Lesson Title	Grating Spectrometer
Length of Lesson	2 days
Created By	Jed Leggett
Subject	Physics
Grade Level	11-12 (Physics)
State Standards	Physics: 6b
DOK Level	DOK 4
DOK Application	Apply Concepts, Analyze
National Standards	9-12: B (physical);
Graduate Research Element	Spectroscopy is often used in many branches of Physics to identify the sources of various types of radiation

Student Learning Goal:
Have students view and measure the visible emission spectra of hydrogen (i.e. the Balmer Series).

Mississippi State Standards:
Physics: 6. Analyze and explain concepts of nuclear physics: (b) Defend the wave-particle duality model of light, using observational evidence: Quantum energy and emission spectra.

National Science Education Standards of Content 9-12
B (Physical): structure of atoms; structure and properties of matter; **interactions of energy and matter**. **Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.**

Materials Needed (supplies, hand-outs, resources):
Optical Spectrometer (can be ordered from various vendors, but they are rather expensive. Check with the physics department at your local university, they often have a large set for undergraduate labs that are only used a few weeks out of the year.), diffraction grating, hydrogen bulbs with lamps, flash lights, magnifying glasses (to read Vernier scale on spectrometers)

Lesson Performance Task/Assessment:
Students will use their knowledge of electron binding energies for hydrogen to calculate the wavelengths of spectral lines in the Balmer Series. They will then use a diffraction grating spectrometer to view and measure the angular deviations of the spectral lines. From the equation for diffraction maxima, the students will use their measured angular deviations to calculate the wavelengths of each spectral line. Students will then compare

their measured wavelengths with the ones they calculated from tabulated binding energies.

Lesson Relevance to Performance Task and Students:
At this point, students will have been introduced to many of the amazing, and sometimes counterintuitive, predictions of Quantum Mechanics. This exercise will give students a chance to observe some Quantum effects first hand, and it will also demonstrate the validity of the mathematical predictions they have been calculating in problem sets.

Anticipatory Set/Capture Interest:
With the lights turned off, have students view both an incandescent bulb and a bulb consisting of a single gas through a diffraction grating. Ask them to explain their observations.

Guided Practice:
Day One:
The teacher will model a few calculations of expected emission lines for various gases. However, the Balmer series should be calculated by the students on their own for home work. The teacher will review the basic principles governing the behavior of a diffraction grating. The teacher will also give a brief overview of the function of the spectrometer.

Day Two:
The teacher will have the spectrometers focused and aligned with the hydrogen lamps when students enter the classroom.

Independent Practice:
Day One:
Students will practice focusing and aligning their spectrometer, and they will use the Vernier scale to measure a few example angles.

Day Two:
Students will first measure the zero deviation angle by lining up their view scope directly across from the source scope and finding the central maximum. Students will then choose one line and measure its deviation to the left and right of the central maximum. If these measurements differ by more than a fourth of a degree, then the students should adjust the orientation of their diffraction grating and retake these measurements. Once the diffraction grating is properly aligned, students should measure the first order deviation of as many lines as they can see (probably 4) in both the left and right directions. Students can then calculate the wavelength of the various spectral lines and compare with their theoretical calculations from their home work.

Remediation and/or Enrichment:
R: individual IEP; partner help throughout lesson; shorten parts of assignment; focus upon smaller elements of the process

E: The teacher can provide bulbs with other gasses for the students to measure.

Check(s) for Understanding:
How does the diffraction grating resolve the different wavelengths of light?
Why does a pure gas only emit certain wavelengths?

Closure:
Have students compare their measurements to those of other groups. Take a class average of each spectral line, and compare to tabulated results.

Possible Alternate Subject Integrations:
*Chemistry – Spectroscopy is a common technique in analytical chemistry.

Teacher Notes: