STELLAR SPECTRAL FINGERPRINTS

Performance Standard 12F/11B.I

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 electromagnetic 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 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 option, 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 electromagnetic 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? etc.

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.

Examples of Student Work not available

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 to these principles are used in other fields, such as astronomy, medicine, forensics, geology, etc.?