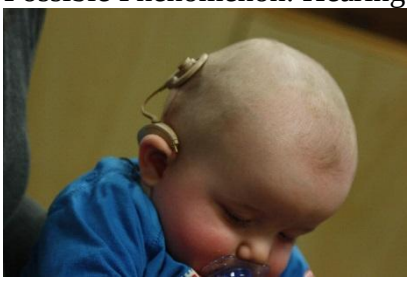
Instructional Segment for Energy and Matter: Waves (Sound)

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 purchasing tickets for specific seats for an upcoming concert. Students will use what they have learned to design a new entertainment venue.	
Grade 8 **Topic: Energy & Matter - Waves (Mechanical/Sound Waves)**	**Title:** Best Seats in the House: Sound 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.) 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.) e. Analyze and interpret data to predict patterns in the relationship between density of media and wave behavior (i.e., speed). 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.	
Lesson Performance Expectations: ● Plan and carry out an investigation to develop evidence for an acoustic sweet spot. ● Develop and communicate an explanation and argument for the causes of an acoustic sweet spot. ● Develop and use models to describe the interaction of sound waves to make a decision about the best seat in the house. Additional notes on student supports	
Engage (Sound Waves)	Phenomenon: Unique Acoustics in a Dome Options for Video/Audio Students predict, observe, and raise questions for discussion about the provided scenario. *Teacher Notes: Prompts for Writing or Discussion – Have you ever experienced anything like this? Where were you? What was it like in the building? Why do you think this happens?*
Explore (Sound Waves)	***Obtaining*** Students obtain information about the structure of sound waves and their interactions with the environment via specific sound-based stations. ***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. Station Suggestions: GPB: Sound & Density of Media *Teacher Notes: Encourage students to explore in pairs. As one person observes within the system (holding the strings attached to the hanger), the other could record their observations outside the system. Each would record and compare their observations about pitch, intensity, etc. from their two perspectives. After exploring several mediums (e.g. something metal, something fluffy, something rigid, etc.), students could develop initial thoughts as to (a) how the properties of the medium impact what they observe and (b) how the connection to the ear with a string versus the air impacts what they observe.* GPB: Pitch *Teacher Notes: Before showing the video, provide students with various musical instruments to explore. Allow students time to explore each of the instruments from a cause/effect lens. For example, provide three instruments (e.g. triangle, kazoo, mini slide whistles, tambourine, etc.) to groups of 4 students. Ask students to draw visual representations that show the causes of the various sounds each instrument produces. (See below for a sample organizer.) Then after watching the video, organize the class by different categories of instruments (e.g. stringed, woodwind, brass, percussion). Establish that the purpose for each group is to create a new musical instrument that represents that family and manipulates the density of the medium to produce various sounds. Students culminate the exploration by playing their instrument, drawing visuals of the wave motion at different pitches, and explaining how the density of their medium(s) impacts the outcomes. As part of their final performance, students should also include a portion where the audience is asked to make predictions about the sound produced based on a given situation. For example, the percussion group might ask the audience, "Based on everything we have shown you about our instrument, what do you think will happen if we hit it right here? Why do you think that?"* *Example of a Cause/Effect coupled with Structure/Function Organizer.* *Teacher Notes: Modify the lesson plan to support students in the production of visual representations of what is observed at each of the stations suggested. In addition, facilitate discussion about what is observed, how this was similar or different from what was expected, and gather information about why students think this phenomenon happened.* Other Background/Student Resources: GPB: Sounds and Solids GPB: Vibration and Pitch

