HS. Waves and Electromagnetic Radiation

A Performance Expectations HS.PS4.WER

1 Use mathematical representations to support a claim regarding relationships among the period, frequency, wavelength, and speed of waves traveling and transferring energy (amplitude, frequency) in various media. HS.PS4.1

2 Evaluate questions about the advantages of using a digital transmission and storage of information. HS.PS4.2

3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model (quantum theory), and that for some situations one model is more useful than the other HS.PS4.3

4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [HS.PS4.4

5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. HS.PS4.5

6 Use mathematical models to determine relationships among the size and location of images, size and location of objects, and focal lengths of lenses and mirrors. HS.PS4.6

B Science and Engineering Practices HS.WER.SEP

1 Asking Questions and Defining Problems HS.WER.SEP.1

- a Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS- PS4-2) HS.WER.SEP.1A

2 Using Mathematics and Computational Thinking HS.WER.SEP.2

- a Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1),(HS-PS4-6) HS.WER.SEP.2A

3 Engaging in Argument from Evidence HS.WER.SEP.3

- a Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3) HS.WER.SEP.3A

4 Obtaining, Evaluating, and Communicating Information HS.WER.SEP.4

- a Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4) HS.WER.SEP.4A
- b Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5) HS.WER.SEP.4B

5 Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena HS.WER.SEP.5

- a A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3) HS.WER.SEP.5A

C Disciplinary Core Ideas HS.WER.DCI

1. PS3.D: Energy HS.WER.DCI.PS3.D
   a. Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) HS.WER.DCI.PS3.D.1
2. PS4.A: Wave Properties HS.WER.DCI.PS4.A
   a. 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. (HS-PS4-1) HS.WER.DCI.PS4.A.1
   b. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HSPS4-5) HS.WER.DCI.PS4.A.2
   c. [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) HS.WER.DCI.PS4.A.3
   d. (NYSED) The location and size of an image are related to the location and size of an object for a plane mirror. The location and size of an image (real or virtual) are related to the location and size of an object and the focal distance for convex and concave mirrors. (HSPS4-6) HS.WER.DCI.PS4.A.4
   e. (NYSED) The location and size of an image (real or virtual) are related to the location and size of an object and the focal distance for biconvex and biconcave lenses. (HS-PS4-6) HS.WER.DCI.PS4.A.5
3. PS4.B: Electromagnetic Radiation HS.WER.DCI.PS4.B
   a. Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) HS.WER.DCI.PS4.B.1
   b. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4) HS.WER.DCI.PS4.B.2
   c. Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) HS.WER.DCI.PS4.B.3
4. PS4.C: Information Technologies and Instrumentation HS.WER.DCI.PS4.C
   a. Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5) HS.WER.DCI.PS4.C.1

D Crosscutting Concepts HS.WER.CC

1. Patterns HS.WER.CC.1
   - a. 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. (HS-PS4-6) HS.WER.CC.1A
   - b. Mathematical representations can be used to identify certain patterns. (HSPS4-6) HS.WER.CC.1B
2. Cause and Effect HS.WER.CC.2
   - a. Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4- 1) HS.WER.CC.2A
   - b. 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. (HS-PS4-4) HS.WER.CC.2B
   - c. Systems can be designed to cause a desired effect. (HS-PS4-5) HS.WER.CC.2C
3. Systems and System Models HS.WER.CC.3
   - a. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3) HS.WER.CC.3A
4. Stability and Chance HS.WER.CC.4
   - a. Systems can be designed for greater or lesser stability. (HS-PS4-2) HS.WER.CC.4A
5. Interdependence of Science, Engineering, and Technology HS.WER.CC.5
   - a. Science and engineering complement each other in the cycle known as research and development (R&D). (HS- PS4-5) HS.WER.CC.5A
6. Influence of Engineering, Technology, and Science on Society and the Natural World HS.WER.CC.6
   - a. Modern civilization depends on major technological systems. (HSPS4-2),(HS-PS4-5) HS.WER.CC.6A
   - b. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HSPS4-2) HS.WER.CC.6B