

# Spectroscope: Teacher Guide

## Introduction

Just as a geologist collects rocks or minerals and a botanist collects plants, an astronomer collects light. Astronomers usually can not touch the objects they study, like stars or galaxies. But they can analyze the light these celestial objects radiate using a spectroscope. When an astronomer looks at a star through a spectroscope, he or she sees a colorful spectrum that is full of information.



Mini Glo Doodler

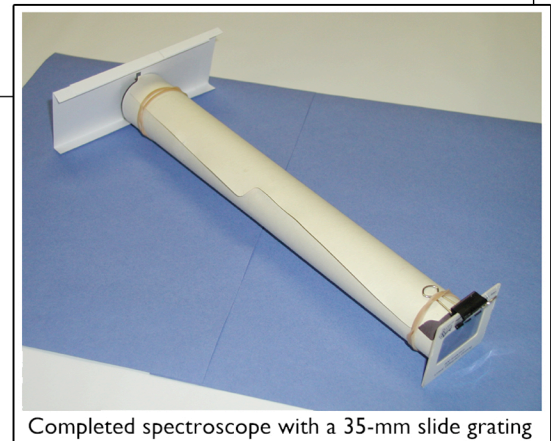
## Materials:

Whole Class	Per Spectroscope
<ol style="list-style-type: none"> <li>1. Incandescent light bulb (60-100 watt frosted) and base.</li> <li>2. Optional: String of clear holiday lights.</li> <li>3. Fluorescent light (single bulb).</li> <li>4. Transmission grating slides (35mm slide).</li> <li>5. Manila folders</li> <li>6. Black construction paper (9 x 11 inches)</li> </ol> <p>Optional: Glo-Doodler (by Colorforms) – a toy writing tablet with a hot pink plastic sheet that “glows” when you write on it. It also strongly absorbs green light and emits yellow, orange and red.</p>	<ol style="list-style-type: none"> <li>1. Half of a manila folder: cut a whole manila folder along the fold to produce two 8 x 11 sheets.</li> <li>2. 1 sheet of black construction paper.</li> <li>3. 2 small (20 mm or 3/4 inch) binder clips.</li> <li>4. 2 index cards (3 by 5 inch size) to make the adjustable slit.</li> <li>5. Clear tape and 2 rubber bands.</li> <li>6. 1 Transmission grating slide (35mm slide).</li> </ol>

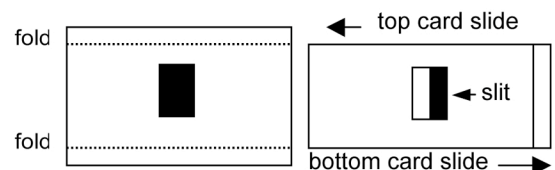
## Preparation

### Make the adjustable spectroscope slits

Make an adjustable slit from two index cards. Cut identical rectangular slots, about 1 by 3 centimeters, into the center of two index cards. Stack the cards then fold both cards together along both long sides. The cards should now slide across each other. Adjust the size of the slit by sliding one slot over the other.

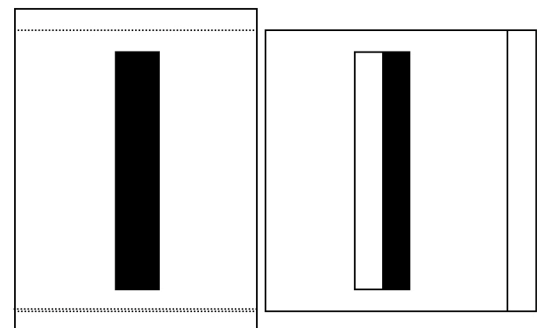


Completed spectroscope with a 35-mm slide grating



### Make the adjustable hand-held slit

During the Explore phase, you will place a tall slit in front of light sources for students to compare the appearance of spectra with and without the slit. The adjustable hand-held slit is similar to the adjustable index card slit you made. Instead of index cards, use two sheets of 9 x 11 inch black construction paper. The slots are tall – 9 x 1 inches. Make the slide fold along the 9-inch side of the paper.



## Engage

Before passing out grating cards, ask students to read the StarDate script about the electromagnetic spectrum. Then ask a question:  
How do you think astronomers “split light”?

## Explore

Leave the classroom lights on, at first. Resist requests to turn the lights off until after students have completed the first exploration step

### 1. Using just the grating card, ask students around the room at 2 or 3 light sources.

As they view each source, they describe the appearance of the spectrum from each of the light sources.

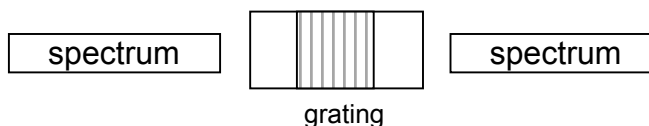
Light Source	Spectrum Description

Ask guiding questions. Each is a step closer to improving the quality of the spectrum image, and identifying the next essential part of the spectroscope.

