NGSS OVERVIEW

WAVES

Performance Expectation MS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

Performance Expectation MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Performance Expectation MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
1. **Investigation: It's a Noisy World** Students are introduced to the physical properties of waves with a scenario that engages them in the properties of sound within the context of hearing loss. Students use mathematical representations to analyze data and identify patterns in sound intensity.	MS-PS4.A	Using Mathematics and Computational Thinking Analyzing and Interpreting Data	Patterns	Mathematics: MP.2, MP.4, 6.RP.A.1, 7.RP.A.2 Literacy/ELA: RST.6-8.3
2. **Investigation: Making Sound Waves** Students experiment with producing noises of varied intensity and frequency as they begin to build an understanding of the properties of sound. Students then create a model of a sound wave using a metal spring.	MS-PS4.A	Developing and Using Models	Structure and Function Patterns	Mathematics: MP.2 Literacy/ELA: RST.6-8.3
3. **Reading: The Nature of Sound** Students learn more about longitudinal waves as they obtain, evaluate, and communicate information from text, diagrams, and graphs. Students engage with the crosscutting concept of structure and function as they read about the hearing process and the anatomy of the ear.	MS-PS4.A	Obtaining, Evaluating, and Communicating Information Analyzing and Interpreting Data Using Mathematics and Computational Thinking	Structure and Function Patterns Connections to Engineering, Technology, and Applications of Science	Mathematics: MP.2 Literacy/ELA: RST.6-8.1 RST.6-8.9
4. **Investigation: Noise-Induced Hearing Loss** Students use mathematics and computational thinking as they analyze and interpret data related to the risk of noise-induced hearing loss. Students read the profiles of several individuals and evaluate the risk of noiseinduced hearing loss for each one. Students examine the structure and function of the protection provided by two kinds of ear protection.	MS-PS4.A	Using Mathematics and Computational Thinking Analyzing and Interpreting Data Obtaining, Evaluating, and Communicating Information	Structure and Function	Mathematics: MP.4

WAVES (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
5. **Investigation: Telephone Model** Students model how noise interference affects the transmission and reception of analog and digital signals. They find that the structure of digitized signals, sent as wave pulses, function as a more reliable way to encode and transmit information.	MS-PS4.C	Developing and Using Models Obtaining, Evaluating, and Communicating Information	Structure and Function Connections to Engineering, Technology, and Applications of Science	ELA/Literacy: RST.6-8.3 WHST.6-8.9
6. **Reading: Analog and Digital Technology** Students clarify the findings of the previous activity by integrating those results with information in written text. Students explore the history of the development of hearing aids as an example of how technology influences the progress of science and how science has influenced advances in technology. Students are formally assessed on Performance Expectation MS-PS4-3.	MS-PS4.C	Obtaining, Evaluating, and Communicating Information	Structure and Function Connections to the Nature of Science Connections to Engineering, Technology, and Applications of Science	ELA/Literacy: RST.6-8.1 RST.6-8.9 WHST.6-8.9
7. **Investigation: Another Kind of Wave** Students use a model to identify patterns to deduce the inverse relationship between frequency and wavelength, and the direct relationship between amplitude and energy. Students perform calculations and make conceptual connections to make an explanation of the relationships found. Students are formally assessed on Performance Expectation MS-PS4-1.	MS-PS4.A	Developing and Using Models Using Mathematics and Computational Thinking Planning and Carrying OutInvestigations Connections to the Nature of Science Analyzing and Interpreting Data	Patterns	Mathematics: MP.4 ELA/Literacy: RST.6-8.3
8. **Laboratory: Wave Reflection** Students investigate the reflection of sound and light waves. Building on observations of the relationship between the direction of incident and reflected sound waves, students analyze collected data and deduce the law of reflection as applied to light waves. They model the law as they create ray diagrams to represent both regular and diffuse reflection.	MS-PS4.B	Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data Using Mathematics and Computational Thinking Connections to the Nature of Science	Patterns Structure and Function	ELA/Literacy: RST.6-8.3

