Unit 3
Optics
Suggested Time: 26 Hours

Unit Overview

Introduction

Applications using the principles of light have resulted in devices that have improved scientific techniques and contributed to our quality of life. In this unit of study, basic concepts that are introduced include the properties of visible light including the reflection and refraction of light. Various reflecting and refracting technologies will also be explored and investigated.

Students should be given opportunities to experience and observe the properties of light using hands-on activities. Opportunities and activities designed to investigate and explore the properties of light would provide the basis for more in-depth experimentation with materials in order to investigate reflection and refraction of light.

Focus and Context

The focus of this unit is inquiry. A possible context could be the variety of everyday experiences the students have with the reflection and refraction of light. Students encounter reflection when they get up in the morning and use a mirror, for example. Buses and cars have a variety of reflective devices that could be explored. Eyeglasses and other refracting technologies could be investigated. In addition, students should have ample opportunity to investigate and study various technologies that are associated with electromagnetic radiation and to explore their positive and negative attributes and their impact on our way of life.

Science Curriculum Links

In elementary grades, students began their formal investigation and study of light. Sources of light and how light travels are topics explored. As well, students investigated how white light can be separated into its composite colours. They also compared how light interacts in a variety of optical devices such as kaleidoscopes, periscopes, telescopes and magnifying glasses. At the high school level, students may enrol in physics where they will learn about the wave and particle models of light. In addition, they would be provided with opportunities that would enable them to explain, qualitatively and quantitatively, the phenomena of wave interference, diffraction, reflection, refraction and the Doppler-Fizeau effect.

Curriculum Outcomes

STSE	Skills	Knowledge
Students will be expected to	*Students will be expected to*	*Students will be expected to*
Nature of Science and Technology 109-5 describe how technologies develop as a systematic trial-and-error process that is constrained by the properties of materials and the laws of nature 109-10 relate personal activities in formal and informal settings to specific science disciplines 109-13 explain the importance of choosing words that are scientifically or technologically appropriate 110-1 provide examples of ideas and theories used in the past to explain natural phenomena **Relationships Between Science and Technology** 111-1 provide examples of scientific knowledge that have resulted in the development of technologies 111-3 provide examples of technologies that have enabled scientific research **Social and Environmental Contexts of Science and Technology** 112-8 provide examples to illustrate that scientific and technological activities take place in a variety of individual or group settings 113-2 describe possible positive and negative effects of a particular scientific or technological development, and explain how different groups in society may have different needs and desires in relation to it	**Initiating and Planning** 208-2 identify questions to investigate arising from practical problems and issues 208-3 define and delimit questions and problems to facilitate investigation 208-5 state a prediction and a hypothesis based on background information or an observed pattern of events 208-6 design an experiment and identify major variables 208-7 formulate operational definitions of major variables and other aspects of their investigations 208-8 select appropriate methods and tools for collecting data and information and for solving problems **Performing and Recording** 209-2 estimate measurements 209-3 use instruments effectively and accurately for collecting data 209-6 use tools and apparatus safely **Analyzing and Interpreting** 210-6 interpret patterns and trends in data, and infer and explain relationships among the variables 210-11 state a conclusion, based on experimental data, and explain how evidence gathered supports or refutes an initial idea 210-16 identify new questions and problems that arise from what was learned **Communication and Teamwork** 211-1 receive, understand, and act on the ideas of others	308-8 identify and describe properties of visible light 308-9 describe the laws of reflection of visible light and their applications in everyday life 308-10 describe qualitatively how visible light is refracted 308-11 describe different types of electromagnetic radiation, including infrared, ultraviolet, X-rays, microwaves, and radio waves 308-12 compare properties of visible light to the properties of other types of electromagnetic radiation, including infrared, ultraviolet, X-rays, microwaves, and radio waves

The Nature of Science - The History of Light

Outcomes

Students will be expected to

- provide examples of ideas and theories of light used in the past to explain observed properties. (110-1) Include:
  - (i) Pythagoras' belief that light consisted of beams of particles
  - (ii) Galileo's experiment trying to determine the speed of light
  - (iii) Michelson's experiment to measure the speed of light

- define light as a form of energy that can be detected by the human eye

Elaborations—Strategies for Learning and Teaching

This unit could begin with a K-W-L activity (Appendix B). By posing motivating questions about light and some of its properties, students' conceptions could be assessed and used in the further development of lessons. Student discussion could focus on sources of light, what light is, how it travel, and how fast it travels. Students will have already encountered the term "visible light" in their study of radiation in the grade 7 Heat unit.