With gratings in hand, ask students to look at incandescent light sources (light bulb, clear holiday lights) through the grating while holding it close to their eye.

### 2. Where does the spectrum appear?

*Spectra appear to the right and left of the light source*



### 3. What is the color order?

*Violet is closest to the light source and red is most distant.*

### 4. What could be done to improve the appearance or view of the spectrum?

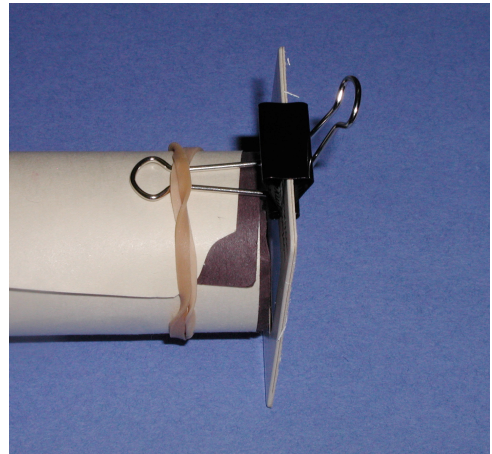
*Darken the room.*

The grating is part of a spectroscope. As the students noticed, spectra are best viewed against a dark background. Ask the students for alternatives to darkening the room. If necessary, hint at something hand-held, since this instrument should be portable. If no one mentions it, suggest that a tube, with the grating fixed at one end, will block stray light from the view of the spectrum and provides the structural support for the spectroscope components.

**5. What could you use to block out the stray light to make a dark background for viewing spectra?**

*Attach the grating to one end of a tube.*

Cut a manila folder in half along the fold. Place a black sheet of construction paper on top of the manila folder half. Roll them together along the long side so that the black paper lines the inside of the tube. Secure with rubber bands. Attach the grating card to the tube. Fasten a binder clip to the grating card. Fasten the binder clip and grating card to the tube using the rubber bands.



Turn off the incandescent bulb and turn on a single fluorescent bulb. Holding their gratings (now attached to the tube) up to their eyes, ask students to examine this light.

**6. Does the spectrum of the fluorescent bulb look like the incandescent bulb spectrum? What is the same or different?**

*Students should see bands of color in the fluorescent bulb spectrum as well as a continuous spread of color.*

With the tall hand-held slit, block the fluorescent light bulb so that students see only a narrow slit of light. Compare the incandescent light and the fluorescent light.

**7. Do you see color bands now in one of the lights? Which one?**

*Color bands appear dimmer and thinner with the slit in place for the fluorescent bulb. The incandescent bulb has no bands.*

**8. Which observing method renders the best detail view of the spectrum features (with or without the slit)?**

*With the slit. There is a limit – if the slit is too narrow, the spectrum appears too faint.*

**9. Where is a better place to put the slit, so that an observer can view other light sources?**

*At the opposite end of the tube.*

Pass out the adjustable slits to students.

Hold the adjustable slit at the opposite end of the tube from the grating and open and close it until you find a position that shows detail and still allows enough light through to see the spectrum clearly. Rotate it if necessary so that the spectrum has its largest height. This insures the parallel grooves in the grating run in the same direction as the slit. Fasten it to the tube using a binder clip.



Congratulations! You have constructed a working spectroscope.

## Explain

1. What happens to the emission spectrum as you slowly close the slit? Explain why.  
*As the slit closes, the emission features appear sharper, but they become fainter. The slit controls the image size and the amount of light that enters the spectroscopy. So, as the image narrows the emission features narrow; but, the narrowing slit reduces the amount of incoming light resulting in dimmer features.*

2. What do you see when you look through the spectroscopy at an incandescent light source, like a light bulb?

*A continuous spectrum, like a rainbow or a spectrum that a prism produces by refraction.*

3. What atomic elements do you think are emitting light inside the fluorescent bulb?

*Mercury. The mercury emission lines are strongest.*

## Elaborate

1. Look at the light bulb with your spectroscopy. As your teacher places the Glo-Doodler in front of the bulb, what happens to the spectrum?

*When students observe the spectrum emitted by the incandescent bulb, they see a familiar continuous spectrum. But when you place the Glo-Doodler in front of the bulb, they will see a strange, new feature: a band of missing (dimmed) colors. The Glo-Doodler absorbs some of the light from the incandescent light bulb, and then emits most of it away from the spectroscopy and observer. The color of the Glo-Doodler gives you a clue about what specific colors it absorbs and emits. This new spectrum is called an absorption spectrum.*

2. Look at the Glo-Doodler from the side, so that you can see the bulb separately. Put the spectroscopy to your eye, and target only the Glo-Doodler. What kind of spectrum do you predict? What kind of spectrum do you observe?