WAVES (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
9. **Laboratory: Refraction of Light** Students experiment with the transmission of light rays by planning and carrying out an investigation of the refraction of light through water. Looking for patterns in their data, students search for a qualitative relationship between the angle of incidence, angle of refraction, and total internal reflection.	MS-PS4.B	Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data Connections to the Nature of Science	Patterns Structure and Function	ELA/Literacy: RST.6-8.3
10. **Laboratory: Comparing Colors** Students collect evidence that indicates that different colors of light carry different amounts of energy. Students analyzing and interpret light transmission graphs for three different sunglass lenses. They determine which sunglass lens (structure) provides the best protection (function) for the eyes.	MS-PS4.B	Planning and Carrying Out Investigations	Structure and Function	ELA/Literacy: RST.6-8.3
11. **Laboratory: Selective Transmission** Students conduct an investigation to test how different films affect the transmission and absorption of light. As they analyze and interpret the data they have collected, they learn that invisible waves are present at both ends of the visible spectrum. Students select and justify which structural films would be most functional to use on windows in three different situations.	MS-PS4.B	Planning and Carrying Out Investigations Analyzing and Interpreting Data	Structure and Function	Mathematics: MP.2 ELA/Literacy: RST.6-8.3
12. **Reading: The Electromagnetic Spectrum** Students complete a reading that integrates textual and visual information that extends their understanding of the electromagnetic spectrum. Through the examples of classic experiments, students see that scientific knowledge is based on logical and conceptual connections between evidence and explanations. While reading about applications of electromagnetic energy, students are shown how technologies extend the capabilities of scientific investigation.	MS-PS4.A MS-PS4.B	Obtaining, Evaluating, and Communicating Information Connections to the Nature of Science (empirical evidence) Connections to the Nature of Science (new evidence)	Connections to Engineering, Technology, and Applications of Science	ELA/Literacy: RST.6-8.1 RST.6-8.9

WAVES (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
13. **Laboratory: Where Does the Light Go?** Students conduct an investigation of the behavior of ultraviolet and infrared on different surfaces. Students analyze and interpret patterns in their data and then use the model in the activity to explain how structures can be designed to minimize or maximize reflection or absorption. Students are formally assessed on Performance Expectation MS-PS4-2.	MS-PS4.B	Developing and Using Models Planning and Carrying Out Investigations Analyzing and Interpreting Data	Structure and Function Patterns	ELA/Literacy: RST.6-8.3
14. **Laboratory: Blocking Out Ultraviolet** Students apply the concepts of transmission, reflection, and absorption of ultraviolet while planning and carrying out an investigation. Students use models to compare the effectiveness of sunscreen and moisturizing lotion in blocking ultraviolet.	MS-PS4.B	Planning and Carrying Out Investigations Analyzing and Interpreting Data Connections to the Nature of Science Developing and Using Models	Structure and Function	ELA/Literacy: RST.6-8.3
15. **Talking It Over: Personal Protection Plan** Students integrate scientific and technical information in a table with written text to evaluate the relative risk of developing cataracts and skin cancer for several individual profiles. Students create connections between scientific knowledge and society by having students consider how the consequences of actions relate to exposure to ultraviolet.	MS-PS4.B	Obtaining, Evaluating, and Communicating Information	Connections to the Nature of Science	ELA/Literacy: RST.6-8.9 WHST.6-8.9

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

WAVES

WAVES

Unit Issue: Waves can have both helpful and harmful effects on human health.

Anchoring Phenomenon: Sound and light waves can both help and harm humans. Examples explored include information transmitted by waves, hearing loss due to loud music, and eye damage from looking at the sun. Students generate and answer questions such as: How can loud sounds cause hearing loss? How can sunlight damage eyes? How do waves transfer energy? How can waves be used to transmit information?

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
Humans can hear a large range of sound intensities.	How much sound energy is safe?	What is the range of sound intensities that humans can hear? (Activity 1)	1, 2, 3, 4	MS-PS4-1	One example of a wave is sound. Sound can be helpful as we can use it to hear soft things as well as loud things and communicate with it. As sound travels as a wave, it has wave properties. One of these properties, energy/intensity, can be harmful but can be mitigated through the use of certain technologies.
		How can we model sound waves? (Activity 2)			
		What are the properties of sound waves? (Activity 3)			
		What can be done to prevent noise-induced hearing loss? (Activity 4)			
Certain technologies make use of or modify waves.	How can wave technology be used to enhance or protect human senses?	What can be done to prevent noise-induced hearing loss? (Activity 4)	4, 5, 6, 11, 14	MS-PS4-2 MS-PS4-3	There are many technologies that utilize waves or modify wave properties. Very recently, one such technology, digital technology, has revolutionized the ways in which we can encode and store information. We are able to record analog signals, likes sound waves, as digital files, like MP3s, which has many benefits.
		Which type of signal, analog or digital, is more reliable? (Activity 5)			
		What is the difference between digital and analog transmission? (Activity 6)			
		What part of sunlight is transmitted through selected films? (Activity 11)			
		How is sunscreen different from other kinds of lotion? (Activity 14)			

