Foam Box Spectroscopy

Subject Area(s) – Physics

Associated Unit - Light

Lesson Title - Foam Box Spectroscopy

Image 1

ADA Description: A cellphone placed in front of a foam box with the camera program open.

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Caption: A cellphone camera application is being used as a data capturing device for a homemade spectrometer.

Grade Level $11^{th} – 12^{th}$

Time Required – 2 (50 minute) classes

Summary – Students will create a spectrometer from a schematic and set of supplies. Students will learn how a spectrometer functions, and will use their own spectrometer to determine the emission spectra of light from different sources, and students will use different colored filters to determines what happens to light when it passes through a filter.

Engineering Connection – Students will be able to get hands on experience of fashioning their own spectrometer, as well as learning about diffraction grating and how a spectrometer works.

Engineering Category = **Relating science and/or math concept(s) to engineering**

Keywords

Diffraction Grating	**Spectroscopy**	**Light**
Emission Spectrum	**Absorption**	**Young's Double Slit Experiment**

Educational Standards (List 2-4)

State STEM Standard SC.912.E.5.8 - Connect the concepts of radiation and the electromagnetic spectrum to the use of historical and newly-developed observational tools.

ITEEA Standard (required) – STL – Standard 11. N & Q.

Standard 11. Students will develop the abilities to apply the design process.

Grade Level	Benchmarks *As part of learning how to apply design processes, students should learn that:*	
K-2	A.	Brainstorm people's needs and wants and pick some problems that can be solved through the design process.
	B.	Build or construct an object using the design process.
	C.	Investigate how things are made and how they can be improved.
3-5	D.	Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem.
	E.	The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.
	F.	Test and evaluate the solutions for the design problem.
	G.	Improve the design solutions.
6-8	H.	Apply a design process to solve problems in and beyond the laboratory-classroom.
	I.	Specify criteria and constraints for the design.
	J.	Make two-dimensional and three-dimensional representations of the designed solution.
	K.	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.
	L.	Make a product or system and document the solution.
9-12	M.	Identify the design problem to solve and decide whether or not to address it.
	N.	Identify criteria and constraints and determine how these will affect the design process.
	O.	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.
	P.	Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.
	Q.	Develop and produce a product or system using a design process.
	R.	Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

Learning Objectives

After this lesson, students should be able to:

- **Explain how a spectrometer can be used to identify materials based on their emission spectra.**
- **How can we separate visible white light into the entire visible spectrum?**
- **Why do different materials and light sources emit different emissions spectra?**
- **When light hits different materials, why is some light reflected, some absorbed, and some transmitted?**

Introduction / Motivation (5E – Engage)

- **Day 1 Demonstration:** Show students a variety of different colored LEDs (at least Red, Green, and Blue), ask them about similarities and differences between these LEDs. Shine the LEDs on

different objects around the room, and ask the students if they notice any difference on how the objects appear in the light of the different LEDs. Ask the students why they think each of the different LEDs is producing a different color.

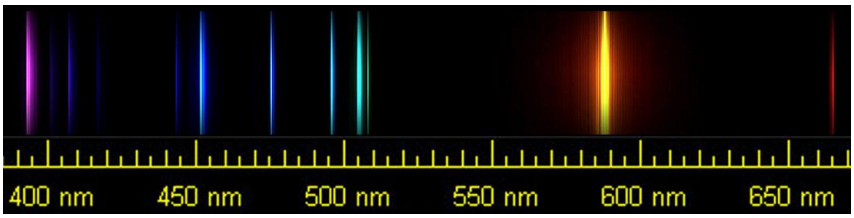
    - Take the moment to reintroduce the topic of ground state and excited state electrons from chemistry. Lead the discussion to the idea that the different materials used in the LEDs are responsible for the different colors, due to the different gaps in their ground and excited states. (BandGap)

- **Day 2 Demonstration:** Pass a white led, a green laser, and a red laser through red and green gummy bears. The green laser will pass through the green gummy bear, but will be absorbed by the red gummy bear. The red laser will pass through the red gummy bear, but will be absorbed by the green gummy bear. The white LED will shine through both gummy bears, but will show the light of the gummy bear passing through.

Lesson Background & Concepts for Teachers (5E – Explain)

- Introduce students to the visible light spectrum, and how the different colors we see from the LEDs are from different wavelengths on that spectrum.
- Introduce how the BandGap of a specific material is related to the specific colors it emits.
- Show students an example of an emission spectra, with the different bands of color from a specific light being separated, and explain how these colors can help lead to identifying a material based on this spectrum.
- Spectrometer Activity. (Day 1+2)
- What happens to light when it passes through a filter activity (Day 2)

Figure 1



ADA Description: A black spectrum with brief colors of purple, blue, teal, orange, and red to identify the emission spectra of Helium.