*When students target just the Glo-Doodler, they see light that only the Glo-Doodler emits. The Glo-Doodler's emission spectrum (the spectrum emitted by only the Glo-Doodler) shows a dim band of color from green, stretching across yellow, orange, and red. Your eyes and brain perceive a mixture of these colors as a cherry-red.*

3. Notice that the emission spectrum does not line up with the absorption feature. What is going on?

*The Glo-Doodler is absorbing light from the light bulb and emitting light across many longer wavelengths – fluorescence. That's why the Glo-doodler "glows".*

4. Compare the spectrum observed in (1) with a direct spectroscopy observations of the incandescent light plus the Glo-Doodler.

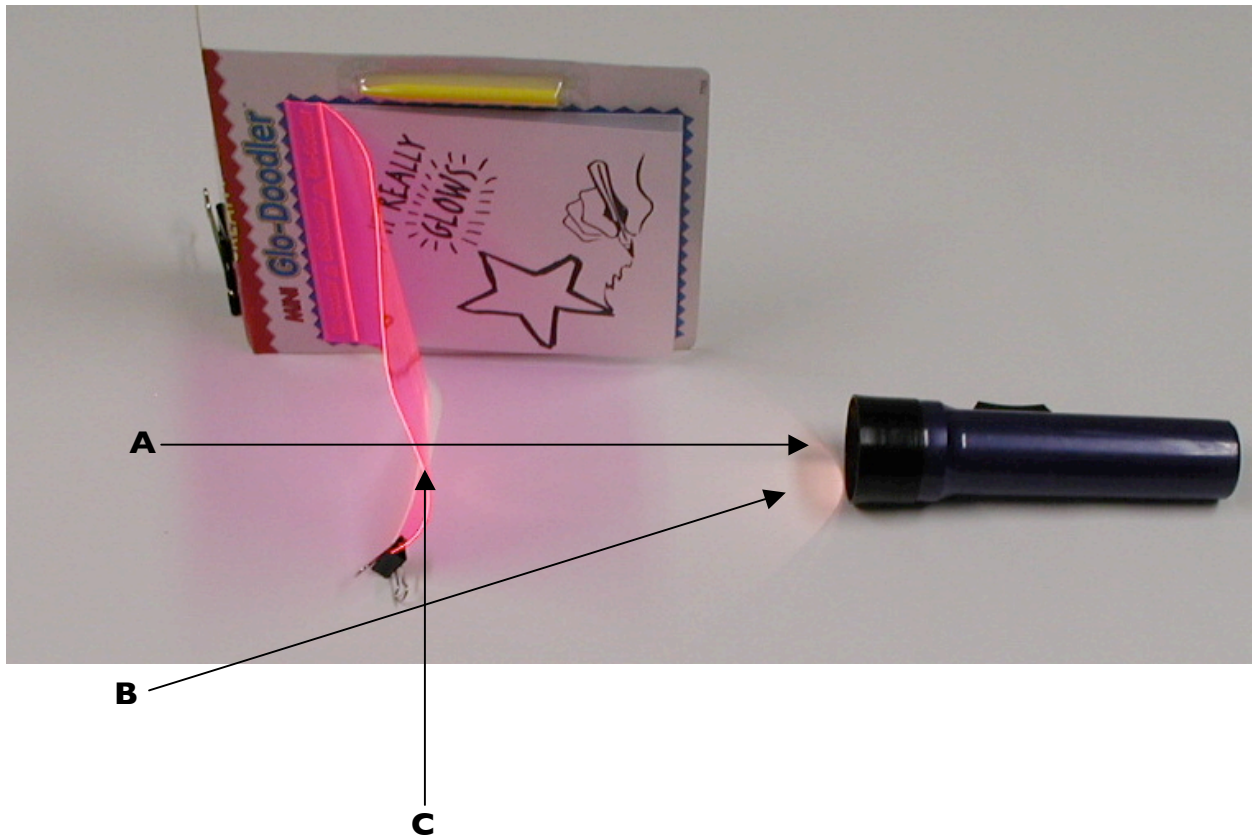
*This spectrum shows green mostly dimmed (energy emitted away). So your eyes and brain mix the brightly showing colors (blue and red, with a little green) into magenta.*

5. What happened to the green light "missing" in the Glo-Doodler absorption spectrum? Is it really missing? How is this an example of conservation of energy?

*Once absorbed, the Glo-Doodler must emit energy in an equal amount, which is an example of conservation of energy. The Glo-Doodler emitted the energy of the green light as mostly yellow, orange, and red light – light with longer wavelengths than the green.*

## Evaluate

Students should be able to disassemble the spectroscope, name each part and its function, reassemble the tool, and explain how it works.



A: Absorption    B: Continuous    C: Emission

# **Spectroscope**

## **Texas Essential Knowledge and Skills**

§112.20 grade 8 (b) - (8) (C): explore how different wavelengths of the electromagnetic spectrum such as light and radio waves are used to gain information about distances and properties of components in the universe.

§112.33 Astronomy (c)-2I: use astronomical technology such as telescopes, binoculars, sextants, computers, and software.

§112.33 Astronomy (c)-14D: recognize the importance of space telescopes to the collection of astronomical data across the electromagnetic spectrum.