Teachers could use the following questions as guides to generate student discussion:

- What are some things that produce light?
- Can light be produced in different ways?
  (While students are not expected to know all of the terms, answers could include:
  Natural – bioluminescence, stars, sun, moon
  Electric – incandescent light bulbs, flashlights and electroluminescence (LED)
  Chemical – chemoluminescence (glow sticks), fluorescence (fluorescent light bulbs) and phosphorescence (glow in the dark materials)
  Combustion-based – candles, fire, torches
  Nuclear
- What is light made of, waves, or particles?
- How does light travel? Does it need something to travel through? If so, what is this "something" in empty space?
- How fast does light travel? Is it slower or faster than sound?

Students should know that Michelson's experiment was conducted for the purpose of calculating the speed of light. Students do not need to know the details of the experiment.

The Nature of Science - The History of Light

Suggested Assessment Strategies

Journal

- The things I know about light are... (can include sources, what it is, how it travels, how fast it travels?) (110-1)

Paper and Pencil

- Conduct research on Pythagoras' beliefs about light. (110-1)
- As an enrichment project, conduct research on Michelson's experiment that measured the speed of light. (110-1)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 132-136
TR 2.4-2.5
TR AC 24

Conventions used in Resources Column

ST = Student Text

TR = Teacher Resource

TR AC = Assessment Checklist

TR PS = Process Skills Rubric

TR AR = Assessment Rubric

BLM = Black Line Master

BLM 8 Activity # = Additional BLMs for each grade level

The Nature of Science - The History of Light (continued)

Outcomes

Students will be expected to

- provide examples of ideas and theories of light used in the past to explain observed properties (110-1)
(continued)
  - identify the speed of light as 300 000 000 m/s, or 3×10^8 m/s
  - qualitatively compare the speed of light to the speed of sound

Elaborations—Strategies for Learning and Teaching

Students may initially have difficulty recognizing that light has a speed given that it appears instantaneously. The previous questions and ensuing discussion, would set the stage for introductory, exploratory activities. Teachers could ask students to compare the speed of light to the speed of sound (~ 330 m/s at sea level) using thunder and lightning as an example. The point to stress is that light travels extremely fast; so fast that we cannot notice the time required for it to travel “normal” distances around us. While sound travels fast (about 1200 km/h), light travels much, much faster (300 000 km/s, or about 1 000 000 000 km/h). In the case of thunder and lightning, the light from a distant lightning strike reaches us (almost) instantly, but the sound from the lightning strike (the thunder) takes longer to reach us. The greater the time delay between seeing the lightning flash and hearing the thunder, the greater the distance between you and the lightning strike. As a rule of thumb, every 3 seconds of time delay equals approximately 1 km of distance.

Teachers could challenge students to relate the concepts of time and light by asking the question, “How is looking at light coming from stars really like looking at the past?” While a star may no longer exist, its light is still traveling towards us because it was so far away from us.

Outcomes

- provide examples of how scientific knowledge of light resulted in the development of early technologies. (111-1) Include:
  (i) microscope
  (ii) telescope

Elaborations—Strategies for Learning and Teaching

Teachers could ask students to generate a list of technologies that are based on the properties of light. This list could include microscopes, telescopes, periscopes, binoculars, fiber optics, cameras, prescription contact lenses, lasers, movie projectors, overhead projectors, etc. Teachers should limit their discussion to the functions of these devices at this point since a more detailed discussion of how the microscope and telescope work will be covered later in this unit and in the grade 9 Space unit.

