

Unit #16 Reflection, Refraction & Interference

Mirrors, Lenses & Interference

Big Ideas:

- Mirrors are particularly good at reflecting light; a mirror's shape determines the size, location and orientation of the reflected image.
- Lenses take advantage of refraction to bend light and form images.
- Like all waves, light waves show the effects of superposition and interference.

Essential Questions:

- What type of reflection produces a clear image?
- How is the angle of reflection related to the angle of incidence?
- How do real images and virtual images differ?
- Can you apply the law of reflection to various shaped mirrors?
- Describe the nature of images formed by flat mirrors...
- How do you construct ray diagrams for convex and concave lenses and can you interpret the images formed?
- What are the nature of images formed by converging and diverging lenses?
- How does the speed of light in a vacuum compare with its speed through a material?
- What are the conditions required for refraction to occur?
- What condition is required for total internal reflection?
- How does the way your eyes focus on an object differ from the way a camera does?
- Under what conditions is the interference of light most noticeable?
- Why do waves spread out after passing through a small opening?
- Why do thin films produce swirling patterns of color?
- Why do sound waves diffract more readily than light waves?
- What type of interference pattern does a diffraction grating produce?

Vocabulary:

reflection	ray	plane wave	diffraction grating	iridescence	focal length
normal	specular reflection	diffuse reflection	Huygens principle	diffraction	magnification
plane mirror	virtual image	corner reflector	incoherent light	resolution	coherent light
resolution	concave mirror	convex mirror	center of curvature	real image	monochromatic light
coherent light	incoherent light	Huygens principle	diffraction	resolution	diffraction grating
iridescence					

Students who demonstrate understanding can:

- HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.**[Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [*Assessment Boundary: Assessment does not include using quantum theory.*]
- HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.**[Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [*Assessment Boundary: Assessment is limited to qualitative descriptions.*]
- HS-PS4-5. 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.*** [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [*Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.*]

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	Disciplinary Core Ideas	Crosscutting Concepts
<p>Engaging in Argument from Evidence</p> <p>Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.</p> <ul style="list-style-type: none"> Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3) <p>Obtaining, Evaluating, and Communicating Information</p> <p>Obtaining, evaluating, and communicating information in 9–</p>	<p>PS3.D: Energy in Chemical Processes</p> <ul style="list-style-type: none"> Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. (<i>secondary to HS-PS4-5</i>) <p>PS4.A: Wave Properties</p> <ul style="list-style-type: none"> 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-PS4-5) [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) 	<p>Cause and Effect</p> <ul style="list-style-type: none"> 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) Systems can be designed to cause a desired effect. (HS-PS4-5) <p>Systems and System Models</p> <ul style="list-style-type: none"> 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)

<p>12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.</p> <ul style="list-style-type: none"> 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) 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) <p>-----</p> <p style="text-align: center;">Connections to Nature of Science</p> <p>Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</p> <ul style="list-style-type: none"> 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) 	<p>PS4.B: Electromagnetic Radiation</p> <ul style="list-style-type: none"> 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) 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) Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) <p>PS4.C: Information Technologies and Instrumentation</p> <ul style="list-style-type: none"> 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) 	<p>-----</p> <p style="text-align: center;">Connections to Engineering, Technology, and Applications of Science</p> <p>Interdependence of Science, Engineering, and Technology</p> <ul style="list-style-type: none"> Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5) <p>Influence of Engineering, Technology, and Science on Society and the Natural World</p> <ul style="list-style-type: none"> Modern civilization depends on major technological systems. (HS-PS4-5)
<p><i>Connections to other DCIs in this grade-band:</i></p> <p>HS.PS1.C (HS-PS4-4); HS.PS3.A (HS-PS4-4),(HS-PS4-5); HS.PS3.D (HS-PS4-3),(HS-PS4-4); HS.LS1.C (HS-PS4-4); HS.ESS1.A (HS-PS4-3); HS.ESS2.D (HS-PS4-3)</p>		
<p><i>Articulation of DCIs across grade-bands:</i></p> <p>MS.PS3.D (HS-PS4-4); MS.PS4.A (HS-PS4-5); MS.PS4.B (HS-PS4-3),(HS-PS4-4),(HS-PS4-5); MS.PS4.C (HS-PS4-5); MS.LS1.C (HS-PS4-4); MS.ESS2.D (HS-PS4-4)</p>		
<p><i>Common Core State Standards Connections:</i></p> <p><i>ELA/Literacy -</i></p> <p>RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-PS4-3),(HS-PS4-4)</p> <p>RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS4-3),(HS-PS4-4)</p> <p>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. (HS-PS4-4)</p> <p>RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-3),(HS-PS4-4)</p>		

WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. <i>(HS-PS4-5)</i>
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. <i>(HS-PS4-4)</i>
<i>Mathematics -</i>	
MP.2	Reason abstractly and quantitatively. <i>(HS-PS4-1),(HS-PS4-3)</i>
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. <i>(HS-PS4-3)</i>
HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. <i>(HS-PS4-3)</i>
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. <i>(HS-PS4-3)</i>