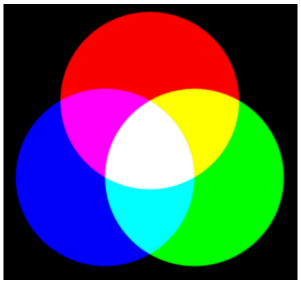
SPECTRUM LAB

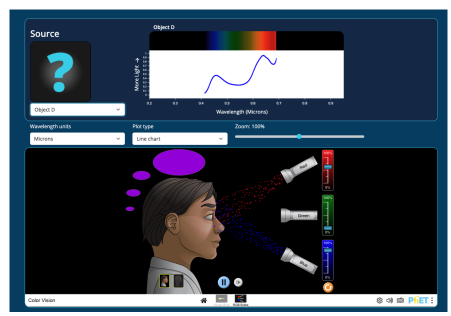
Exploring the World of Color: An Overview

Spectrum Lab is a modular technology-enabled curriculum that, over 3-8 class periods, engages high school students in authentic investigations about light, color, and spectra using real data and online data visualization tools. Educators can select the Spectrum Lab modules that best suit their classes.

Key learning goals include:

- How light interacts with matter through the processes of reflection, absorption, emission, and transmission
- Physical properties of light: light carries energy; can be modeled as a wave or as a particle; and there are predictable relationships between wavelength, frequency, energy, and color of light.
- Electromagnetic Spectrum: there are colors (wavelengths) of light beyond the ones we can see
- How spectroscopy is used to determine an object's composition or temperature
- Analysis and interpretation of graphical data; supporting a scientific claim with appropriate evidence & reasoning (NGSS Practices)

Module 1: Light	How does the interaction of light and matter affect the colors we see? • Preview some disciplines that make use of spectra (astronomy, chemistry, art history, earth science, environmental chemistry, and lighting design) • Make predictions while exploring light and color with hands-on materials (colored filters and light sources) • Explore an online Phet simulation that demonstrates the photon model of light and how light colors mix differently from paint colors • Use photon model to explain the phenomena of emission, reflection, absorption, transmission	

Module 2: Spectra	How can a spectrum tell us more than our eyes can perceive? ● Learn how diffraction gratings work; build a spectroscope using a diffraction grating and cardboard tube and use it to observe spectra of different types of lights in your environment ● Use online Spectrum Tool to learn how scientists represent light spectra graphically and practice interpreting spectrum graphs ● Explore how spectrum graphs relate to what is seen through a spectroscope ● Visualize the relationship between the wavelength, energy, and color of light	
Module 3: Color	How is a spectrum graph related to color? ● Review the features of the online Spectrum Tool and how it represents the amount of light captured by a spectrometer or spectrophotometer at different wavelengths (or colors, or energies). ● Trace the path of light from a source to a detector (e.g. our eyes) and use the concepts of emission, absorption, reflection, and transmission to consider how that affects the colors that we see. ● Make predictions of what color your eye might detect based on the multi-wavelength spectra of different “mystery” objects.	