Explain	***Obtaining*** Students obtain information about sound wave structure and interactions (cause & effect) via informational text, video, simulations, walking tour of the school, and other models. *Teacher Notes: Peak student interest throughout the explain phase by setting a context for learning through additional phenomena. Examples have been included.* *Teacher Notes: Support students in obtaining information by providing a structure (e.g. Cornell notes, guided notes) for record keeping and organization of pertinent information.* Possible Phenomenon: Ear buds/Headphones – How Loud is Too Loud?   There are multiple online resources for students to explore as they investigate this phenomenon. Possible Phenomenon: Hearing Aids  There are multiple online resources for students to explore as they investigate this phenomenon. Suggestions for Models: Role Play – Longitudinal Waves Roles in particles, outside force, and/or wall(s) Facilitate the human wave by asking students to line shoulder to shoulder. Put the wall in place at one end of the students. Position the outside force opposite the wall. The outside force should gently push the first particle. Students should sequentially bump the next particle and return to their resting position. Upon hitting the wall, the particle motion will reflect. Transverse Waves = Students lift arms up and down in a manner similar to a stadium wave. *Teacher Notes: Remind students to remain safe while role playing the particles' motions. Pause role play at specific points to emphasize the wave structures.*

For example, when a group of the students are all smooshed together, call, "Pause," and then ask students to tell you what structure is represented.

Kinesthetic Model –
Students instructed to stand and position arms rigidly to form a letter **T,** similar to how a cheerleader might cheer. Teacher facilitates discussion about how the letter T can also help them remember that matter is moved perpendicular (⊥) to the direction of energy in transverse waves. Then ask students to hold up both arms rigidly, forming 2 l's. Facilitate discussion about how the lower-case l's can help them remember that longitudinal waves transfer energy parallel to the particulate motion. Include acknowledgement that the word longitudinal starts/ends with an l and that the mathematical symbol for ∥ parallel looks like two l's.

Teacher Notes: After providing the initial ideas for the model, ask students to make suggestions for adding in motions for crest, trough, compression, and longitudinal. From these student suggestions, then support students in ways for modeling amplitude, calculating wavelength, changing the speed due to a new medium, etc.

Possible Phenomena: Acoustic Treatments: What is the sound like ….?
Home Studio:

(Most) Homes:

Sports Stadium:

Recording Studio:

Teacher Notes: Consider the use of a predict-observe-explain structure, where student observations derive from investigations/simulations into the various media and wave behavior. (Simulation suggestions provided below.) Upon working through the simulations support students in making predictions about how the energy of the sound waves and media impact the properties of the wave.

Suggestion for Simulation(s):
PhET: Sound
(Attribution: PhET Interactive Simulations, University of Colorado Boulder;

	https://phet.colorado.edu) *Teacher Notes: Remind students to show wave as sound.* Suggestion for School Walking Tour: As part of the investigation into acoustic treatments, take your students on a tour of the school to look for design aspects that impact acoustics. *Teacher Notes: For the walking tour consider areas like the cafeteria, stage, band room, gym, etc. Ask guiding questions to direct student attention to specific structures you know were purposefully included. For example, focus attention on the material used to construct the walls, curtains around the stage, absorption/foam-like pads that may be suspended or hung on the wall, etc.* *Teacher Notes: As a culminating assignment, require students to make design recommendations that could improve the acoustics (e.g. acoustic treatment) for a specific room in the school. Require students to provide an argument (claim, evidence and reasoning) with visuals for the acoustic treatment recommendations.* ***Evaluating*** Students connect obtained information to outcomes from sound stations in explore phase. Students write initial explanations into provided example organizer. ***Think****-Pair-Share* ***Communicating*** Inter-group: Students discuss and compare their initial explanations with other individuals. *Teacher Notes: Think-**Pair**-Share As needed students are encouraged to come to an agreement with agreed upon rationale.* Intra-group: Students explain how the sound waves are reflected, refracted, absorbed, diffracted or transmitted within the provided situations. *Teacher Notes: Think-Pair-**Share** Explicitly address the crosscutting concepts of patterns, cause and effect, and structure and function with students. Prompts for Discussion: What was repeatedly observed in each station? What was always required for sound to be heard? How would the sounds differ? What was always present when objects were seen clearly? What would always be present when the direction of sound would change?*
Elaborate	*Smaller Scale Phenomenon: Acoustic Sweet Spots in the Classroom* ***Obtaining*** Students obtain information about an acoustic sweet spot in a movie theatre. ***Evaluating*** Students connect obtained information from explain phase to the