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Caption: Figure 1. Shows the emission spectrum of Helium.

Vocabulary / Definitions

Word	Definition
Reflection	The throwing back by a body or surface of light, heat, or sound.
Refraction	The change of direction of a ray of light, sound, heat, or the like, in passing indirectly from one medium into another in which its wave velocity is different.
Transmit	To pass through.
Emission	To generate or produce something.

Associated Activities (5E – Explore)

1. Spectrometer Activity (Attached at the end)
2. What happens to light when it passes through a filter? (Attached at the end)

Lesson Closure

Class discussion of the results of each activity. Make sure to go over the post-activity questions with the whole class.

Assessment (5E – Evaluate)

Post-Introduction Assessment

Assessing the lesson after the introduction will mostly take place during the students activities; by assessing the students' progress through the activities, as well as their responses.

Lesson Summary Assessment

Microsoft Forms Activity Data Collection.

Have the students submit their results from the lab into a Microsoft form set-up by the teacher, to collect the data. The data can be used as an assessment grade, a knowledge check, and a discussion point during the final class discussion.

Additional Multimedia Support

- https://www.youtube.com/watch?v=DOsro2kGjGc
  - Bozeman Science on Absorbing light, transmitting, and reflecting light.
- https://www.youtube.com/watch?v=fl42pnUbCCA
  - DIY Cd spectrometer from MIT.
- https://www.le.ac.uk/se/centres/sci/selfstudy/lht5.htm
  - Good explanation on the transmission and absorption of light.
- **Microsoft Form Example –**
  - https://forms.office.com/Pages/ResponsePage.aspx?id=-f2oEP_CDU6cGR_iwYgWSiKfRbAy87ZEoYtM-0_jBBVUN0ZCQ1ZaMTFMMjJKUFdOTVpTQkFWTEExTi4u

Attachments

Spectrometer Mix n' Match

Introduction: You are going to be given the materials to make your own spectrometer, test several different light sources, record their emission spectrums, and then finally identify an unknown light source by its emission spectrum.

Supplies: 4 4"x2" foam core pieces, a 2"x2" foam core piece, duct tape, painters tape, a CD, a ruler, xacto blade, overhead laminate sheet, and 2 razor blades.

- You will follow the steps from the following video to create your own spectrometer: https://www.youtube.com/watch?v=fl42pnUbCCA
    - Be cautious when handling the razor blades! The blades are extremely sharp.
- Once you have made your spectrometer, you will use your spectrometer to identify the emission spectrums from the four following lightbulb types, and record them on the back of this page. Make sure to match the correct bulb type with your data.
- Lastly, there is a 5th light source that is partially covered so that you cannot see the type of bulb emitting the light. You must record the emission spectrum from this lightbulb, and attempt to match it to one of the original four light samples.

Post Activity Questions:

1. What information did your spectrometer give you that allowed you to identify this light source from the other sources?
2. What causes the different emission spectrums for the different materials?
3. Did you notice any similarities between any of the light sources? If so, what were they?
4. What light source did your unknown light source match?
5. How do your emissions spectrums support your claims for #4?

LED Light Emission Spectrum

Halogen Light Emission Spectrum

CFL Light Emission Spectrum

Incandescent Light Emission Spectrum

Unknown Light Emission Spectrum

What happens to light when it passes through a filter?

Purpose: In this activity, you will be responsible for describing what happens to white light after it is transmitted through a colored filter using the emission spectrum from the light before and after the filter.

Materials: Spectrometer, a white light source, red filter, green filter, blue filter.

- Take your spectrometer and aim it towards the light from the ceiling, and record the emission spectrum below.

LED Light Emission Spectrum

- Add the blue filter, and repeat the previous step. Do the same with the red and green filters as well.

Blue Filter Light Emission Spectrum

Red Filter Light Emission Spectrum

Green Filter Light Emission Spectrum

Post Activity Questions:

1. **What pattern did you notice about the light that is allowed through a filter?**
2. **Is there any specific color of light that is not allowed through each of the filters?**
3. **What do you think happens to the light that is not allowed through each filter? How can we test this?**

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Classroom Testing Information

This unit is designed to use a little bit of initial lecturing to support a big session of hands on activities for students to be able to build a device which might normally be thought of as an expensive piece of equipment. The goal is to get students interested in the topic of light through being able to use something they built on their own.