The Nature of Science - The History of Light (continued)

Suggested Assessment Strategies

Presentation

- Conduct research on how the microscope or telescope was developed and present to class. (111-1)

Performance

- Create a time line that shows the history of the development of the microscope or telescope. (111-1)
- Create a collage to show the development of the telescope or microscope. (111-1)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 135-136,149

ST pp. 133-134, 243-246

Properties of Visible Light

Outcomes

Students will be expected to

- identify and describe properties of visible light. (308-8) Include the following properties, definitions and examples:
  - (i) travels in a straight line (rectilinear propagation) e.g. shadow formation
  - (ii) reflects (reflection) e.g. mirrors (specular) and dust (diffuse)
  - (iii) refracts (refraction) e.g. bent stick effect
  - (iv) disperses (dispersion) e.g. formation of a rainbow as light separates into its constituent colours
  - (v) travels through a vacuum (does not require a medium) e.g. light from Sun and stars reaching Earth through space
  - (vi) travels through transparent, translucent and opaque materials to different amounts e.g. window pane, frosted window, and door

Elaborations—Strategies for Learning and Teaching

Teachers could use the demonstrations listed below to introduce the properties of light. Teachers should note that many of these properties will be explored in greater detail later in the unit.

1. rectilinear propagation: hold your hand in front of a beam of light from an overhead projector. Note the sharp details of the shadow of your hand (i.e. ring, knuckles, etc).
2. reflection: place a hand held mirror in the beam of light. Shine the reflected beam from the mirror on the back or side wall.
3. refraction: fill a large beaker or aquarium with water and place a popsicle or stir stick in the beaker. Observe from the side.
4. dispersion: shine a beam of light from a ray box through a prism to observe its constituent colours.
5. travels through a vacuum: use a clear light bulb. The light from the tungsten wire filament travels through the (almost complete) vacuum inside the bulb. The vacuum is evidenced by the “pop” the bulb makes when it is broken.
6. travels through materials to different amounts: hold a beaker or glass in the beam of an overhead projector. Compare this to the amount of light that passes through a pair of sunglasses, a pane of frosted glass, and a door.

Teachers could highlight how the property may or may not be unique to light. For example, light undergoes rectilinear propagation (it does not bend around corners), while sound does not (it can easily bend around corners). However, both light and sound reflect.

Students have already explored refraction in elementary science. In grade 7, students learned about the various types of electromagnetic waves and that they do not require a medium in which to travel. Infrared radiation is one type of wave that falls under the category of electromagnetic waves. Teachers could refer to the Heat unit covered in Science 7 where students would have discussed thermographs which make use of infrared waves. Also, students would have learned about heat transfer by radiation, which does not require a medium. By making this link, teachers can help students use their prior knowledge to more easily understand the concepts being covered here.

After the terminology has been introduced and various demonstrations have been conducted, teachers could use a Quiz-Quiz-Trade activity (Appendix B) to provide students with an opportunity to practice and use these terms.

Properties of Visible Light

Suggested Assessment Strategies

Presentation

- Create a game that includes the properties of light. (308-8)
- Create a poster or slide show that describes the properties of visible light. (308-8)

Paper and Pencil

- Describe how a beam of light from a ray box appears and acts when it strikes or passes through air filled with chalk dust or smoke (dispersion), mirrors (reflection), and a prism (refraction). (308-8)
- Create a table of the properties of light and fill in examples of each. (308-8)

Performance

- Create and perform a song or skit that describes the properties of visible light. (308-8)
- Create a foldable that describes the properties of visible light. (308-8)
- Create a collage of everyday transparent, translucent and opaque materials indicating which is which. (308-8)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 142, 149-152, 157, 173-182
(i) p. 175
(ii) pp. 152, 176-178
(iii) pp. 149-150, 179-182
(iv) pp. 149-151
(v) pp. 142, 157
(vi) pp. 173-174
BLM 2-20, 2-21
TR 2.26-2.27

Properties of Visible Light (continued)

Outcomes

Students will be expected to

- identify and describe properties of visible light (308-8) **(continued)**
  - use a prism to observe the dispersion of light
  - define the visible light spectrum
  - list the constituent colours of white light, in order of degree of refraction

Elaborations—Strategies for Learning and Teaching

Teachers should refer to the discussion on dispersion at the beginning of this unit. Students will have some experience with the constituent colours of white light. Reference can be made to rainbows that sometimes form in the sky, or the much smaller one that may appear with the use of a sprinkler on a lawn. Sun catchers often take advantage of this property to create some interesting effects. The addition of primary colours to create other colours will likely have been a topic students covered during art class. Reference can be made to such previously acquired knowledge.

