SPECTRUM LAB

Module 1: Light Teacher Guide

Essential Question: How does the interaction of light and matter affect the colors we see?

Purpose

This first session is an opportunity to introduce the Spectrum Lab curriculum and its use of an online platform to explore light, color, and spectra. Students will use the online Spectrum Lab platform as well as hands-on materials to:

- Preview some disciplines and careers where the analysis of light, color, and spectra is important (astronomy, chemistry, art history, earth science, environmental science, and lighting design)
- Make predictions about how light behaves while exploring colored filters and LED lights
- Explore an online PhET simulation that demonstrates the photon model of light and how colors of light mix differently than paint colors
- Use the photon model to explain the phenomena of emission, reflection, absorption, and transmission.

NGSS Educational Objectives

In this module, students use a particle model for light to describe how photons associated with different wavelengths and energies (colors) are emitted, absorbed, reflected, or transmitted through various materials. This chart represents the specific NGSS practices, core ideas, and crosscutting concepts students encounter.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems ● Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. **Developing and Using Models** ● Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	**Electromagnetic Radiation** ● When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2) ● Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3)	**Systems and System Models** ● Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Background

In this module, we'll use the Photon Theory of light. Light is made of photons, which behave like waves in some situations and like particles in others. For simplicity, we will refer to photons as particles of light. The photon model—in which each photon is associated with a very specific color of light—will help us make sense of all the observations made throughout these lessons.

A prism can separate light from the Sun into all the colors of the rainbow—red, orange, yellow, green, blue, indigo, and violet—because sunlight is made up of photons of those specific colors.

The color receptors in human eyes respond to photons of all these individual colors, meaning, for example, we would perceive a stream of yellow photons as being yellow in color. Our eyes respond most strongly to red, green, and blue photons, and all other colors of light can also be made from different combinations of red, green, and blue light.

Materials Needed

Color Filters: You can purchase Roscolux gels here: https://www.rosco.com/filters/roscolux.cfm or you may be able to find these or similar filters on amazon

- Red: medium red Roscolux #27
- Green: dark yellow green Roscolux #90
- Blue: primary blue Roscolux #74

For ease of use we suggest cutting them into ~2cm squares and taping them to an index card or bookmark.

Suggestions for Leading the Lesson

Introduction

Your students are about to dive into one of the most useful analytic tools in all of science. Understanding light and color and applying this knowledge through spectroscopy is fundamental to many fields of science, engineering, art and more!

Light in Different Professions

The opening slides in the Spectrum Lab introduce students to the world of spectra through a variety of exciting professions. Additional information is provided in the notes of the Classroom Slides on how the different featured disciplines use spectra.

- NOTE: The curriculum will explore some but not all of the phenomena described in this section. The examples are meant to show the breadth of how spectra are important in a variety of fields.

Discussion Opportunity

After you and your students explore the opening slides, or even before you begin your Spectrum Lab exploration, facilitate a brief discussion around light and color. The following prompts for this discussion can elicit the knowledge and ideas that students bring to the topic:

- What do you know about the different ways that light can interact with matter?
- How do you think we see color?
- What can light reveal about an object or phenomenon, beyond what our eyes can see?
- What's a personal connection you have to light and color?

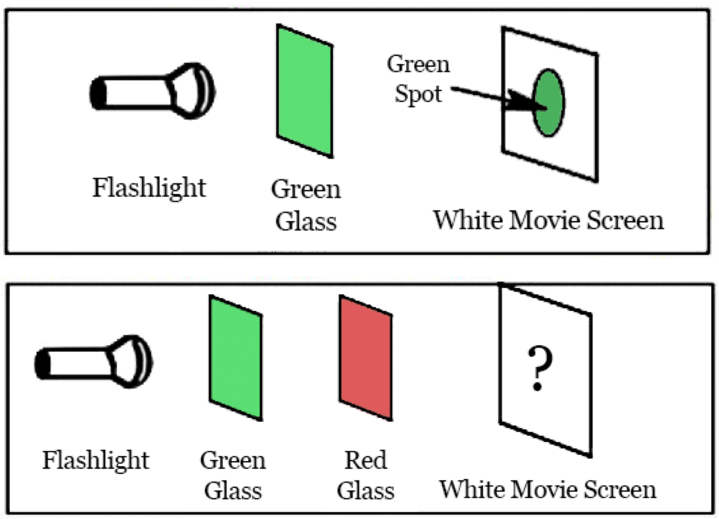
Color Filters: Predictions and Investigation

The Color Filters activity in particular benefits from educator facilitation – especially because students bring many of their ideas about light and color from experiences mixing paint color or pigments. Therefore, many students (and most people) are likely to predict that green plus red light will equal brown, confusing subtractive pigment mixing (where pigments absorb different colors of light) with additive color mixing (where red and green light together stimulate the visual perception of yellow)! If at all possible, use the classroom slides for this activity, and be sure to have your students make predictions BEFORE they look through the filters. Close attention to student ideas can help you to address common conceptual challenges.

NOTE: As you hand out the red, green, and blue colored filters, ask students not to use them until directed.

Poll - Get your students thinking

To engage students and activate their thinking for this section, present them with the following poll question. It's designed to uncover common misconceptions and can give you valuable insight into your students' initial understanding of light and color.



a. It will turn green.
b. It will turn yellow.
c. It will turn brown.
d. It will turn red.
e. It will disappear.

At this point, don't provide the answer (e) until after students have completed Module 1 and can explain their responses using the concepts of emission, absorption, transmission and reflection. You may also want to use this question as an Exit Ticket.

Before your students look through the red filter, have them commit to their prediction about what the 3 intersecting circles will look like.

Discussion Opportunity

As students check their predictions, encourage them to share whether they are surprised by what they see. It can also be helpful to have a student describe what they're observing out loud to ensure that everyone is on the same page.

When looking through the red filter:

- You should see that the red circle is still red, while the blue and green circles disappear or look black.
- Depending on the monitors or the classroom projector, the red gels might not completely block out blue and green light, so some people might still see the blue

or green circles very faintly through the red gel.

Follow the instructions in the Notes section of the Classroom Slides as you move on to the other color filters.

Photons and Color

Students should now explore the PhET Color Vision Simulation (embedded in the Photons and Color Section), following the instructions in their Student Notebook, and completing the Reflection Questions for this section. You may wish to facilitate a whole class discussion of the Photon Model used in this PhET simulation and why it may be more useful here than a wave model for light.

Color Mixing

In this section students investigate how just 3 colors of light can combine in various ways to produce the human perception of many (in fact millions of) different colors. This module does not go into detail about typical human vision and how the red, green, and blue-sensing cone cells in our retinas allow us to perceive this wide variety of colors, but you may wish to facilitate a discussion of this. Once again, students can complete this section of their notebook in a self-guided way.

Behaviors of Light - Recap

Both the student notebook and the Classroom Slides offer an opportunity for you to check student understanding of the concepts of emission, reflection, absorption, transmission (and scattering as a form of reflection).