**Waves in NGSS**

**Oct. 1, 2014**

A new area of emphasis in NGSS is **waves, including the use of waves in digital communications**, and many teachers are likely wondering about how to teach this, and may themselves not be very confident in their own content knowledge. Below are selected Performance Expectations (PE) that are the direct targets for the experiences today – there are of course other PEs in the same group but are not included in today’s experiences. My intent is to offer a set of experiences that could be readily adapted as needed for grades 4-high school, including both pedagogy and 3-D content. However, mathematical treatment will be limited today.

NOTE: the cross-out below is Tom’s recommendation

Science and Engineering Practices target = **Developing and Using Models**

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| **PS4.A Waves: Light and Sound** |
| Students who demonstrate understanding can:

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| **1.PS4.1** |  |

 | **Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.**[Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork. |

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Crosscutting Concept = **Energy**

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| **4-PS4 Waves and Their Applications in Technologies for Information Transfer** |
| Students who demonstrate understanding can:

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| **4-PS4-1.** | **Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.**[Clarification Statement: Examples of models could include diagrams, analogies, and physical models ~~using wire~~ to illustrate wavelength and amplitude of waves.] [*Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.*] |
| **4-PS4-3.** | **Generate and compare multiple solutions that use patterns to transfer information.\***[Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1’s and 0’s representing black and white to send information about a picture, and using Morse code to send text.] |

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| **MS.Waves and Electromagnetic Radiation**  |
| Students who demonstrate understanding can: **07-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.] **07-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.]  |

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| **HS-PS4 Waves and their Applications in Technologies for Information Transfer** |
| Students who demonstrate understanding can:

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| **HS-PS4-1.** | **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**[Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [*Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.*] |
| **HS-PS4-2.** | **Evaluate questions about the advantages of using a digital transmission and storage of information.**[Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.] |

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