Teachers should have students use prisms to investigate how light from different sources is refracted and dispersed. Teachers could have students observe and experience what happens to light that is dispersed in a mixture of water and a few drops of milk.

Teachers could use a laser to illustrate the point that white light is made from a combination of colours. When white light (e.g. from a ray box or flashlight) is shone through a prism, a spectrum of colours is produced. When a laser light is shone through the prism, the light is refracted (bent) but not dispersed. No other colours are produced because a laser light is one colour only (i.e. is composed of only one wavelength of light).

Teachers could provide students with the acronym ROY G BIV to help them remember the order of light wavelengths that make up white light based on smallest refraction (Red) to greatest refraction (violet).

Properties of Visible Light (continued)

Suggested Assessment Strategies

Performance

- Create a poster or collage to demonstrate your understanding of the visible light spectrum. (308-8)
- Create a mnemonic device or acronym to help someone remember the constituent colours of white light in order of degree of refraction. (308-8)

Journal

- What questions come to mind when you hear the term “visible light”? (308-8)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp 149-152
TR 2.13-2.23

ST pp. 149-152
BLM 2-13, 2-14, 2-15

Electromagnetic Radiation and Dispersion

Outcomes

Students will be expected to

- recognize the importance of using the words frequency and wavelength correctly (109-13)
  - define frequency
  - define wavelength

Elaborations—Strategies for Learning and Teaching

Students will have encountered the term “wave” in a number of different contexts. Teachers could help students draw comparisons between the various definitions or understandings they have for the term wave. For example, a hand wave represents a repetitive motion of the hand. A wave through a crowd at a sporting event is represented by a repetitive motion of the crowd, as the individuals stand and sit at a regular interval (the rate at which they stand and sit would be the frequency; frequency being the number of repetitions divided by the time). A water wave is represented by a regular upward and downward motion of water particles. A common misconception of students is to believe that the particles in a wave travel forward with the energy transfer. However, this is not the case. The wave through a crowd at a sporting event would be a good way to illustrate this point. As the people stand and sit the wave moves across the stadium but the people themselves do not move from one seat to another. Another way to illustrate this point is to attach a piece of tape onto a spring or rope, and create a wave by moving the spring or rope back and forth. As the wave moves away from your hand the tape simply moves back and forth.

A basic introduction into wave theory would be appropriate at this level. Students may have investigated the characteristics of ocean waves which they could then compare to light waves. The use of oscillating ropes and/or slinkies would enable students to have a visual representation of some of the key features of waves such as wave speed, wavelength and frequency.

While the term “wavelength” will likely be new for many students, they should be familiar with the term “frequency”. Students may have encountered this term previously, especially in mathematics. For example, what is the frequency at which you wash your hair? How frequently do you go to the dentist for check ups? Teachers could use these examples of the common use of the word “frequency” to build on students’ prior knowledge and to lead them to an understanding of the term “frequency” as it applies to wave travel (i.e. how many waves pass a point in a second). Some students may also be able to relate wavelength to different ocean conditions. For example, a “rolling sea” would have a long wavelength; that is a sea where the boat slowly moves from one peak (crest) to a low point (trough) and then to another peak. However, a “choppy sea” would have a shorter wavelength.

