MS-PS4-1 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

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. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [*Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.

- Use mathematical representations to describe and/or support scientific conclusions and design solutions.

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Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Disciplinary Core Ideas

PS4.A: Wave Properties

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

Crosscutting Concepts

Patterns

- Graphs and charts can be used to identify patterns in data.

Observable features of the student performance by the end of the course:

1	Representation		
	a	Students identify the characteristics of a simple mathematical wave model of a phenomenon, including:	
		i.	Waves represent repeating quantities.
		ii.	Frequency, as the number of times the pattern repeats in a given amount of time (e.g., beats per second).
		iii.	Amplitude, as the maximum extent of the repeating quantity from equilibrium (e.g., height or depth of a water wave from average sea level).
		iv.	Wavelength, as a certain distance in which the quantity repeats its value (e.g., the distance between the tops of a series of water waves).
2	Mathematical modeling		
	a	Students apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations (e.g., frequency corresponds to sound pitch, amplitude corresponds to sound volume).	
3	Analysis		
	a	Given data about a repeating physical phenomenon that can be represented as a wave, and amounts of energy present or transmitted, students use their simple mathematical wave models to identify patterns, including:	
		i.	That the energy of the wave is proportional to the square of the amplitude (e.g., if the height of a water wave is doubled, each wave will have four times the energy).
		ii.	That the amount of energy transferred by waves in a given time is proportional to frequency (e.g., if twice as many water waves hit the shore each minute, then twice as much energy will be transferred to the shore).
	b	Students predict the change in the energy of the wave if any one of the parameters of the wave is changed.	

MS-PS4-2 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [*Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena.

Disciplinary Core Ideas

PS4.A: Wave Properties

- A sound wave needs a medium through which it is transmitted.

PS4.B: 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.
- 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.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Crosscutting Concepts

Structure and Function

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Observable features of the student performance by the end of the course:			
1	Components of the model		
	a	Students develop a model to make sense of a given phenomenon. In the model, students identify the relevant components, including:	
		i.	Type of wave.
			1. Matter waves (e.g., sound or water waves) and their amplitudes and frequencies.
			2. Light, including brightness (amplitude) and color (frequency).
		ii.	Various materials through which the waves are reflected, absorbed, or transmitted.
		iii.	Relevant characteristics of the wave after it has interacted with a material (e.g., frequency, amplitude, wavelength).
		iv.	Position of the source of the wave.
2	Relationships		
	a	In the model, students identify and describe* the relationships between components, including:	
		i.	Waves interact with materials by being:
			1. Reflected.
			2. Absorbed.
			3. Transmitted.
		ii.	Light travels in straight lines, but the path of light is bent at the interface between materials when it travels from one material to another.
		iii.	Light does not require a material for propagation (e.g., space), but matter waves do require a material for propagation.
3	Connections		
	a	Students use their model to make sense of given phenomena involving reflection, absorption, or transmission properties of different materials for light and matter waves.	

	b	Students use their model about phenomena involving light and/or matter waves to describe* the differences between how light and matter waves interact with different materials.
	c	Students use the model to describe* why materials with certain properties are well-suited for particular functions (e.g., lenses and mirrors, sound absorbers in concert halls, colored light filters, sound barriers next to highways).

MS-PS4-3 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

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.** [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [*Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods.

- Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.

Disciplinary Core Ideas

PS4.C: Information Technologies and Instrumentation

- Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.

Crosscutting Concepts

Structure and Function

- Structures can be designed to serve particular functions.

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.

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Connections to Nature of Science

Science is a Human Endeavor

- Advances in technology influence the progress of science and science has influenced advances in technology.

Observable features of the student performance by the end of the course:				
1	Obtaining information			
	a	Given materials from a variety of different types of sources of information (e.g., texts, graphical, video, digital), students gather evidence sufficient to support a claim about a phenomenon that includes the idea that using waves to carry digital signals is a more reliable way to encode and transmit information than using waves to carry analog signals.		
2	Evaluating information			
	a	Students combine the relevant information (from multiple sources) to support the claim by describing*:		
		i.	Specific features that make digital transmission of signals more reliable than analog transmission of signals, including that, when in digitized form, information can be:	
			1.	Recorded reliably.
			2.	Stored for future recovery.
			3.	Transmitted over long distances without significant degradation.
		ii.	At least one technology that uses digital encoding and transmission of information. Students should describe* how the digitization of that technology has advanced science and scientific investigations (e.g., digital probes, including thermometers and pH probes; audio recordings).	