Refraction

Science Grade-Level Expectations

This instructional task addresses content related to the following science grade-level expectations:

SI-M-B3 Explain how technology can expand the senses and contribute to the increase and/or modification of scientific knowledge (GLE 29)

PS-M-C4 Predict the direction in which light will refract when it passes from one transparent material to another (e.g., from air to water, from prism to air) (GLE 33)

	Objectives
Task	- Determine the relationship between the refractive index and the bending of light - Identify real-world applications of refraction (technology) and their functions
[Sample Exemplar Student Response](#)	

Implementation Tips:

- This task is intended to be integrated into a larger unit that contains hands-on science opportunities, student-led investigations, non-fiction reading, and a variety of other instructional strategies.
- Teachers may choose to use or modify the task as part of an instructional lesson or as a formative or summative assessment.
- Strategic instructional decisions will need to be determined prior to implementation such as:
    - Should the provided text be read aloud to students or read independently by students?
    - Will students work collaboratively or individually to complete the task?
    - What content knowledge and skills will students need to have prior to attempting the task?
    - Does the task need to be modified based on the needs of the students at the time of implementation?

Task Part 1:

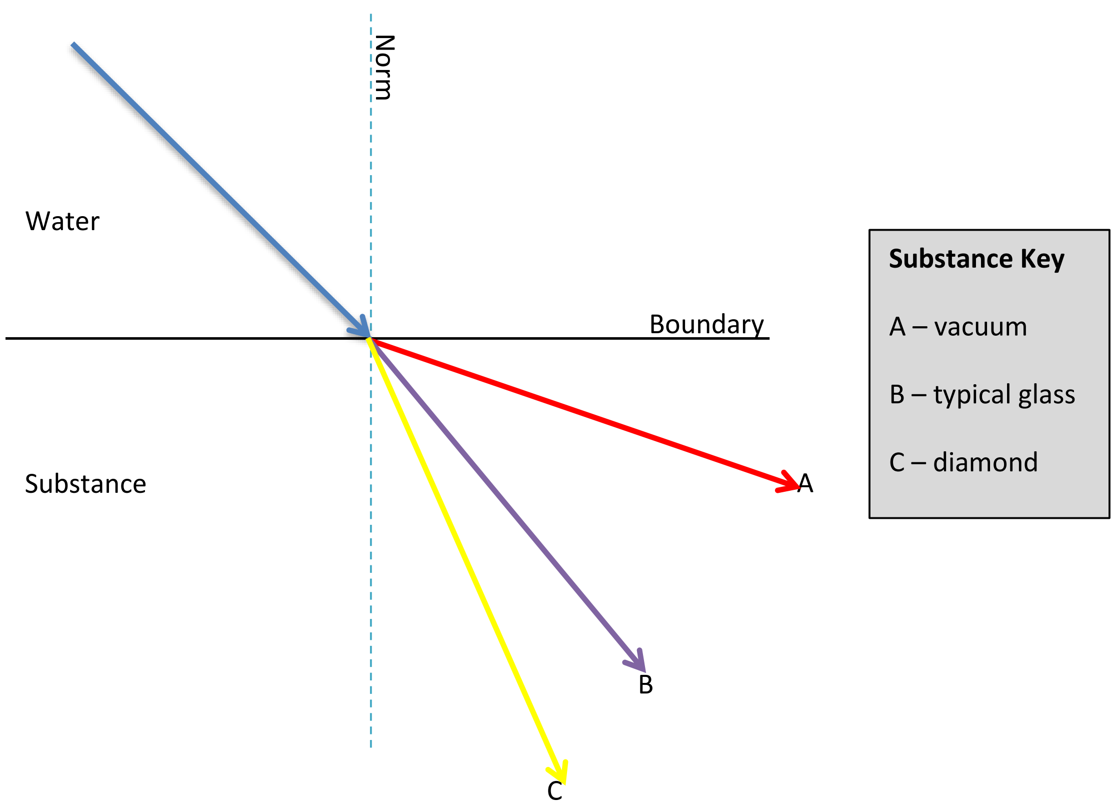
The chart below shows the refractive index of various materials. The model compares the behavior of light traveling from water into a variety of substances, which are labeled with letters. This model is useful for comparative purposes.

Use the model to describe how the refractive index relates to the behavior of light.

Refractive Index Chart

Material	Index
vacuum	1.000
air	1.0003
water	1.33
alcohol	1.36
vegetable oil	1.47
ice	1.46
typical glass	1.52
diamond	2.42

Refractive Index Comparison Model



- Read the article The First Telescope Opens a Window on the Universe.
- Read Yerkes Observatory: Home of the Largest Refracting Telescope.
- Read Refractometers in Agriculture.
- Read Refraction in Gemstones.

Task Part 2: Though refraction is used in various fields, each application is unique. Use the articles to compare how each field uses the science of refraction. Include similarities, differences, benefits, and limitations of the application in your explanation.

Sample Student Exemplar Response

Part 1

The refractive index indicates the amount that a light ray will bend when it enters the specific medium. For example, the refractive index of liquid water is different from the refractive index of ice, meaning that light behaves differently when it enters each of these substances. According to the model, light bends more toward the norm when it hits substances with a higher refractive index. Light bends farther away from the norm in materials with a lower refractive index. A clear example of this is when the refractive index of a diamond (2.42) is compared to the refractive index of a vacuum (1.0). Light bends more towards the norm in a diamond than it does in a vacuum.

Part 2

Refraction describes the bending of light when it travels from one medium to another. Scientists and other professionals use this knowledge in a variety of fields of study with practical applications.

The use of refraction allowed scientists such as Galileo and George Hale to study space in a way they could not do before. Telescopes were made using various sizes of lenses to refract light in such a way that makes objects appear closer than with the naked eye. Many discoveries were made in the 1800s and 1900s using refractive telescopes. For example, according to the article "Yerkes Observatory: Home of the Largest Refracting Telescope," the atmosphere of Saturn's moon Titan was discovered, the fifth moon of Uranus was discovered, and double and multiple star systems were studied.

There are limitations to refractive telescopes. Light traveling through certain parts of the lens can cause the images to appear fuzzy. Galileo, according to the article "The First Telescope Opens a Window on the Universe," was not satisfied with the quality of most of the telescopes he built. Another limitation relates to the size the lens must be to magnify images. Later refractive telescopes became larger and larger but these were more difficult to build, expensive to create, and bulky to use.

The science of refraction is also used in agriculture to determine the best timing of crops to be harvested or fertilized, according to "Refractometers in Agriculture." Juices from fruit refract light differently depending upon the sugar content of the juice. Higher sugar content equals better juice, so farmers use refractometers to determine the best harvesting time. However, farmers cannot simply take one measurement to make decisions. Refraction should be comparative in agriculture and farmers should study the affects of multiple variables.

Refraction is also used to identify gemstones. Rubies and garnets may often appear to be the same color but they have different refractive indexes. Jewelers, miners, or laypeople can use refractometers to confidently identify gems. However, there are limitations. Current refractometers will not read the refraction over 1.86, according to "Refraction in Gemstones."

All of these uses are similar because they take advantage of the consistent behavior of the bending of light. They are different in the application. In two of the examples, agriculture and gemstones, the measurement of the refraction is used to identify characteristics of the substance. In the telescope, the light is bent specifically to increase the magnification of an object.