Electromagnetic Radiation and Dispersion

Suggested Assessment Strategies

Performance

- Create a song, poem or rap that explains the difference between frequency and wavelength. (109-13, 308-8)
- Write a letter to a friend explaining the difference between frequency and wavelength. (109-13, 308-8)
- Create a story book or comic strip that explains the difference between frequency and wavelength. (109-13, 308-8)

Journal

- Describe the cues you use to remember the difference between frequency and wavelength. (109-13, 308-8)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 139-140
BLM 2-9, 2-10

ST pp. 139-142

Electromagnetic Radiation and Dispersion (continued)

Outcomes

Students will be expected to

- recognize the importance of using the words frequency and wavelength correctly (109-13) **(continued)**
  - describe the relationship between frequency and wavelength. Include:
    - (i) high frequency waves have short wavelengths
    - (ii) low frequency waves have long wavelengths

Elaborations—Strategies for Learning and Teaching

Teachers could use a 3-4 metre piece of rope attached to a fixed point at one end to model the characteristics of waves: amplitude, wavelength, and frequency. It should be noted that amplitude is not a characteristic we use to distinguish between the different types of waves in the electromagnetic spectrum. However, students will likely identify it as a wave characteristic. By changing one of these characteristics, students can observe and note how the others change. This would be a qualitative exploration and appreciation of the differences and similarities of the different types of electromagnetic radiation.

As a point of interest, teachers could inform students that electromagnetic radiation is often labeled based on either its wavelength or frequency. For example, radio stations are often identified by their frequency (OZ FM has a frequency of 94.7 MHz on the Avalon Peninsula, and 95.9 MHz in central Newfoundland.) Radio dials allow you to tune to the specific frequency of this electromagnetic radiation. The radiation used by many cordless phones has a frequency of 2.4 GHz, and is also called microwave radiation.

Electromagnetic Radiation and Dispersion (continued)

Suggested Assessment Strategies

Performance

- Create the cartoon characters Wavelength, Frequency, and Energy. Describe the land, Electromagnetic Spectrum, in which they reside. Show how some powers can vary in different parts of the land. (109-13, 308-12)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 140, 144-145
BLM 2-11

Electromagnetic Radiation and Dispersion (continued)

Outcomes

Students will be expected to

- recognize the importance of using the words frequency and wavelength correctly (109-13) **(continued)**

  - relate the amount of refraction for each colour to its wavelength. Include:
    - (i) red (longest wavelength - least refraction)
    - (ii) violet (shortest wavelength - greatest refraction)

Elaborations—Strategies for Learning and Teaching

Students should recognize the relationship between wavelength and the colours we see. At this level, discussion should be limited to the fact that all wavelengths of the electromagnetic spectrum enter our eyes. However, our brain can only recognize those with wavelengths in the visible spectrum (i.e. ROY G BIV) and this is limited by the physical make up of our eye. It is important to note that the waves in the visible spectrum comprise only one category of the entire electromagnetic spectrum.

Students should realize that white light, when refracted by a prism, illustrates the different wavelengths of visible electromagnetic radiation. The spectrum is often indicated as a continuum of colours with the shortest waves being at the violet end and the longest at the red end.

Teachers could have students investigate the colour combinations when the three primary colours of light (red, green and blue) are mixed (Note: the primary colours of light are different from the primary colours used in art: red, yellow, and blue).

Teachers could ask students why some objects have a red colour, while others are blue, and still others are white. This could be brought back to the wavelengths of light and that when light strikes an object it is either absorbed or reflected. We only see the wavelengths that are reflected. Thus, a green object is absorbing all the other wavelengths of light and reflecting the wavelength that our brain interprets as green.

Electromagnetic Radiation and Dispersion (continued)

Suggested Assessment Strategies

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 148-153
BLM 2-12, 2-13, 2-14, 2-15

The Electromagnetic Spectrum

Outcomes

Students will be expected to

- describe the different types of electromagnetic radiation and compare properties to visible light (308-11, 308-12)

Elaborations—Strategies for Learning and Teaching

Students may struggle with the prevalence of the various types of electromagnetic radiation. This may be natural, given that the information we take in visually plays such a significant role in our lives; hence, visible light might be considered to be a significant portion of the electromagnetic spectrum. To help students realize the magnitude of the other components of the electromagnetic spectrum, teachers could ask students, “As you sit in your chair, what devices could you use to receive or send information that do not avail of visible light?” In the response, devices such as radios, cell phones, television remote controls, television signals (not through wire), wireless internet connections, might just be a few such devices identified. Teachers should ensure that students realize that all of this radiation is continuously present, however, we do not detect it because its wavelength is either too short (eg; ultraviolet) or too long (eg; infrared). We only continually detect visible light with our eyes.