PHENOMENA, DRIVING QUESTIONS AND SEPUP STORYLINE

WAVES (continued)

Investigative Phenomena	Driving Questions	Guiding Questions	Activities	PE	Storyline
We experience many different types of waves. (Sound, light, water, seismic, etc.)	How do different types of waves transfer energy?	How can we model sound waves? (Activity 2)	2, 3, 7, 8, 9, 12, 13	MS-PS4-1 MS-PS4-2	One example of a wave is sound. Sound can be helpful as we can use it to hear soft things as well as loud things and communicate with it. As sound travels as a wave, it has wave properties. One of these properties, energy/intensity, can be harmful but can be mitigated through the use of certain technologies.
		What are the properties of sound waves? (Activity 3)			
		What are the characteristics of a transverse wave? (Activity 7)			
		What kind of surface makes a good reflector? (Activity 8)			
		How does light behave at the boundary between two different materials? (Activity 9)			
		What are the characteristics of electromagnetic waves? (Activity 12)			
		How do different materials absorb or reflect light? (Activity 13)			
The energy carried by a beam of light is affected by the color of the light.	How can exposure to sunlight harm humans?	How are the colors of the visible light spectrum similar to and different from one other? (Activity 10)	10, 11, 12, 13, 14, 15	MS-PS4-2	For light, frequency corresponds to the color of light – electromagnetic spectrum – as well as the energy of light. That is, the energy carried by a beam of light is affected by the color of the light. So while light is good for you – vitamin D; the ability to see – it can also be harmful at high energies like UV. What can we do to mitigate the risk of high energy/harmful sunlight?
		What part of sunlight is transmitted through selected films? (Activity 11)			
		What are the characteristics of electromagnetic waves? (Activity 12)			
		How do different materials absorb or reflect light? (Activity 13)			
		How is sunscreen different from other kinds of lotion? (Activity 14)			
		What personal ultraviolet protection plan fits your risk factors and lifestyle? (Activity 15)			

NGSS CORRELATIONS

WAVES

Crosscutting Concepts		Activity number
Patterns	Patterns can be used to identify cause and effect relationships.	2, 7, 8
	Graphs, charts, and images can be used to identify patterns in data.	1, 3, 7, 9, 13
Structure and Function	Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.	8
	Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	2, 4, 5, 6, 8, 9, 10, 11, 13, 14
Connections to the Nature of Science	Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	9
	Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.	15
	Advances in technology influence the progress of science, and science has influenced advanced in technology.	6
Connections to Engineering, Technology, and Applications of Science	Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.	3, 5, 6, 12
Science and Engineering Practices		**Activity number**
Analyzing and Interpreting Data	Analyze and interpret data to determine similarities and differences in findings.	3
	Construct and interpret graphical displays of data to identify linear and nonlinear relationships.	3, 4
	Analyze and interpret data to provide evidence for phenomena.	8, 9, 11, 13, 14
	Analyze displays of data to identify linear and nonlinear relationships.	1
	Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).	5
Developing and Using Models	Develop a model to predict and/or describe phenomena.	2, 5, 7, 8, 9, 13
	Develop a model to describe unobservable mechanisms.	2, 14

NGSS CORRELATIONS

WAVES (continued)

