MIDDLE SCHOOL PHYSICAL SCIENCE: WAVES

Standards Bundle

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon potential for related phenomena that can be used throughout a unit.

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.*]

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.*]

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

A wave is a disturbance involving the transfer of energy from place to place. Each wave has a repeating pattern of wavelengths, frequency, and amplitude that allows for energy or information to travel distances. Waves behave differently depending on the material they are traveling through, including reflection, absorption and transmission.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- Dogs can hear sounds that are undetectable by humans.
- Stretch out a slinky and push on one end without letting go.
- Dropping items into a pool of water causes ripples in the water's surface.
- Listen to the sound of an ambulance siren as it passes by you.
- Scientists are sending radio waves beyond our solar system.

Storyline

This section aims to decode not only the DCI connections, but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking ● Use mathematical representations to describe and/or support scientific conclusions and design solutions. **Developing and Using Models** ● Develop and use a model to describe phenomena.	**PS4.A: Wave Properties** ● A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. ● 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.	**Patterns** ● Graphs and charts can be used to identify patterns in data. **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.

In this bundle, the properties of mechanical waves and electromagnetic waves can be investigated using the crosscutting concepts of patterns as well as structure and function. Waves requiring a medium (air, water or solid material) to travel through are called mechanical waves and form when an energy source causes a medium to vibrate. A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. The distance between two corresponding parts of a wave is its wavelength. The frequency is the number of waves that pass a given point during a given amount of time. The amplitude of a wave is the maximum distance the medium vibrates from the resting position. The energy transported by a wave is directly proportional to the square of the amplitude of the wave. In other words, a high energy wave is characterized by a high amplitude. Students can 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. Students can analyze data to identify patterns indicating the increase in energy transported by a wave when the amplitude increases by units of one.

Light waves, on the other hand, are a form of electromagnetic waves and do not require a medium. Electromagnetic waves are made up of vibrating electric and magnetic fields that can move through empty space or a medium. Types of electromagnetic waves include radio waves, microwaves, infrared rays, ultraviolet rays, X-rays, and gamma rays as well as visible light. Two different models are needed to explain the behavior of light waves. The particle model explains light as a stream of tiny particles of energy called photons. When a beam of high frequency light shines on some metals, it causes electrons to move so much they can be knocked out of the metal. A wave model is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. For example, 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. Also, 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. Using this information, students can develop and use models to describe that waves are reflected, absorbed, or transmitted through various materials. Examples of models could include drawings, simulations, and written descriptions. Through an understanding that structures can be designed to serve particular functions by taking into account properties of different materials, students can design structures that absorb, reflect, and refract light.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.

Resources to inform your formative assessment.

http://stemteachingtools.org/brief/30

http://stemteachingtools.org/brief/41

http://stemteachingtools.org/pd/sessionb

SEP Using Mathematics and Computational Thinking

- Present students with multiple wave models, then students construct quantitative attributes (e.g., measurements of heights) of the objects, and display the data using simple graphs.

SEP Developing and Using Models

- Present two wave drawing to students, they then compare the models to identify both common and unique model components, relationships, and mechanisms.

CCC Patterns

- Provide a data table with wave measurements including frequency, amplitude, and wavelength. Students should explain what the pattern of data allows them to conclude from the experiment.

CCC Structure and Function

- Provide a model showing waves behaving in a variety of materials. For the model, describe the behaviors of the waves and how their behaviors differ with varying materials.

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain-size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Analyze and interpret** *graphical displays of data* to identify that a simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

- **Use mathematical concepts** to describe that the energy transported by the waves is directly proportional to the amplitude of the wave.
- **Develop a model** to describe how sound waves require a medium in order to be transmitted and *how the type of medium affects the characteristics of the sound waves.*
- **Construct an explanation,** *through data analysis* that light can travel through space and does not need to travel through a medium.
- **Plan and conduct an investigation** to describe, test, and predict the behavior of light when it shines on an object, is reflected, absorbed, or transmitted through the object, *depending on the object's material* and the frequency (color) of the light.
- **Plan and carry out investigations** that describe, test and predict the path that light travels when it passes between different transparent materials (e.g., air and water, air and glass).
- **Use a wave model** to describe how the path of light is affected when it moves from one medium to another (e.g. air to water) and how *this difference in medium* can affect the brightness and color (i.e. frequency-dependency) of the lights.