THROUGH THE LOOKING GLASS (1 HOUR)

In this activity, students construct a spectroscope and use it to observe the spectra of various sources of light.

Overview

Topic: Spectroscopes

Real World Science Topics

- An exploration of how light is bent by a diffraction grating.
- An exploration of how various sources of light differ.

Objective

Students will gain an understanding both of building a scientific tool and of how different sources of light emit different wavelengths of light.

Materials Needed for Each Team of 2-4 students

paper towel tube
2 index cards
3cm x 3cm diffraction grating (available through science supply on-line stores for as little as $.30 each such as: *http://sciencekit.com/replica-diffraction-gratings/p/IG0023808/)*
scissors
colored pencils
ruler

Materials Needed for Demonstration

glass prism
colored chalk

Standards Met

National Science Standards Addressed

Content Standard A: Science as Inquiry Students:

- Use appropriate tools and techniques to gather, analyze, and interpret data.

Content Standard B: Physical Science

National Technology Standards Addressed

Understand and use technology system.

Sources:

National Science Teachers Association
http://books.nap.edu/html/nses/overview.html#content
National Educational Technology Standards
http://cnets.iste.org/currstands/cstands-netss.html

STEPS FOR *THROUGH THE LOOKING GLASS*

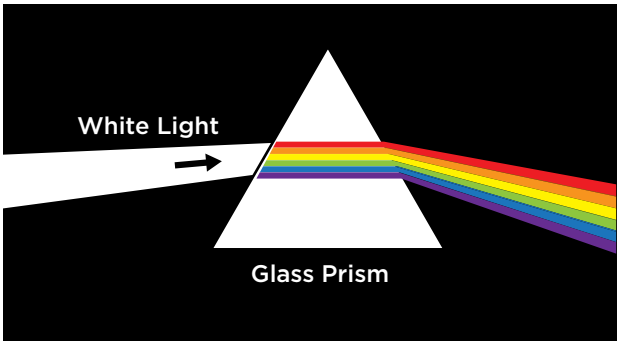
1. **Warm-up Activity**: Begin the class by showing the students a prism and asking them if they know what it is and what it does. Some students may recognize that it is a prism and that it splits white light into a rainbow.

Demonstrate how the prism can split white light into colors by holding it up to a source of sunlight. Adjust its position until the refracted light (a rainbow) lands on a wall so the whole class can see it.

After you have demonstrated this, ask students if they know why the light becomes a rainbow. Some students may know that white light is made up of many different colors of light, and that the prism bends those different colors by different amounts. When the light comes out of the prism, the colors are split up.

Help students explain this idea to their classmates. If no students know how a prism works, first explain that white light is actually many different colors of light. Then, explain that the light bends when it enters the prism, a process called **refraction**. Finally, explain that each color of light bends by a slightly different amount as it travels through the prism.

If students are having trouble understanding this idea, draw a diagram on the board of what happens to the light that enters the prism. Use different colored chalk or markers to represent different colors of light. Show that some colors bend more than others.



White light enters the prism, but the constituent components of the light beam bend by different amounts in the prism (red bends the least, and violet bends the most). This leads to a rainbow.

Conclude this introduction by telling students that not all light is made up of the same set of colors, and that tools like prisms can be used to distinguish which colors make up light from different sources.

2. Distribute the *Through the Looking Glass* handout and materials to each group of 2–4 students. Tell the students that they will use these materials to make a tool called a **spectroscope**, which will be used to observe different sources of light. Instructions for making the spectroscope are included below.

3. If your class contains younger students, you may want to perform this step and the next two steps for them before class begins. Students should use the end of the paper towel roll to trace three circles on an index card. Each circle should be about a half a centimeter wider than the opening of the tube itself. Students should cut out the circles.

4. Next, t he students should next cut a 2cm x 2cm square in the middle of one of the three circles. Then students should tape a piece of diffraction grating over the square. They should make sure not to cover with tape any parts of the diffraction grating that are visible through the cut-out square. After they have taped the diffraction grating onto the circle, they should tape the circle to one end of the tube, with the diffraction grating facing inwards. The card should be taped onto the tube tightly, so that no light can get in through the area between the index card and the tube.

5. Students should cut the second circle in half. They should tape each half on the end of the tube that does not have the diffraction grating attached. The two circle halves should be taped onto the tube so that a narrow slit (less than 1 mm in width) remains between them. Finally, students should cut the third circle in half. They should tape these halves over the ends of the existing slit so that a gap of about 1 mm X 1 cm remains on the end of the tube. For both of these steps, students should tape the circles to the tube in a way that blocks light from entering the tube from anywhere but the slit. The diagram at the end of the activity shows how this setup should look.