Science and Engineering Practices		Activity number
Obtaining, Evaluating, and Communicating Information	Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.	3, 4, 5, 6, 12, 15
	Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts.	9
Planning and Carrying Out Investigations	Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.	8, 9
	Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.	14
	Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.	7, 8, 9, 10, 11, 13
	Evaluate the accuracy of various methods for collecting data.	14
Using Mathematics and Computational Thinking	Use mathematical representations to describe and/or support scientific conclusions and design solutions.	1, 3, 4, 7, 8
Asking Questions and Defining Problems	Ask questions that can be investigated within the scope of the classroom, outdoor environment, an museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	6
Connections to the Nature of Science	Scientific knowledge is based on logical and conceptual connections between evidence and explanations.	8, 12, 14
	Science findings are frequently revised and/or reinterpreted based on new evidence.	12
Disciplinary Core Ideas		**Activity number**
Wave Properties (PS4.A)	A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	1, 2, 3, 4, 7
	A sound wave needs a medium through which it is transmitted.	3, 12

NGSS CORRELATIONS

WAVES (continued)

Disciplinary Core Ideas		Activity number
Electromagnetic Radiation (PS4.B)	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.	8, 9, 10, 11, 12, 13, 14, 15
	The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.	8, 9
	A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.	9, 10, 12
	Because light can travel through space, it cannot be a matter wave, like sound or water waves.	12
Information Technologies and Instrumentation (PS4.C)	Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.	5, 6
Performance Expectations		**Activity number**
Waves and Their Applications in Technologies for Information Transfer (PS4)	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. (MS-PS4-1)	7
	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (MS-PS4-2)	13
	Integrate qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information than analog signals. (MS-PS4-3)	6

COMMON CORE STATE STANDARDS: CONNECTIONS AND CORRELATIONS

WAVES

Making Connections in ELA

As with all SEPUP instructional materials, this unit introduces multiple opportunities for students to engage in a range of ELA practices and skills that are important grade-specific goals of the common core state standards and are also essential to the sensemaking students are doing throughout the unit. Specifically, throughout the unit, students carry out a variety of scientific investigations to understand more about waves and wave-related concepts. For example, in activity 2, students build on their understanding of sound by observing the frequency and intensity of various sounds (RST.6-8.3). As a second example, in activity 5, students observe the transmission of analog and digital signals, and how noise affects both of these signals (RST.6-8.3). In activity 3, students learn about longitudinal waves through texts, diagrams, and graphs. Students bring their experience with previous hands-on activities from this unit, along with the technical information from readings, to better understand the content (RST.6-8.1; RST.6-8.9). In activity 6, students read a text about sound transmission that supports and builds on their findings from the previous activity (WHST.6-8.9). In addition, Appendix E: Literacy Strategies in the Student Book contains optional resources to support reading, writing and oral communication.

Common Core State Standards – English Language Arts		Activity number
Reading in Science and Technical Subjects (RST)	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (RST.6-8.1)	3, 6, 12, 15
	Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. (RST.6-8.3)	1, 2, 5, 7, 8, 9, 10, 11, 13, 14
	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (RST.6-8.9)	3, 6, 12
Writing in History/ Social Studies, Science, and Technological Subjects (WHST)	Draw evidence from informational texts to support analysis, reflection, and research. (WHST.6-8.9)	5, 6, 15

Making Connections in Mathematics

This unit introduces multiple opportunities for students to engage in math practices and skills that are important grade-specific goals of the common core state standards and are also essential to the sensemaking students are doing throughout the unit. For example, in activity 1, students explore the loudness of sounds and the related unit of sound intensity, decibels. In doing so, they look at cards that have information about different sounds, and determine the relative intensity of each sound using proportionality (7.RP.A.2). In this same activity, students use ratios to compare decibels to change in sound intensity (6.RP.A.1; MP.2). Building on students' understanding of sound, in activity 4, they create a graph to better understand how it's not just sound intensity, but also sound duration, that can cause hearing damage (MP.4). To support students as they create graphs, teachers can provide them with an optional visual aid (4.1 - "Scatterplot and Line Graphing Checklist") found in Appendix C of the student book.

Common Core State Standards – Mathematics		Activity number
Mathematical Practice (MP)	Reason abstractly and quantitatively. (MP.2)	1, 2, 3, 11
	Model with mathematics. (MP.4)	1, 3, 4
Ratios and Proportional Reasoning (RP)	Understand the concept of a ratio, and use ratio language to describe a ratio between two quantities. (6.RP.A.1)	1
	Recognize and represent proportional relationships between quantities. (7.RP.A.2)	1