Instructional Segment for Energy and Matter: Waves (Electromagnetic Spectrum/Light)

In our homes the transfer of energy runs our garage door openers, TV, radios, etc. This instructional segment uses these everyday applications to lead to a larger decision about where to buy tickets for an upcoming concert and designing a new entertainment venue.

Student Science Performance

Grade 8	**Title:**
Topic: Energy & Matter - Waves (Electromagnetic Spectrum/Light)	Best Seats in the House: Electromagnetic Waves

Georgia Standards of Excellence

S8P4. Obtain, evaluate, and communicate information to support the claim that electromagnetic (light) waves behave differently than mechanical (sound) waves.

a. Ask questions to develop explanations about the similarities and differences between electromagnetic and mechanical waves.
(*Clarification statement:* Include transverse and longitudinal waves and wave parts such as crest, trough, compressions, and rarefactions.)
b. Construct an explanation using data to illustrate the relationship between the electromagnetic spectrum and energy.
c. Design a device to illustrate practical applications of the electromagnetic spectrum (e.g., communication, medical, military).
d. Develop and use a model to compare and contrast how light and sound waves are reflected, refracted, absorbed, diffracted or transmitted through various materials.
(*Clarification statement:* Include echo and how color is seen but do not cover interference and scattering.)
f. Develop and use a model (e.g., simulations, graphs, illustrations) to predict and describe the relationships between wave properties (e.g., frequency, amplitude, and wavelength) and energy.
g. Develop and use models to demonstrate the effects that lenses have on light (i.e., formation an image) and their possible technological applications.

Lesson Performance Expectations:

- Plan and carry out investigations to develop evidence for the structure and function of electromagnetic waves.
- Develop and communicate an explanation using models to explain how light waves function (e.g. reflect, refract, absorb, diffract, and transmit).
- Develop an argument for why the evidence supports an explanation for the relationship between the electromagnetic spectrum and energy.
- Develop and use models to describe the interaction of light and sound waves to make a decision about the best seat in the house.
- Develop and use models to demonstrate how lenses refract light, including formation of images (real and virtual) and magnification.

Additional notes on student supports

Engage	Phenomenon 1:  Students observe and raise questions for discussion about the phenomenon. *Teacher Notes: Prompts for Writing/Discussion: Have you ever seen the sky like this? What time of day was it? Where were you? Have you ever seen light do this in some other situation?* ***Obtaining*** Students are provided prisms and encouraged to manipulate the prisms to model the phenomenon. ***Communicating*** Students make connections of how the prism's structure is similar to particles in the atmosphere. Students then make predictions about how these structures change the way we see light. *Teacher Notes: Provide flashlights and/or access to sunlight. If you have a projector, suspend a prism so that the light projected is diffracted on the screen.* *Guiding Questions for Writing/Discussion: What do most of us observe? As a result, what can you infer about light? How do you think these prisms can help you understand what happens when the sky looks like this? What other things have you observed that might be similar? How do you think all of this happens? Since you now recognize that we are limited in our abilities to observe light energy, what other kinds of light energy may exist that you have not thought about before? Guide students toward the purpose of this learning cycle aimed at exploring/explaining the electromagnetic spectrum in its entirety.*
Explore	***Obtaining*** Students obtain information about the structure of light waves and their interactions with the environment via specific light-based lab stations or explorations. ***Communicating*** Students communicate explanations of new understandings via models, discussion, and performances. *Teacher Notes: Provide written instructions, any necessary materials, and organizer for obtaining information to include visual representations of outcomes. Resources for sample station suggestions and organizers can be found below.*

- Reflection/Law of Reflection Station Suggestions:
  - Task: Students verify Law of Reflection.
  - Materials needed: small mirrors, flashlight or lightbox, construction paper, compass/ruler, laser pointer (teacher demonstration).
  - Students construct models showing light reflection.

- Security Systems: How is light used in motion detectors?

- Teach Engineering: Exploring Light

- PBS: Speed of Light/Einstein- History of Science

- PBS: Refraction/Sparkling Diamonds

- NASA: Building a Telescope

- PhET: Detecting Color Simulation
  (Attribution: PhET Interactive Simulations, University of Colorado Boulder; https://phet.colorado.edu)

Teacher Notes: Additional resources for information or investigation can be found online.

Part 2:

Obtaining Students obtain information about the electromagnetic spectrum and energy via Light Video.

Communicating Students share new information obtained from the video.

Teacher Notes: Consider the use this graphic organizer to support students in contributing to discussion/writing.

Teacher Notes: Guiding Questions for Discussion/Writing: How does the video describe what life would be like if you could only see one color? What is light? How does light act like a wave? How does light act like a particle? How does the video help you understand wavelength and frequency? How is one kind of energy different from another? Can you think of different examples from the video? Since we can't see all of the light energy ourselves, how do we use the other forms of energy? How does the telescope act as our virtual eye?