- describe the electromagnetic spectrum in terms of wavelength, frequency, and energy. Include, in order of decreasing wavelength:
  - (i) radio waves
  - (ii) microwaves
  - (iii) infrared
  - (iv) visible light
  - (v) ultraviolet
  - (vi) x-rays
  - (vii) gamma rays

Teachers should compare the wavelength, frequency, and energy in relation to the visible spectrum for the other categories that comprise the electromagnetic spectrum. For example, radio waves have a longer wavelength, lower frequency, and lower energy in comparison to the visible spectrum.

Students will have heard of various forms of electromagnetic radiation, such as microwaves and radio waves, but will not necessarily know that there is a connection among them. Teachers could use a learning strategy such as Think-Pair-Share or Numbered Heads (Appendix B) to help illustrate the relationship among the various forms of electromagnetic radiation, their similarities and differences.

- provide examples of the use of each type of electromagnetic radiation. Include:
  - (i) radio waves: telecommunications
  - (ii) microwaves: cooking food
  - (iii) infrared: motion sensors
  - (iv) visible light: microscope
  - (v) ultraviolet: sun tanning
  - (vi) x-rays: medical detection
  - (vii) gamma rays: radiation therapy for cancer

Teachers could have students investigate the various uses of electromagnetic radiation and identify problems or issues related to particular kinds. Ultraviolet radiation (UVA rays) getting through the atmosphere and storage of radioactive materials are but two of many that could be addressed in this section.

The Electromagnetic Spectrum

Suggested Assessment Strategies

Performance

- Create a poster or slide show of the electromagnetic spectrum showing the wavelength, frequency, and energy of the various types of radiation (308-12)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 158-164

TR 2.18-2.19

BLM 2-3

ST pp. 156-164

ST pp. 158-159, 161-164, 242-243

(i) p. 158
(ii) p. 159
(iii) p. 161
(iv) pp. 242-243
(v) pp. 162-163
(vi) pp. 163-164
(vii) p. 164

The Electromagnetic Spectrum (continued)

Outcomes

Students will be expected to

- describe possible negative and positive effects of technologies associated with electromagnetic radiation (113-2)
  - recognize that generally, higher energy radiation is more harmful to humans

- identify new questions and problems that arise from what was learned about electromagnetic radiation. (210-16)

Elaborations—Strategies for Learning and Teaching

Teachers should ensure that students have an opportunity to investigate common technologies that incorporate the use of electromagnetic radiation and describe their possible positive and negative effects. Microwave ovens, x-ray machines, cellular phones, and the nuclear industry are some examples of technologies that could be explored.

Radio waves have photons with low energies. Microwaves have a little more energy than radio waves. Infrared has still more energy than visible light, ultraviolet, X-rays and gamma-rays. Teachers are not expected to discuss the term “photons” but simply present the general order of energies.

Teachers could use the following table to help students:

Electromagnetic Radiation	Positive Effects	Negative Effects
Radio Waves	improved telecommunications	uncertain of long-term exposure effects
X-rays	medical detection	over exposure can lead to cancer
Ultraviolet	used to treat jaundice in babies	skin cancer
Gamma Rays	radiation therapy for cancer	can kill exposed cells

Exposure to high frequency, short wavelength electromagnetic radiation, such as gamma rays, is generally more dangerous. Exposure to low frequency, long wavelength electromagnetic radiation, such as radio waves, is generally less dangerous. As a result, colloquially, high frequency waves are sometimes referred to as high energy waves and low frequency waves are sometimes referred to as low energy waves.

Teachers could involve students in a discussion of how the unique characteristics of Earth’s atmosphere make Earth a habitable planet for humans. Earth’s atmosphere is able to protect us from some of the more dangerous electromagnetic radiation present in space, making Earth a safe place for humans. Living in space or on another planet would expose humans to much more electromagnetic radiation. As discussed in grade 7 Science, humans are adapted to Earth’s conditions. Changes to these conditions could compromise our safety.

