<table>
<tr><td>Lesson Title</td><td>Emission Spectra</td></tr>
<tr><td>Subject/Grade</td><td>High School Physics or Astronomy</td></tr>
<tr><td>Materials</td><td>- Spectral tubes for H, He, Ne
- Diffraction glasses
- Spectra keys
- Spectrometer</td></tr>
<tr><td>NGSS Standard</td><td>HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.</td></tr>
<tr><td>Objectives</td><td>SWBAT
- Describe the process by which an atom can emit EM radiation.
- Identify elements based on their emission spectra.
- Explain the connection between electron orbital jumps during excitation and wavelength of light emitted during relaxation.</td></tr>
<tr><td>Differentiation</td><td>Accept single-word and diagrammed answers from ELL students. Explanation is a class discussion that gives students time to think and write/diagram their answers so that students who process information differently have the space they need to think.

A cool way to accommodate blind students would be to assign notes to different parts of the visible spectrum and play the emission spectra.</td></tr>
<tr><td>Engagement
(10 min)</td><td>What is the sun made of? How do we know? (2-min freewrite)

Give a brief history: Josef Fraunhofer looking at the first solar spectrum, and Fleming/Cannon/Leavitt developing the stellar classification system. Can use clips from Cosmos if I have to. At this point, I'll say that each element in the sun leaves a unique pattern in the sun's spectrum, but I won't say why.</td></tr>
<tr><td>Exploration
(20 min)</td><td>Overall procedure:
● Students will be given diffraction glasses and a key with a few different spectra on it. They'll go to each of three or four (ideally four but we only have 20 minutes) spectral tubes and view the tubes through the glasses; then they'll have to ID the element. Then we can check our answers by using the spectrometer with each to measure the wavelengths emitted; the diffraction glasses will show the right pattern but not the actual wavelengths.
To open: We all do hydrogen together to get the procedure down. Using diffraction glasses rather than spectrometers is a little tricky, because mirror images form, so we need to take some time to all get comfortable with the method.</td></tr>
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Explanation (15 min)	For each question: give students the opportunity to think and write answers down for each question, then regroup to discuss. ● Do you notice any correlation between atomic number and spectrum complexity? Why do you think that is? (This will likely get students thinking about *protons* but probably not *electrons.*) ● After some student response, I'll tell them that protons aren't the major player here, but what else in an atom is likely to respond to EM energy? (So then we should get to electrons.) ● But ions exist. Electron number and atomic number do not have to be the same. So why should there be that correlation between atomic number and spectrum complexity when electrons are doing all the work? (Totally excited to hear what students come up with for this!)
Elaboration (10 min)	This is where I'll have my slideshow, showing a hydrogen atom's electron getting excited and then relaxing to emit light. I'll say that an electron's allowable energy levels are determined by the forces governing the nucleus-electron interactions, but I don't want to get too quantum-mechanicky on them.
Evaluation (5 min)	At the end of the slideshow, I'll ask students to predict whether an electron in a 3→1 energy transition will emit redder or bluer light than an electron in a 2→1 energy transition. They'll write it down and this will be their exit ticket. As we get into the explanation questions, which I will guide but I'll try not to dominate, students will be able to talk their way to some deeper understanding. ID-ing elements is more about pattern recognition vs. anything else, so that's not really an understanding of the underlying process.