EXHIBIT DESCRIPTIONS, GOAL & OBJECTIVES

Star Spectrum

Objective: Students will learn that astronomers can identify chemical elements in stars by studying their light.
How To use: Best operated by two people: one to crank the generator (very fast), the other to push one of the buttons corresponding to a gas spectrum tube. Look through the red-framed diffraction grating to see the spectrum that is unique to each gas. Compare to the chart to determine which gas is in the tube.
Explanation: Each gases in a star emits a unique spectrum. A spectrum is a bit like a bar code you see on merchandise purchased at a store. The difference is a spectrum's lines are colored. It is like a fingerprint for each gas and enables us to know what is in the star even though we cannot sample it.
Concepts: spectrum, solar gases,

Watch the video titled "Star Spectrum" (0:54).

How do we know what the Sun or other stars are made of if we've never gone there and sampled them? It's their spectra. Pass the Sun's light through a prism you get a rainbow. Each gas present will leave unique lines, called spectra, on the rainbow. It's like a celestial bar code.

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Star Spectrum

Illinois Assessment Framework Grade 4

12.4.14	Understand that matter is usually found in 3 states: liquid, solid, and **gas** and be able to identify the properties of each. Understand that water can be found in all three forms.
12.4.22	Understand that lighter colors reflect more light, darker absorb more, and that the color one sees depends on what kind of **light is reflected** (rather than absorbed) by the object seen.
12.4.23	Understand that white **light can be broken into all the colors** of the rainbow by means of prisms.
12.4.24	Understand that **light** travels in a straight line and **can be** reflected, **refracted**, transmitted, and absorbed by matter.

Mission: Determine a star's gases by its spectrum.

Information: Turn the crank while pressing one of the buttons.
Look through the diffraction grating to the side of a light tube for its spectrum (rainbow lines).
See which gases are in the light tubes using the chart.

Background: Every glowing gas has its own pattern of lines, like a fingerprint.

The Spectrum of a star can tell astronomers a lot about it, such as: distance, size, the gases in it, if magnetic fields are nearby, if planets are near it, and how fast it's moving or spiraling.

Gases: hydrogen, iodine, mercury, neon, argon, helium, nitrogen

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Star Spectrum

Illinois Assessment Framework Grade 7

12.7.39	Define element as a substance that cannot be broken down into simpler substances by chemical interactions. Understand that there are over 100 known **elements** that combine in many ways to form many kinds of compounds. Each element has its own number on the periodic table.
12.7.49	Understand that energy appears in many forms, such as heat, **light**, sound, chemical, mechanical, solar, nuclear, and **electromagnetic energy**. Understand the basic characteristics of each of these kinds of energy. Understand the nature of kinetic and potential energy.
12.7.54	Understand that almost all of Earth's energy comes from the sun. Understand that this energy is in the form of visible and invisible light with a range of wavelengths (**electromagnetic spectrum**).
12.7.57	Understand that light travels at different speeds in different materials. Understand that this is why **light refracts**—or changes direction—namely because it goes from one material in which it moves at one speed into another material through which it moves at a different speed.
12.7.58	Understand that the angle of **refraction** is determined by (1) the angle of incidence and (2) the index of refraction of the new material which the light is entering.
12.7.62	Understand that in the **spectrum of visible light**, lower frequency colors are toward red, and higher frequency colors are toward blue.

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STELLAR SPECTRAL FINGERPRINTS

Performance Standard 11B.I, 12F

Students will apply the processes of technological design to explore the electromagnetic spectrum with an emphasis on bright-line spectra accordingly:

- *Knowledge:* Associate the basic concepts associated with electro-magnetic energy to their technological background and discovery.
- *Application:* Design an investigation for the measuring the diffracted spectral lines of light energy.
- *Communication:* Relate the basic conclusions from the diffraction investigations to the compositions of stellar objects.

Procedures

1. In order to know and apply the concepts that describe properties of matter and energy and the interactions between them (12C), the concepts, principles and processes of technological design (11B), students should experience sufficient learning opportunities to develop the following:
   - Brainstorm the design dilemma of measurements associated with simple spectrometers.
   - Research early research and technological designs for testing light and its diffraction.
   - Determine procedural sequence and design options to measure the emissions of light with the choices of variables associated with the use of a spectrometer or diffraction grating.
   - Create a schematic design which shows the angles of diffraction of the various wavelengths of light.
   - Consistently and accurately measure and record the distances and angles of diffraction from light sources.
   - Display and analyze data from investigation.
   - Communicate the findings that demonstrate the diffraction of light.
   - Generate possible alternative designs for testing diffraction differently or applying to different uses.

Note to teacher: This introductory activity relates to knowledge associated with standard 12 F and can be linked to 12C, while addressing the performance descriptors for stage I within standard 11B.

