Manipulating Waves

DESCRIPTION
This lesson guide integrates a series of activities designed to demonstrate methods of manipulating waves and applications of that manipulation.

OBJECTIVES
Students will:

- Demonstrate methods of magnifying light waves.
- Operate a simple spectroscope to analyze spectra.
- Compare methods of transmitting and receiving electromagnetic waves for space communications.

NASA SUMMER OF INNOVATION

UNIT
Physical Science -- Waves and Optics

GRADE LEVELS
4-6

CONNECTION TO CURRICULUM
Science, Mathematics and Technology

TEACHER PREPARATION TIME
1 hour

LESSON TIME NEEDED
6.5 hours *Complexity: Moderate*

NATIONAL STANDARDS

National Science Education Standards
Science as Inquiry
• Skills necessary to become independent inquirers about the natural world.
Physical Science
• Light, Heat, Electricity and Magnetism.
History and Nature of Science
• Science as a human endeavor.

Common Core State Standards for Mathematics
Number and Operations
• Understand the place value system.
• Generalize place value understanding for multidigit whole numbers.
Measurement and Data
• Convert like measurement units within a given measurement system.
• Represent and interpret data.

MANAGEMENT
This set of activities will require commercially purchased diffraction gratings that may be purchased through a science supply catalog. The spectroscope construction also requires razor blades to create a clearly defined slit for light entry. An alternate method of generating a slit of sufficient thinness is listed in additional resources. The Space Operations Learning Center requires computers with Internet access.

CONTENT RESEARCH
Electromagnetic waves, like all waves, may be reflected, refracted and diffracted. These manipulations may be used to alter, magnify or change the location of images created by electromagnetic waves. Diffraction spreads light into its component colors through constructive and destructive interference.

Different types of antennae allow us to transmit and receive electromagnetic waves with various amounts of directional and focal control. Selection of the proper antennae for transmission and reception is vital to communications between spacecraft and land-bound stations.

Key Terms

- **Reflection** -- the bouncing of a wave from a surface.
- **Refraction** -- the bending of a wave's path as it travels across the boundary between media.
- **Diffraction** -- the spreading of a wave as it passes through an opening in a wave barrier.
- **Magnification** -- increasing or decreasing the size of an image by manipulating electromagnetic waves.
- **Spectrum** -- the range of frequencies of the electromagnetic waves.
- **Medium** -- material through which a wave passes.
- **Interference** -- variation of wave amplitude due to multiple waves occupying the same space.

Misconceptions -- Students often believe that white is a color of light when in fact it is the presence of all colors of light, as demonstrated by the use of a diffraction grating to split it into its spectrum. Students also commonly believe that the speed of light is an absolute constant. The speed of light is constant for a particular medium with its highest speed at 3.0×10^8 meters per second in a vacuum.

MATERIALS

- Photographic slide frame or thin piece of cardboard with 1 inch square hole
- Transparent tape
- Small transparent sauce or condiment bottles
- Jars of different shapes
- Water
- Old magazine or newspaper
- Spectroscope (1 per 4 students)
- Light sources
- Compact disc
- Cardboard box with lid
- Sharp knife
- Double edge razor blade
- Scissors
- Black marker
- Tape
- Manila file folder
- Diffraction grating (13,440 groves/ square inch)
- Computer with internet connection

LESSON ACTIVITIES

The suggested sequence starts with simple manipulation of the path of light and increases in complexity through spreading light by diffraction and interference to controlling electromagnetic waves for information transfer to and from space.

Simple Magnifiers
Students use bottles, jars and water to create different magnifiers.
http://www.nasa.gov/pdf/350543main_Optics_Simple_Magnifiers.pdf

Exploring Diffraction With a Spectroscope
Students build a simple spectroscope and use it to investigate diffraction.
http://www.nasa.gov/pdf/350514main_Optics_Exploring_Diffraction.pdf
http://www.nasa.gov/pdf/350508main_Optics_Constructing_a_Spectroscope.pdf

Space Operations Learning Center
Select the Space Communication mission training to go with this lesson. It explains how satellites transmit using the electromagnetic spectrum. http://solc.gsfc.nasa.gov/index.html

RELATED RESOURCES

This activity contains an alternate spectroscope design from the Space Based Astronomy Educator Guide.
http://aesp.psu.edu/files/soi/simple%20spectroscope.pdf

DISCUSSION QUESTIONS

Each activity includes questions for discussion.
Additional questions:

- Why would NASA scientists want to make an image larger? *Increased size allows us to see more detail in the image.*
- Why would NASA scientists want to make an image smaller? *Focusing the image down sometimes allows for sharper definition of edges.*

- How does the ability to split electromagnetic waves into a spectrum help us learn about distant objects? *Different parts of the spectrum tell us different things about an object.*

ASSESSMENT ACTIVITIES

Each activity has a series of questions in the student pages.

Pre-test / Post-test questions:

- Give two methods for magnifying light**.** *Reflection, refraction.*
- What colors are present in white light? *All colors are present -- ROYGBIV or RGB.*
- Name at least two types of antennae for transmitting and receiving electromagnetic waves**.** *Omni-directional, panel, Yagi, parabolic.*

ENRICHMENT

- Students may want to explore magnification by reflection using both straight and curved mirrors.
- Have students complete all four modules of the Space Operations Learning Center.
- Use a set of light tubes to show students the emission spectra of various elements and ask them to explore uses of those spectra.