folder. Close folder so that the roll of adding machine tape is to the left of the folder. See diagram 5.
13. With one person holding the folder, another person pulls the "Start" end of the adding machine tape slowly. A third person uses a stopwatch to time the activity as a fourth person counts the number of red wavelength marks that pass through the rectangular opening in 10 seconds.
14. Timekeeper will announce when to begin and end the activity.
15. After the timekeeper has ended the activity, record in science journal the number of red wavelength marks that passed.
16. Making sure that the tape is pulled at about the same speed for every trial, repeat two more times. Find the average number of wavelength marks that were passed for all three trials.
17. Repeat steps 11-16 for the green and violet lines.

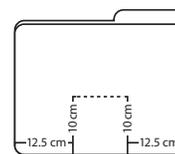


Diagram 3



Diagram 4

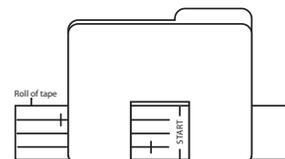


Diagram 5

Conclusion

1. Compare the wavelengths and frequencies of the three waves. Describe any patterns or relationships that were noted. _____
2. Which color had the shortest wavelength? Longest? _____
3. Which color has the highest frequency? Lowest frequency? _____
4. Why was it important to take an average? _____
5. Why do the tree house detectives think that there are low frequency waves causing the red skies? _____
6. In your science journal, summarize this activity and tell how it relates to *The Case of the Mysterious Red Light*.



Answer Key

Natural or Artificial

1. street light and illuminated clock
2. burning match and flaming coals
3. Natural light is created from natural sources such as the Sun. Artificial light is created by man-made sources such as lamps.

Photons

1. The photons travel in a straight line just as a beam of light travels. Light is made up of a stream of photons.
2. If there were no photons, there would not be any light.
3. Drawings will vary.

Traveling the Straight and Narrow

1. The light around the hole in each card gets smaller and dimmer the farther it is from the light source.
2. When the light is aimed at an angle, it doesn't strike the second, third, or last card.
3. Only when the light is aligned with the straight line through the index card holes can light reach the last cards. This demonstration shows that light travels in a straight line.
4. Answers will vary.

Roping the Wave

1. When force was increased, the length of the wave became shorter.
2. An energy source that produces high energy produces very short wavelengths, and an energy source that produces low energy produces very long wavelengths.
3. Long waves are produced by low-energy sources. The less energy used to create a wave, the longer the wavelength.
4. Short waves are produced by high-energy sources. The more energy used to create a wave, the shorter the wavelength.

The Incredible Edible Wave

1. In a wave, the crests will always be the same height because they are all produced by the same energy source.

Wave Upon Wave

1. Striking the water more rapidly creates more waves. Each strike to the water produces energy that creates waves; therefore, the more strikes to the surface of the water, the more waves.
2. When timing and the number of seconds were increased, the waves slowed down and there were fewer waves per second than in the beginning.
3. Frequency is the number of waves that pass a given point in a certain amount of time.

Roll Out the Frequency

1. The wavelengths graduated from longest to shortest. The shorter the wavelength, the more wavelength marks in the ten second time period.
2. violet, red
3. violet, red
4. It was important to take an average because it was difficult to maintain the same speed in each trial.
5. The tree house detectives think low-frequency waves are causing the sky to be red because low frequency waves are red in the visible spectrum.
6. Answers will vary.