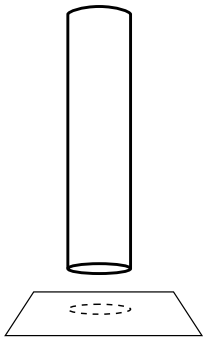
6. Now that the spectroscope is complete, students can start observing various light sources. To use a spectroscope, a student should hold the tube like a telescope, with the slit end closer to the source of light. They should look through the diffraction grating at the light coming through the slit. For the spectroscope to work correctly, it should be pointing directly at the light source. Warn students strongly that they should never look directly at the sun using the spectroscope. They can, however, look at sunlight coming through the window. They should also study interesting sources of light in the classroom. These sources of light could include fluorescent lights, incandescent lights, computer screens, various LED lights on electronic devices, and even cell phones and other portable devices. An interesting comparison is to view light from a standard bulb, and then light from a "bug" light (yellow) used on porches in the summer. The bug light removes violet to blue light, which is most visible to insects. You could also light a candle, if that is allowable in your school. Have students observe four to five sources of light and record their observations on the handout.

7. **Wrap-Up Activity:** Lead a discussion of the properties that make the diffraction grating work. Start the discussion by reminding students of the prism from the warm-up activity. Ask the students to recount how light was changed when it went through the prism. They should remember that white light was split into a rainbow of colors. The actual optics of the diffraction grating are too complicated for this level, so explain to them that patterns on the grating cause light to bend, similar to using the prism.

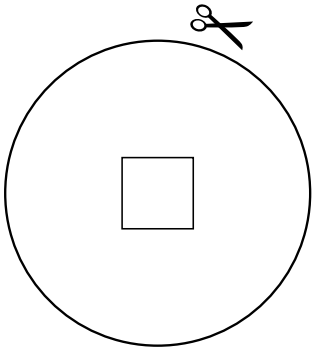
Through the Looking Glass Extension Activity

There are many interesting sources of light that are unlikely to be available in the classroom, or are unlikely to be visible during daytime. These light sources include street lights and neon signs, which produce unique light spectra. Encourage students to take their spectroscopes home and observe sources of light that are not available at school during the day.

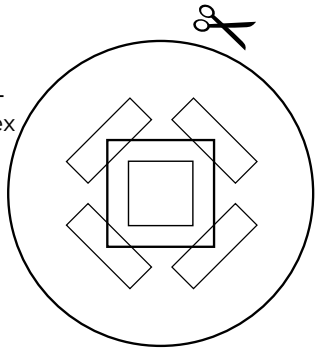
STEP 1
Trace three circles.



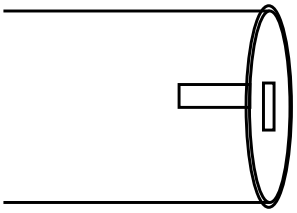
STEP 2
Cut out square.



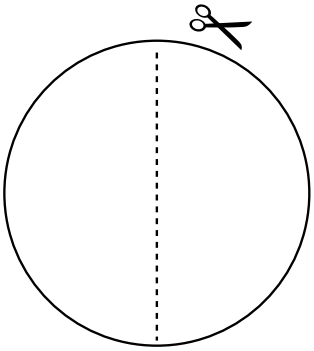
STEP 3
Tape grating to index card with taping over open square.



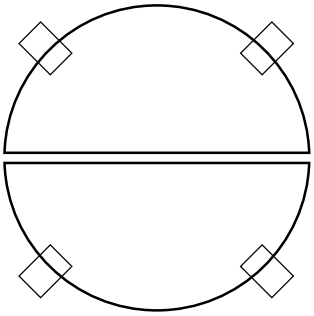
STEP 4
Tape diffraction grating to tube with grating facing inwards.



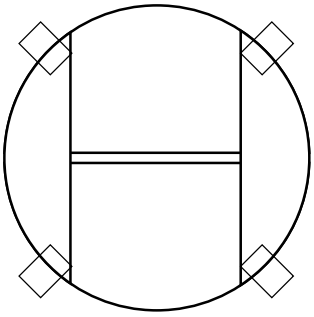
STEP 5
Cut two circles in half.



STEP 6
Tape two halves of index card to end of tube leaving a narrow slit.



STEP 7
Tape other two halves of index card to end of tube making slit less wide.



Note: All circles should be the same size

THROUGH THE LOOKING GLASS
BACKGROUND INFORMATION

What is light?
What we see as light is actually a type of electromagnetic wave. Electromagnetic waves cover a spectrum of wavelengths from very short gamma rays to meters-long radio waves. Visible light is a portion of this spectrum.

Why does white light form a rainbow when it passes through a prism?
Light waves bend as they pass through different media. This can be seen when looking at a straw placed in a glass of water. The light waves that enter the glass bend, making it look like the straw itself is bent. This phenomenon is called refraction. The amount of refraction depends on the wavelength of the light, as well as what kind of media the light is passing through. White light is actually composed of many different wavelengths of light. The shorter wavelengths (blue and violet light) are bent more than the longer wavelengths (red and orange light). The different amounts of bending cause the white light to separate into a rainbow.