The Electromagnetic Spectrum (continued)

Suggested Assessment Strategies

Performance

- Create a collage of pictures showing the uses of various forms of electromagnetic radiation. (113-2)
- Create a safety pamphlet highlighting the dangers associated with exposure to specific types of high energy radiations and how to avoid these energies (e.g. UV, x-ray, gamma). (113-2)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 158-166

Reflection

Outcomes

Students will be expected to

- formulate operational definitions for incidence, reflection, and the normal (208-7)

  - define:
    - (i) incident light ray
    - (ii) reflected light ray
    - (iii) normal
    - (iv) angle of incidence
    - (v) angle of reflection
    - (vi) specular reflection
    - (vii) diffuse reflection

Elaborations—Strategies for Learning and Teaching

Teachers could introduce this section by demonstrating specular reflection using a ray box and plane mirror. Teachers could shine two or more rays of light onto a mirror and ask students to look for patterns or similarities in what they observe. Observations could be used to formulate operational definitions for these terms. Teachers could use the flex-camera to help students observe this demonstration.

Students could use a tennis ball thrown against the floor at different angles. Using white poster paper / bristol board paper on the wall, the motion of the ball can be mapped as it hits the floor and bounces up. Alternatively, teachers could use an overhead, soft rubber ball and a straight edge piece of wood. Roll the ball at the wood at different angles. Using the images on the board, have students map the motion of the ball. Use several different incident angles. This demonstration could be used as an introduction to drawing simple ray diagrams.

Teachers could guide students to formulate their own definitions by drawing a diagram on the board showing the mirror, the incident ray, the reflected ray and the normal. Teachers could then have students propose and discuss their definition for each term. Regardless of the instructional strategy employed, teachers should ensure that students understand that the angles of incidence and reflection are estimated or measured with respect to the normal.

Teachers could have students explore and investigate the differences between specular and diffuse reflection by comparing the reflection from smooth and crumpled aluminum foil.

Teachers could employ the Two-minute Review strategy (Appendix B) to review these terms.

Reflection

Suggested Assessment Strategies

Journal

- Imagine you are a science teacher. Summarize what students should know about mirrors and reflections. (209-3, 210-6)

Paper and Pencil

- Produce a simple ray diagram that helps to compare and contrast regular and diffuse reflection. (208-7)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 176-178

BLM 2-22, 2-25

Reflection (continued)

Outcomes

Students will be expected to

- describe the laws of reflection of visible light and their applications in everyday life (308-9)
  - identify applications of specular and diffuse reflection

Elaborations—Strategies for Learning and Teaching

Teachers should make students aware of applications of specular and diffuse reflection. An example students may be familiar with is the difference between matte and glossy paints. Matte paints have a higher proportion of diffuse reflection resulting in lower luster. Glossy paints have a greater proportion of specular reflection resulting in a shinier appearance. Teachers could show students examples of these paint types to help reinforce the concept. Other examples teachers could refer to include:

- the different surfaces used for counter tops
- furniture wax or car wax
- glazed vs. unglazed ceramics
- matte vs. glossy finish on photographs

Teachers could also show how our knowledge of specular and diffuse reflection has lead to new technologies, such as the science of stealth aircraft.

- list three types of mirrors. Include:
  - (i) plane
  - (ii) concave
  - (iii) convex

To introduce mirrors and their uses, teachers could use a plane mirror positioned at the front of the class. Ask students, "What changes can be a made to the mirror, so that what you see in the mirror is changed?"

Some alternative sample questions are:

- How can the mirror's field of view be changed?
- How can the mirror be changed to produce a larger image?
- How can the mirror be changed to produce a smaller image?

Students may refer to their personal experiences with surveillance mirrors, school-bus mirrors, some vehicle side-view mirrors, and "circus" or distorting mirrors. Teachers should ensure that students have the opportunity to observe flat, convex and concave mirrors to illustrate the different effects and uses of these types of reflections.

- provide examples of each type of mirror. Include:
  - (i) bathroom mirror (plane)
  - (ii) inside of a metal spoon (concave)
  - (iii) safety mirror on the front of a school bus (convex)

Students could be challenged to identify additional examples of each type of mirror in their daily lives or to conduct research on the different types. This could include manufactured mirrors (e.g., hand-held personal mirror) or surfaces that behave as mirrors (e.g., outside of metal spoon is a convex mirror).