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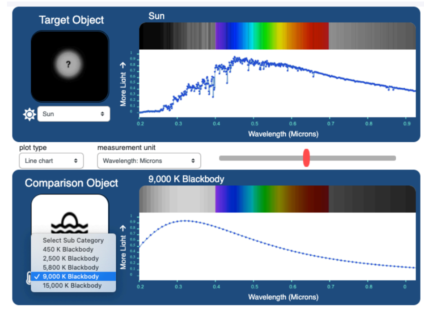
<td>Module 4:
Temperature</td>
<td>What can spectra tell us about an object’s temperature?
Explore how an object’s spectrum relates to its color
Use online Spectrum Tool to explore how an object’s thermal emission relates to color and temperature
Explore features of thermal emission spectra—including both theoretical spectra and actual emission spectra from stars of different temperatures, light bulbs, and planets</td>
<td>
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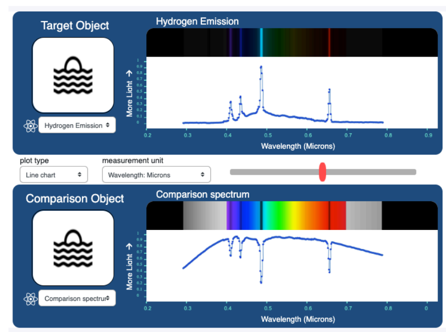
<td>Module 5:
Composition</td>
<td>What can spectra tell us about an object’s composition?
• Learn about the atomic model and how it relates to emission and absorption lines in spectra
• Use online Spectrum Tool to explore how scientists identify elements and compounds through their spectral signatures
• Determine what elements and compounds are present in various space and earth-based spectra</td>
<td>
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<td>Final Project:
Fish Tank</td>
<td>Design a saltwater reef aquarium that is healthy, and looks great too.
• Choose fish and plants from a dataset based on their behaviors and health requirements
• Synthesize information about the reflection spectra of the colorful fish; the lighting needs of chlorophyll-containing algae and coral; and the emission spectra of fish tank LEDs.
• Choose a lighting scheme for your tank and use the spectral data to explain how the organisms would look under your lighting scheme and why you choose those colors (Claim, Evidence, Reasoning)</td>
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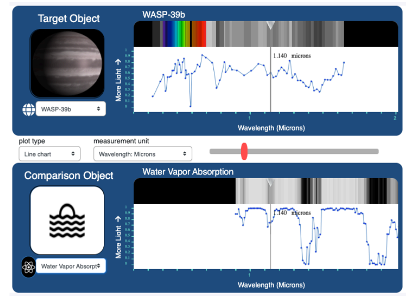
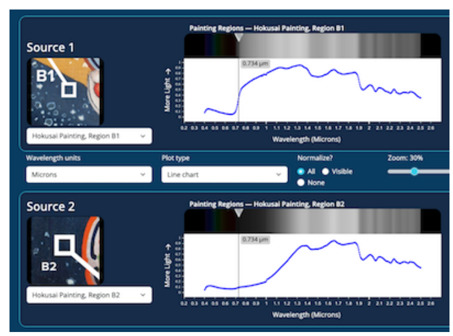
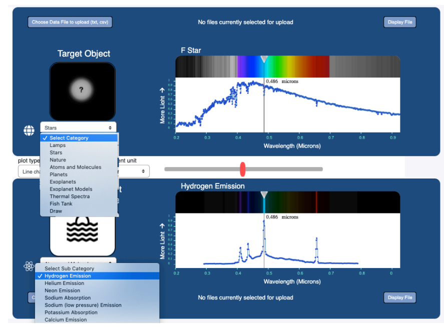
Final Project: Exoplanet	Use spectroscopy to explore atmospheres of alien worlds trillions of miles away ● Learn what exoplanets are and how we know about them ● Gain insight into the process scientists use to learn about exoplanets' atmospheres by comparing low-resolution spectra of real exoplanets with high-resolution spectra of objects within our solar system and theoretical model spectra ● Write a hypothetical proposal to NASA describing which exoplanet you would like to observe with JWST's spectrometer and use existing spectrum data to justify why you would like to observe this planet and what you expect to learn (Claim, Evidence, Reasoning)	
Final Project: Museum Conservation	Set up a museum display that conveys how spectra are used in art conservation ● Learn techniques that Smithsonian conservation scientists use to identify pigments and materials in artworks ● Examine spectral data from two paintings from the Smithsonian's National Museum of Asian Art. ● Choose one of the works of art featured in this project and develop a display that explains how multi-spectral imaging can tell a story of hidden details in the artwork (Claim, Evidence, Reasoning)	

Playground	• Flexibly access, analyze, and compare data from a curated database of over 100 spectra in multiple categories (Stars, Planets, Lamps, Nature, Atoms & Molecules, Thermal Emission, Paint Pigments) • Upload new data to design your own projects and investigate questions of personal interest	

NGSS Educational Objectives

Spectrum Lab supports the Next Generation Science Standards (NGSS) vision of "three-dimensional" student learning, whereby students apply and integrate domain-specific knowledge with scientific practices, while making connections to unifying big ideas in science. The table below highlights the key Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCCs) encountered by students throughout the Spectrum Lab curriculum.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**

• Asking Questions and Defining Problems
• Developing and using models
• Planning and carrying out investigations
• Analyzing and interpreting data
• Constructing explanations
• Engaging in argument from evidence
• Obtaining, evaluating, and communicating information
	• Matter and its Interactions
	    ○ Structure and properties of matter
	    ○ Definitions of energy
	    ○ Conservation of energy and energy transfer
	• Waves and their applications in technologies for information transfer
	    ○ Electromagnetic Radiation
	    ○ Information Technologies and Instrumentation
	• Earth's place in the universe
	    ○ The universe and its stars
		• Patterns
		• Cause and effect: Mechanism and explanation
		• Scale, proportion, and quantity
		• Systems and system models
		• Energy and Matter