Explain	***Communicating*** *Students list/ask questions about what was seen and heard from the light stations.* *Prompts for Writing or Discussion: Based on your observations, what questions do you have? Tell us about something that was unexpected. What explorations did you have to repeat because you simply couldn't believe the outcomes? When you repeated it, did the same thing happen again and again? What does this tell you about the way science explains the world around us?* ***Evaluating*** *Students create models via visual representations that explain the light behaviors.* *Teacher Notes:* ***Think****-Pair-Share* ***Communicating/Evaluating*** **Inter-group Communication:** Students discuss and compare their initial explanations with other individuals. *Teacher Notes*: Think-**Pair**-Share ***Communicating*** Students **share** current explanations of their current understandings of how light waves function (e.g. reflect, refract, diffract, absorb, and transmit) and begin to make predictions as to how this behavior is evident in the structure of the wave (e.g. amplitude, wavelength, frequency). *Teacher Notes: Explicitly address crosscutting concepts patterns, cause and effect, and structure and function with students. Explicitly address the structure of light waves as transverse. Explicitly address how the structure of the wave might change as it interacts with the environment. Encourage students to modify their visual representations based on discussion outcomes. Prompts for Sharing/Discussion: What is the electromagnetic spectrum? What is the range we see called? What was always present when we could see objects clearly? What is always present when the direction of light would change? What is always present if the light would break into different colors? What is always present if the light could not be observed? Give example of other light we cannot see.* *Consider the use of this graphic organizer to support students in contributing to discussion/writing about lab stations.* Part 2: ***Obtaining*** Students obtain information about energy, the electromagnetic spectrum, and properties of these transverse waves via stations specific to practical applications (e.g. lenses, mirrors, broadcast waves, X Rays, etc.), informational text, simulations, videos, etc. Suggested Teacher Facilitated Station: • NASA: The Electromagnetic Spectrum (go to Activity: Wavelength and Energy, p25)

	Suggested Student Paced Stations: • Optics4Kids: Detecting Infrared Light/Remote Controls • TeachEngineering: Lasers or Laser Types and Uses Suggested Informational Text: • NASA: Electromagnetic Spectrum • EarthSky: Electromagnetic Spectrum Suggested Website with Combined Informational Text and Simulations: • NASA: Uses of Electromagnetic Spectrum Suggested Simulations • PhET: Radio Waves (Attribution: PhET Interactive Simulations, University of Colorado Boulder; https://phet.colorado.edu) ***Evaluating*** Students connect obtained information to outcomes of electromagnetic stations. Students write and/or draw models that modify explanations from obtained data about the relationship between energy and the electromagnetic spectrum. Students also model how wave properties function based on interactions with the environment (e.g. density of media, type of matter). ***Communicating*** **Inter-group Communication:** Students discuss and compare their initial explanations with other individuals. *Teacher Notes: As needed students are encouraged to come to an agreement with agreed upon rationale. Explicitly address cross cutting concepts patterns, cause and effect, and structure and function with students.*

Elaborate Student elaboration and evaluation works in conjunction with the instructional segment for mechanical/sound waves.	*Phenomenon: Students are purchasing tickets for a concert. Before purchasing tickets, students need to make a decision about which seats to request.*   ***Obtaining*** Students obtain information about the venue, including original sources of sound and light, speaker placements, acoustic treatments, structures within the venue, etc. Students individually generate initial explanations of the interactions of sound and light waves via visual representations. *Teacher Notes: To make the phenomena more relevant, consider checking upcoming concert schedules at nearby venues.* *Teacher Notes/Discussion Prompts: What would the sound waves look like close to the stage?...further away from the stage? What might impact the way light is observed?* ***Evaluating*** Students work in a small group, compare initial explanations, and collectively connect obtained information to what they collectively understand about sound and light to make a decision about the best seat selection. *Teacher Notes/Discussion Prompts: What kinds of things do you need to think about pertaining to the potential electromagnetic energy that is used at the concert? What forms of electromagnetic energy do you expect to be used as part of the concert? How will the _____ form of light energy interacts with different structures in the seating area? How will the light energy appear closer to the stage?...further? What can you predict about how sound waves/light waves will interact with the seating? What can you predict about how sound waves/light waves will interact with ….? How does the structure of the stage affect your decision making? Why do you think they are structured this way?* ***Communicating*** Students construct an argument for their seat selection using evidence and reasoning acquired from engage/explore/explain to support their claim for the best seat. Students use visual representations of the venue as part of their supporting evidence about the best seat. *Teacher Notes: Consider provision of a writing framework with a performance rubric, such as Claims-Evidence-Reasoning to support student communication.*
Evaluate	***Performance Assessment of Student Learning***
	Phenomenon: Mercedes Benz Stadium: The Innovation in Designing Venues *Teacher Notes: Mercedes Benz Stadium video construction provides a drone fly over with short interviews of various people involved with the construction*

