Elaboration and Unpacking of the DCIs

Grade 8, Measurement Target 2	Students are able to develop and interpret models and use mathematical representations and scientific information to make claims about how waves transfer energy and information through various materials.		
	PS4.A: Wave Properties	**PS4.B: Electromagnetic Radiation**	**PS4.C: Information Technologies and Instrumentation**
DCIs	• A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. **(MS-PS4-1)** • A sound wave needs a medium through which it is transmitted. **(MS-PS4-2)**	• 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. **(MS-PS4-2)** • 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. **(MS-PS4-2)** • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. **(MS-PS4-2)** • However, because light can travel through space, it cannot be a matter wave, like sound or water waves. **(MS-PS4-2)**	• Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. **(MS-PS4-3)**
Elaboration of the DCIs	**MS-PS4A.a** • A simple wave has a repeating pattern. • A simple wave has a specific wavelength. • A simple wave has a specific frequency. • A simple wave has a specific amplitude.	**MS-PS4B.a** • When light shines on an object, it can be reflected by the object. • When light shines on an object, it can be absorbed by the object. • When light shines on an object, it can be transmitted by the object.	**MS-PS4C.a** • Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information than analog signals. • Waves can be used to transmit digital information. • Digitized information is comprised of a pattern of 1s and 0s.

Elaboration of the DCIs Cont'd	• The wavelength and frequency of a wave are related to one another by the speed of travel of the wave. • The higher the frequency of the wave the shorter the wavelength. • The lower the frequency of the wave the longer the wavelength. • The higher the frequency of the wave the higher the amplitude. • The lower the frequency of the wave the lower the amplitude. **MS-PS4A.b** • Sound waves need a medium (air, water, or solid material) to travel through. • Sound is a pressure wave in air or any other material medium.	• When light shines on an object, it can be scattered through the object. • What happens to light when it shines on an object depends on the object's material. • What happens to light when it shines on an object depends on the frequency (color) of the light. • The selective absorption of different wavelengths of white light determines the color of most objects. **MS-PS4B.b** • The path of light travels in a straight line. • The path of light bends at surfaces between different transparent materials (e.g., air and water, air and glass). • Light usually refracts when passing from one material into another. **MS-PS4B.c** • Light can be described using a wave model. • A wave model of light can be used to explain its brightness. • A wave model of light can be used to explain its color. • A wave model of light can be used to explain the bending of light at a surface between media. • Light can travel through a vacuum. • Light cannot be described as a mechanical wave. • At the surface between two media, like any wave, light can be reflected, refracted (its path bent), or absorbed.	

Proficiency Boundaries	• Assessment should be limited to standard repeating waves and should not include electromagnetic waves. • Assessment should be limited to qualitative applications pertaining to light and mechanical waves. • Binary counting is not included. • The specific mechanism of any given device is not included.		
Prior Knowledge	• Energy can be transferred from place to place by sound, light, heat, and electric currents. • Energy can be converted from one form to another. • The speed of an object is related to the energy of the object. • Waves can cause objects to move. • Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). • Light reflecting from objects and entering the eye allows objects to be seen. • Patterns can be used to transfer information. • Digitized information can be transmitted over long distances without significant degradation.		
Student Misconceptions	• The majority of elementary students and some middle school students who have not received any systematic instruction about light tend to identify light with its source (e.g., light is in the bulb) or its effects (e.g., patch of light). They do not have a notion of light as something that travels from one place to another. As a result, these students have difficulties explaining the direction and formation of shadows, and the reflection of light by objects. For example, some students simply note the similarity of shape between the object and the shadow or say that the object hides the light. Middle school students often accept that mirrors reflect light but, at least in some situations, reject the idea that ordinary objects reflect light. [1] Many elementary and middle school students do not believe that their eyes receive light when they look at an object. Students' conceptions of vision vary from the notion that light fills space ("the room is full of light") and the eye "sees" without anything linking it to the object to the idea that light illuminates surfaces that we can see by the action of our eyes on them. [2] The conception that the eye sees without anything linking it to the object persists after traditional instruction in optics. [3] Some fifth graders can understand seeing as "detecting" reflected light after specially designed instruction. [4]		
Articulation of DCIs Across Grade Levels	**4.PS4.A** (MS-PS4-1) **HS.PS4.A** (MS-PS4-1), (MS-PS4-2), (MS-PS4-3)	**4.PS3.B** (MS-PS4-1) **4.PS4.A** (MS-PS4-1) **4.PS4.B** (MS-PS4-2) **HS.PS4.B** (MS-PS4-1), (MS-PS4-2) **HS.ESS1.A** (MS-PS4-2) **HS.ESS2.A** (MS-PS4-2)	**4.PS4.C** (MS-PS4-3) **HS.PS4.C** (MS-PS4-3) **HS.ESS2.C** (MS-PS4-2) **HS.ESS2.D** (MS-PS4-2)

[1] Guesne, E. (1985). Light. In R. Driver, E. Guesne & A. Tiberghien (Eds.), *Children's Ideas in Science* (pp. 10-32). Milton Keynes: Open University Press.; Ramadas, J. & Driver, R. (1989). *Aspects of secondary students' ideas about light.* Leeds: University of Leeds, Centre for Studies in Science and Mathematics Education.

[2] Guesne, E. (1985). Light. In R. Driver, E. Guesne & A. Tiberghien (Eds.), *Children's Ideas in Science* (pp. 10-32). Milton Keynes: Open University Press.

[3] Guesne, E. (1985). Light. In R. Driver, E. Guesne & A. Tiberghien (Eds.), *Children's Ideas in Science* (pp. 10-32). Milton Keynes: Open University Press.

[4] Anderson, C. W., & Smith, E. L. (1986). *Children's conceptions of light and color: Understanding the role of unseen rays* (Res. Series No. 166). Michigan State University, College of Education, Institute for Research on Teaching.