	potential for an acoustic sweet spot in the classroom. ***Communicating*** **Performance Based Task:** Students construct a written argument for the acoustic sweet spot in the classroom with supporting evidence about making slight acoustic treatments to improve the overall acoustics from various spots. *Teacher Notes: Consider the use of a writing rubric with explicit expectations for inclusion of visual representation(s) and use of language as part of reasoning.* *Larger Scale 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, speaker placements, acoustic treatments, structures within the venue, etc. Students individually create initial explanations of the interactions of sound waves via visual representations. *Teacher Notes: To make the phenomenon more relevant, consider using an upcoming concert scheduled 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 sound 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: Describe what you understand about how sound travels in air. What kinds of things do you need to think about as it pertains to the potential electromagnetic energy that could be used at the concert? 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 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 construction video 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: Electromagnetic 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: Make explicit an engineer design process and 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. Aid students in reading graphs and constructing models with a scale.

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 may need to show the video more than once for struggling students to identify the most important parts of the video.
2. The teacher could make 3 columns on the board and have students come record things that they observed, predict and questions that they had. This will give students something to look back at as they move through the lesson.
3. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include writing, drawing or verbally explaining.

Exploring:

1. Students may need additional time to do research, complete the stations and develop an explanation or model.
2. Struggling learners may benefit from an organizer to write down information, observations from the stations and material to aid in developing their explanation.
3. Any video or audio at a station may need to be shown/watched more than once for the students to identify the most important pieces.
4. The teacher should use intentional pairing to match the students up with a partner. Best practice is to use data to drive grouping.

Explaining:

1. The teacher needs to provide specific guidelines for the kinesthetic activity in this lesson. As the students bump into each other the teacher needs to be aware of any problems that arise. Also, some students may not like to be touched or be averse to participating. The teacher could have students that do not want to participate observe the group and explain what they are seeing.
2. Have students draw what occurred during the role play activities.
3. Have students do the motions to remember how energy and matter move. Then have students draw what they think they did. This could be used as a formative assessment.
4. The teacher should pull out small group to re-teach or review as needed.
5. The teacher can find a video, a song or other method of showing the movement directions to students as well. This will help students that are not specifically kinesthetic learners remember as well.
6. Give struggling students a form to record their observation, predictions and reasonings as you look at different acoustic models.
7. The teacher should give very specific instructions that relate to the walking tour. What are students looking for? Are students allowed to talk in the hallways? Should students walk in a single file line? etc.
8. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include writing, drawing or verbally explaining.
9. Provide students with discussion questions in advance to allow struggling students to prepare for class discussion. This allows students time to formulate response and be prepared to participate in the discussion.

Elaborating:

1. The teacher should provide students resources to use when looking for acoustic sweet spots.
2. The teacher should provide an organizer to students to record their research.
3. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material. These formats could include writing, drawing or verbally explaining.
4. The teacher should provide the students with a rubric to use to self-assess their work.
5. The teacher can ask questions as they move around the room that could help students fix misconceptions in their argument.
6. The teacher should use intentional grouping to put students into groups. Best practice is to use data to drive student groupings.
7. Provide the discussion questions to struggling students in advance. This will help students formulate a response prior to the discussion and this should help students feel more comfortable participating in a class discussion.

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

Cause/Effect Organizer for Engage Phase

Before Playing – *How is the instrument designed to work?* ***(General Structure/Cause)***	*During Play –* *What happens to the air?* ***(General Function/Effect)***	*Final Effect –* *What is the pitch like?* *What is the intensity like?*
Extra air released here  *Sound (or music)* *Hum released here*		
Air inside the kazoo:	***Student Hint**: Draw the air particles **motion** inside the kazoo when the instrument is played.*	***Student Hint**: Draw the pattern of disturbance that gives the instrument its unique sound.*

Return to Instructional Segment

Think-Pair-Share Evaluation

Station:	Stereo Hangers	Pitch making Guitar	Listening Stick
Outcomes (Use a visual representation when possible.)			
Possible Explanation for Outcomes			
Revised Explanation based on Further Research and/or Exploration (Be sure to underline related terms.)			
Revised Visual Representation			

Return to Instructional Segment