	of stadium. *This is the same evaluation task as the other instructional segment for this unit, Best Seats in the House: Sound Waves. The task could be completed separately or together after students have completed both segments and performance expectations.* ***Obtaining*** Students, in groups of 3-4, obtain information about the rationale for design decisions from existing concert/entertainment venues. Students then plan and carry out an investigation for specific materials and designs for a model/prototype of their own. ***Evaluating*** Students work together to design an initial prototype for a new entertainment venue and then revise design based on outcomes of sound/light trials. *Teacher Notes: Explicit emphasis on engineer design process and the use of scientific understandings in decisions.* **Communicating** Students provide written rationale (to include scientific concepts of sound and light waves) for final materials and blueprint-like design for their model of a concert/entertainment venue. Students present final models of concert/entertainment venue.
	Science Essentials
Science and Engineering Practices	• Developing and using models • Analyze and interpret data • Constructing explanations and designing solutions • Asking questions
Crosscutting Concepts	• Energy and matter • Systems and system models • Cause and effect • Structure and function
Disciplinary Core Ideas	From: *A Framework of K-12 Science Education:* PS3.A: Definitions of Energy PS3.B: Conservation of Energy and Energy Transfer PS4.A: Wave Properties PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation

Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the lab	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. Provide calculators as needed. 2. Provide graph paper as needed.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide information to students in various formats to reach as many students as possible.
2. The students should be given adequate time to complete each part of the lesson.
3. The students should be allowed to express their knowledge in various formats.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.

Engage:

1. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.
2. Students that are working with the prisms may need assistance with the set up of the prism.
3. The teacher may need to repeat directions more than once.
4. The teacher can offer other examples of how we see light to assist students in identifying questions that the students have about light.
5. Struggling students may need some help making connections that there are things in the atmosphere that change how light behaves. This connection to elements, atoms and other structures may prove difficult for students without reminders and explanations of other concepts.
6. The teacher should consider providing discussion questions to struggling students in advance. This will give students with processing disorders a chance to formulate responses and increase the likelihood that they will participate in the discussion.
7. Clear guidelines should be provided about class discussions. This is to allow students to feel safe sharing in the classroom environment.
8. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include writing, drawing or designing a play.

Exploring:

1. The teacher should repeat directions as needed.

2. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include writing, drawing or designing a play.
3. The teacher should provide organizers to help students keep track of information from station to station.
4. The teacher may need to assist students at each station.
5. After the station activity would be a good time to do a formative assessment. Then review/re-teach as needed.
6. The teacher may need to show the video more than once to give students time to identify the most important concepts.
7. The teacher should consider providing discussion questions to struggling students in advance. This will give students with processing disorders a chance to formulate responses and increase the likelihood that they will participate in the discussion.
8. Clear guidelines should be provided about class discussions. This is to allow students to feel safe sharing in the classroom environment.
9. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include writing, drawing or designing a play.

Explaining:

1. The teacher should record the questions on the board and then help students decide what they need to research and what they can already answer.
2. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include writing, drawing or designing a play.
3. The teacher should use intentional grouping to pair the students. Best practice is to use data to group students.
4. The teacher should consider providing discussion questions to struggling students in advance. This will give students with processing disorders a chance to formulate responses and increase the likelihood that they will participate in the discussion.
5. Clear guidelines should be provided about class discussions. This is to allow students to feel safe sharing in the classroom environment.
6. The teacher should provide an organizer to support students in contributing to the discussion and/or writing about the stations.
7. The teacher may need to help students manage time as they move through the stations.
8. The teacher may need to repeat directions.
9. The teacher needs to provide supports for the informational texts. These supports could take the form of a text to speech program, the teacher leading a read aloud, partner reads or using a video in place of the texts.
10. The teacher should provide an organizer to record observations, thoughts and questions from the stations and simulations.

Elaborating:

1. Students may need an organizer to record their predictions and initial claims.
2. Students should use intentional grouping to pair students. Best practice is to practice data driven grouping.
3. The teacher should consider providing discussion questions to struggling students in advance. This will give students with processing disorders a chance to formulate responses and increase the likelihood that they will participate in the discussion.
4. Clear guidelines should be provided about class discussions. This is to allow students to feel safe sharing in the classroom environment.
5. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. This could include writing, drawing or designing a play.
6. Students may need additional time to construct their claims and responses.

Evaluating:

1. Any video or audio may need to be shown/watched more than once for the students to identify the most important pieces.
2. The teacher should use intentional grouping to put students into groups. Best practice is to use data to drive student grouping.
3. Students should be allowed to express their knowledge in various ways. This could include writing their argument, drawing a cartoon, designing a play or making a power point.
4. Students may need additional time to construct their model.

Return to Instructional Segment

Light Lab Station Sheet

Station	Outcome/ Observations	Visual Representation (Model)	Modified Visual (Post Discussion)

Return to Instructional Segment

Electromagnetic Graphic Organizer

	Visual	Description w/Example	How would you quantify the energy?
Low Frequency			
High Frequency			
Short Wavelength			
Long Wavelength			

Return to Instructional Segment