

HS-PS4-5 Waves and their Applications in Technologies for Information Transfer

California Science Test—Item Content Specifications

# HS-PS4-5 Waves and their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

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.*]

Continue to the next page for the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
| --- | --- | --- |
| Obtaining, Evaluating, and Communicating Information  Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.  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). | PS3.D: Energy in Chemical Processes  8. Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. *(secondary to HS-PS4-5)*  PS4.A: Wave Properties  8. 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.  PS4.B: Electromagnetic Radiation  11. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.  PS4.C: Information Technologies and Instrumentation  4. 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. | Cause and Effect  Systems can be designed to cause a desired effect.  Connections to Engineering, Technology, and Applications of Science  Interdependence of Science, Engineering, and Technology  Science and engineering complement each other in the cycle known as research and development (R&D).  Influence of Engineering, Technology, and Science on Society and the Natural World  Modern civilization depends on major technological systems. |

## Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

### Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

8.2 Ability to communicate about science and engineering (especially regarding the investigations conducted and the observations made)

### Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

8.2.1 Ability to produce written and illustrated text that communicates one’s own ideas

8.2.2 Ability to use appropriate combinations of language, models, and mathematical expressions to communicate one’s understanding or to ask questions about a concept, event, system, or design

### Disciplinary Core Idea Assessment Targets

#### PS3.D.8

* Qualitatively describe the basic physics principles that were utilized in a design to produce corresponding functionality (e.g., absorbing electromagnetic energy and converting it to thermal energy to heat an object)

#### PS4.A.8

* Identify the wave behavior utilized by a device when describing how it operates

#### PS4.B.11

* Describe the absorption of photons and production of electrons for devices that rely on the photoelectric effect

#### PS4.C.4

* Communicate technical information and ideas, including fully describing at least two devices and the physical principles upon which the devices depend
* Discuss the real-world problem a device solves or the need it addresses and how civilization now depends on the device
* Identify and communicate the cause-and-effect relationships that are used to produce the functionality of a device

### Crosscutting Concept Assessment Target(s)

CCC2 Identify systems that are designed to cause a specific effect

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides data on the temperature-dependent efficiency of a device that captures thermal or electromagnetic energy:

* Explains how the data provided describes the function of the device (8.2.1, PS3.D.8, and CCC2)
* Creates and explains a graph based on the data (8.2.1, PS3.D.8, and CCC2)

Task provides information on a device that functions by detecting temperature differences:

* Explains how the device works in terms of capturing thermal (infrared) energy and then interpreting the information conveyed by the thermal energy (8.2.1, PS4.C.4, and CCC2)
* Predicts the outcome of using the device for a given application in which a difference in temperature needs to be assessed (8.2.1, PS4.C.4, and CCC2)

Task provides graphs of quantum efficiency with an explanation that quantum efficiency is the number of photons detected by a sensor compared to the total number of photons that reach the sensor:

* Estimates the wavelength that the human eye is most sensitive to and identifies which camera has the best efficiency in that wavelength using graphs showing the human eye’s sensitivity to colors (8.2.2 and PS4.C.4)
* Explains why a camera with high quantum efficiency would be cost effective (8.2.2 and PS4.C.4)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* Digitizing signals in devices such as cell phones and wired or wireless computer networks that use wave pulses
* Electromagnetic radiation using the photoelectric effect in solar cells to capture and convert photons into electricity
* Different methods for detecting distant objects that are not visible to the naked eye
* Medical imaging using X-rays and ultrasound
* Efficiency versus temperature for a solar panel

## Common Misconceptions

Note that the list in this section is not exhaustive.

* Only objects that are glowing or hot can transfer energy in the form of electromagnetic radiation.
* Only the Sun transfers energy in the form of electromagnetic radiation.
* Inanimate objects do not have thermal energy.
* The term radiation only refers to harmful sources (e.g., X-rays, ultraviolet rays, gamma rays).

## Additional Assessment Boundaries

None listed at this time.

## Additional References

HS-PS4-5 Evidence Statement [https://www.nextgenscience.org/sites/default/files/evidence\_statement/black\_white/HS-PS4-5 Evidence Statements June 2015 asterisks.pdf](https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-PS4-5%20Evidence%20Statements%20June%202015%20asterisks.pdf)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 <https://www.cde.ca.gov/ci/sc/cf/documents/scifwappendix1.pdf>

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