2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. Introduce Newton's early 'discovery' of the diffraction of light. (Other discoveries may be introduced also.) Consider how simply his experiment could be replicated today. Introduce multiple examples of light sources, such as fluorescent, incandescent, sunlight, or different kinds of light tubes, etc. Use a prism first and then introduce a diffraction grating. Suggest questions

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about the observer's distance from the source of light, the intensity of the light, how the light can be diffracted, and how to consistently and accurately record data. The technological design dilemma questions how to measure light that is diffracted in a spectroscope/diffraction grating on a test surface. In all cases, the students must design an effective and accurate way to measure the distances between resulting spectral lines from light sources. Assign groups to test single variables or design options, such as:

- Variation of light sources (bright light of incandescent, or fluorescent bulbs, light sticks, neon lights, light tubes of different elements).
- Variation of the distance the observer is from the source of light.
- Variation of the intensity (wattage) of the source of light.
- Variation of the brightness of the spectral lines.
- Variation of the diffraction design (prism, diffraction grating alone, spectroscope, etc.). Offer sufficient time for testing the different kinds of light with the spectrometers.

4. The role of reading the spectrometer correctly in this investigation is very important. Careful reading will be very important to the success of the investigation. Students need to view and measure the light's diffraction angles and appearance on the test surface. They should conduct multiple trials of their design option. It is important to emphasize that students should record their data accurately and consistently and plot their data graphically. Generalize the results of all of the investigations and the final graphic displays.
5. Using a chart of the electro-magnetic spectrum and their results of the spectrometer, they can infer the source of energy emission in each light source and the element or elements in the light. Encourage students to generate further questions, which could follow from their initial research and presentation. Such questions could include: Does the light distance from a star or planet change the intensity of the spectrometry reading? Are the readings of the spectrometer always going to indicate that a certain element is present in the source of light? Do certain elements always produce the same spectrograph?
6. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
   - Knowledge: Basic terms and concepts of the electromagnetic spectrum are used accurately in proper context.
   - Application: The measurement strategy for use in the investigation was effective and accurate.
   - Communication: The investigation's conclusions were well-reasoned and accurate.

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Time Requirements

- 3-5 class periods for introduction, testing and communication of findings.

Resources

- Diffraction gratings or simple spectrometers.
- Sources of light, such as fluorescent light, incandescent light, glowing tubes, neon light, etc.
- Different wattage incandescent light bulbs.
- Meter stick; centimeter rulers.
- Graph paper.
- Emission spectra chart, available from most science supply catalogs.
- Science Rubric.

Extensions

- Two EXCELLENT websites are suggested for additional technological design activities associated with spectral displays using compact discs as the diffractors and step-by-step instructions.
- Joachim Koppen Kiel at: http://astro.u-strasbg.fr/~koppen/spectro/spectroe.html#SUN
- www.uwm.edu/~awschwab/specweb.htm
- Autobiography by Oliver Sacks, Uncle Tungsten: Memories of a ` Chemical Boyhood. New York: Vintage Books, 2002 for an adolescent's descriptions about learning about elements and the diffraction of light.

Additional questions for study

- How were the other energies of the electromagnetic spectrum detected?
- How can the distances from the sources of the energy (stellar bodies) be calculated? How does the Doppler effect apply?
- How can the intensity of the energy be calculated?
- What applications of these principles are used in other fields, such as astronomy, medicine, forensics, geology, etc.?

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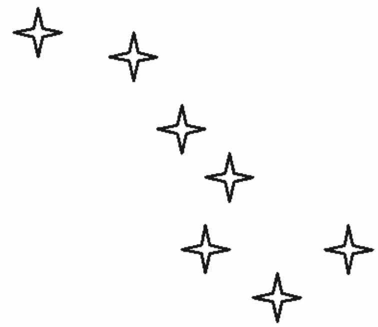
Star Spectrum



Materials needed:
- Computer access
- Big Dipper image
- Paper
- Glue
- Tissue paper
- Pencil or marker

What is a star's spectrum? - The various colors of light that are coming from a star
What can we learn from the color of a star? - The color of a star provides a fairly accurate measurement of the stars surface temperature
Go further: How can we distinguish a star's "real" color from the change in color that we observe due to the star's motion?

What are the colors of each star that make up the Big Dipper? What does that tell you about the temperature and age of the star? Label each color of the star on the image of the Big Dipper.

On your blank paper, draw (or print out) the Big Dipper. Use the tissue paper to accurately represent the color of each star in the constellation. Make a ball out of the tissue paper and glue it to in the appropriate "star," making sure the color is correct.

Additional question: Did the Big Dipper always look this way? Would the colors have been different 100,000 years ago? Will they be different 100,000 years from now? What are the star colors found in different constellations?

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