HS.PS-W Waves

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Students who demonstrate understanding can:

a. Plan and carry out investigations to determine the mathematical relationships among wave speed, frequency, and wavelength and how they are affected by the medium through which the wave travels. [Assessment Boundary: Algebraic calculations only.]

b. Carry out an investigation to describe a boundary between two media that affects the reflection, refraction, and transmission of waves crossing the boundary. [Clarification Statement: Descriptions should include mathematical relationships.] [Assessment Boundary: Descriptions requiring trigonometric functions are excluded.]

c. Investigate the patterns created when waves of different frequencies combine and explain how these patterns are used to encode and transmit information. [Assessment Boundary: Qualitative only.]

d. Use drawings, physical replicas, or computer simulation models to explain that resonance occurs when waves add up in phase in a structure, and that structures have a unique frequency at which resonance occurs. [Clarification Statement: Constructive and destructive interference of waves results in a standing wave pattern (resonance).] [Assessment Boundary: Qualitative explanations only.]

The performance expectations above were 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 9–12 builds on K–8 and progresses to using, synthesizing, and constructing models to predict and explain relationships between systems and their components in the natural and designed world.

- Use models (including mathematical and computational) to generate data to explain and predict phenomena, analyze systems, and solve problems. (d)

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that build, test, and revise conceptual, mathematical, physical and empirical models.

- Plan and carry out investigations individually and collaboratively and test designs as part of building and revising models, explaining phenomena, or testing solutions to problems. Consider possible confounding variables or effects, and ensure that the investigation's design has controlled for them. (a),(b),(c)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical expressions to represent phenomena or design solutions in order to solve algebraically for desired quantities. (b)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct and revise explanations and arguments based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories) and peer review. (c)

Disciplinary Core Ideas

PS4.A: Wave Properties

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. The reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of these properties. (a),(b)
- Combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. (c)
- Resonance is a phenomenon in which waves add up in phase in a structure, growing in amplitude due to energy input near the natural vibration frequency. Structures have particular frequencies at which they resonate. This phenomenon (e.g., waves in a stretched string, vibrating air in a pipe) is used in speech and in the design of all musical instruments. (d)

Crosscutting Concepts

Patterns

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. Mathematical representations are needed to identity some patterns. (a),(c),(d)

- [Clarification Statement for d: Constructive and destructive interference of waves results in a standing wave pattern, i.e. resonance.]

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects. (b)

Connections to other DCIs in this grade-level: **HS-ETS-ETSS, HS-ETS-ED, HS.ESS-ES**

Articulation to DCIs across grade-levels: **MS.PS-WER**

Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]

ELA –

W.9-10.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

W.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Mathematics –

MP.2 Reason abstractly and quantitatively.

MP.4 Model with Mathematics.

F.LE Construct and compare linear, quadratic, and exponential models and solve problems.

A-REI.10 Represent and solve equations and inequalities graphically.

A.CED Create equations that describe numbers or relationships.