What determines the spectrum of a light source?
Every color and type of visible light is made up of one or more wavelengths of light. The combination of all of the wavelengths emitted by a light source is called the light source's spectrum. The spectrum of a light source is determined primarily by two things: the temperature of the light source and the chemical composition of the light source. Light sources with higher temperatures generally emit shorter wavelengths of light. The sun is very hot compared to other sources of light, such as a candle, so the light it gives off shifts towards blue and even ultraviolet (which is invisible to the human eye). The elemental makeup of a light source also affects the spectrum of the light it produces. For example, neon lights produce light when gas molecules are excited by the flow of electricity through a tube. The color of light depends on the type of gas. Street lights are often orange or yellow because of the sodium inside.

How can spectroscopy be used by scientists?
Scientists have many uses for spectroscopy. One of the primary uses for this technique is to analyze the spectra of stars and other astronomical bodies. Scientists look at the light stars produce, or the light that reflects off of other objects, such as planets. Analyzing the spectra of these sources of light can tell scientists which elements are present. This in turn can help scientists understand the history and evolution of the universe.

Key Vocabulary
Refraction: the bending of light as it passes through a medium
Spectroscope: a device that allows the user to see the spectrum of a light source
Diffraction Grating: a device with a large number of parallel grooves designed to bend light and used to produce light spectra

TEACHER HANDOUT FOR *THROUGH THE LOOKING GLASS*

Name _____ **Date** _____

Describe what happens to light when it passes through the prism.

[The sunlight breaks into a rainbow.]

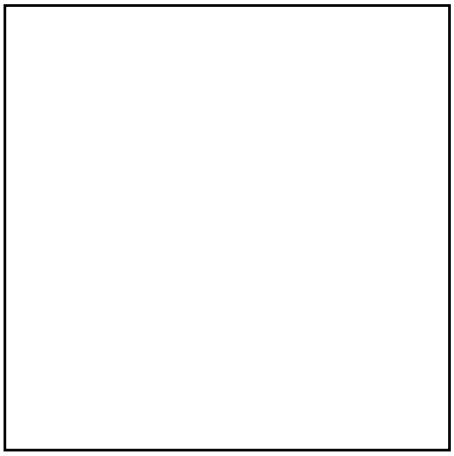
Draw your observations of different light sources as seen through the spectroscope below. Write the name of the light source on the line below the square.

STUDENT HANDOUT FOR *THROUGH THE LOOKING GLASS*

Name _____ **Date** _____

Describe what happens to light when it passes through the prism.

Draw your observations of different light sources as seen through the spectroscope below. Write the name of the light source on the line below the square.



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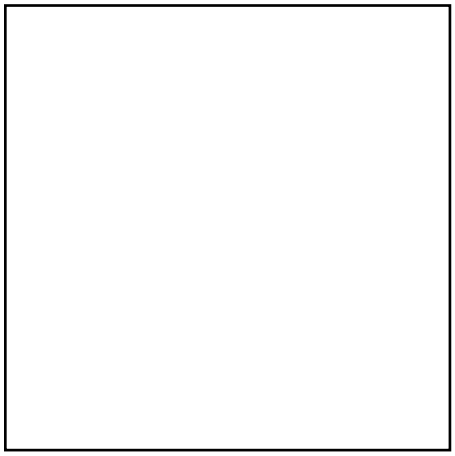

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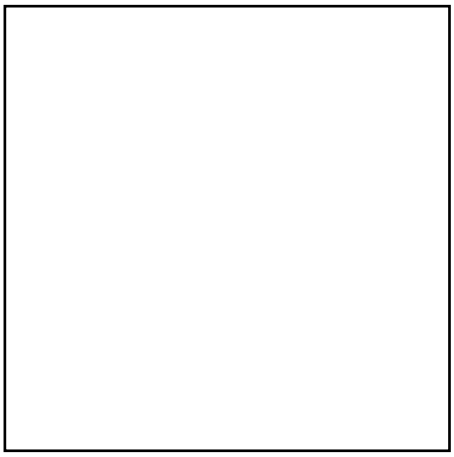

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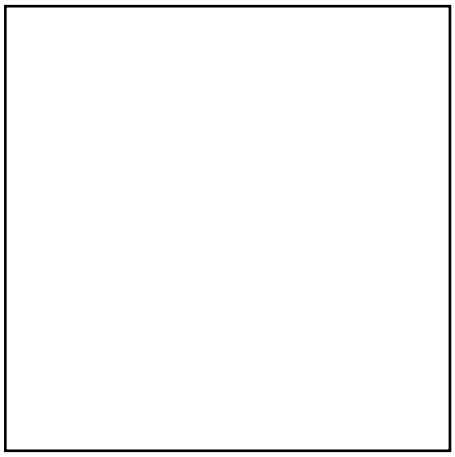

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