Reflection (continued)

Suggested Assessment Strategies

Journal

- Reflect on where we use mirrors in everyday life and the uses we have for them. (308-9)

Performance

- List examples of everyday objects that use mirrors or other reflective surfaces to view objects at various angles (diffuse reflection). (308-9)
- Observe objects using the three different types of mirrors. Describe the images you observe and suggest uses for this type of mirror. (210-1)
- After practicing ray diagrams, in small groups create posters representing the various ray diagrams to be displayed in class. (210-16)
- Place a mirror in front of a ray box at an angle. Estimate and then measure the angle of incidence and reflection. (208-7, 209-2)

Presentation

- Create a poster or multimedia presentation to describe and give examples of plane, concave, and convex mirrors. (308-9)

Paper and Pencil

- Why are surveillance mirrors, and side view mirrors on vehicles always convex mirrors? (308-9)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 176-178

ST pp. 188, 197, 204

BLM 2-24, 2-26, 2-27, 2-31

ST pp. 191, 196, 199-200, 203-204, 206

Reflection (continued)

Outcomes

Students will be expected to

- use mirrors effectively and accurately for investigating the characteristics of images formed (209-3)
- define and delimit questions and problems to facilitate investigation (208-3)
- state a prediction and a hypothesis based on background information or an observed pattern (208-5)
- use tools and apparatus safely (209-6)
- state a conclusion, based on experimental data, and explain how evidence gathered supports or refutes an initial idea (210-11)

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity: Demonstrating the Law of Reflection and Applying the Law of Reflection

The laboratory outcomes 208-3, 208-5, 208-7, 209-3, 209-6, 210-11 and, 308-9 are addressed, in whole or in part, by completing CORE LAB 5-2B "Demonstrating the Law of Reflection" and 5-2C "Applying the Law or Reflection".

Teachers should ensure students know how to measure angles using a protractor. This would include the angle of incidence and the angle of reflection. Students should use a ruler for drawing rays to ensure that they are straight.

Teachers should ensure students arrive at the conclusion that the angle of incidence and angle of reflection are equal. Also, through measurements taken, the relationship between object distance and image distance should be observed.

Students may ask why the image produced in a plane mirror appears to be behind the mirror even though the object is in front of the mirror. To help students understand, teachers could emphasize the relationship between how the human eye forms an image and how a ray diagram is drawn. That is, the human brain extrapolates the reflected rays from a point on an object to a point where they intersect. The image is formed at this point of intersection, where the brain believes the object to be. Teachers could also discuss lateral inversion (the reversing of an image). This could be demonstrated by holding printed text in front of a plane mirror, and observing that the text is reversed.

Reflection (continued)

Suggested Assessment Strategies

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

Core Lab # 5: “Demonstrating the Law of Reflection” and “Applying the Law of Reflection”

ST pp. 192-194

ST pp. 474-475, 488 (Science Skills)

TR 2.38-2.40

TR AR 3, 5

BLM 2-26, 2-27, 2-28

Reflection - Plane Mirrors

Outcomes

Students will be expected to

- describe the laws of reflection of visible light and their applications in everyday life (308-9)
  - recognize that the angle of incidence is equal to the angle of reflection
  - state the law of reflection
  - recognize that a ray diagram is a useful way to represent the behavior of light

Elaborations—Strategies for Learning and Teaching

Through the activities of CORE LAB 5-2B and 5-2C, students should be able to explain the relationship between the incident and reflected angles and be able to identify each type. Through these experiences and discussions of reflected beams, teachers should ensure students are able to estimate angles of incidence and reflection. After completion of first part of CORE LAB 5-2B, students should be able to state the law of reflection .

Teachers should make students aware that the diagram produced in CORE LAB 5-2C is a simple ray diagram. Teachers should limit discussion of ray diagrams as a means of representing the path of a single beam of light. Students will develop a more complete understanding of ray diagrams in subsequent sections of this unit.

Following the core lab activity, teachers should provide students with opportunities to construct ray diagrams showing image formation in a plane mirror. The ray diagrams should clearly illustrate image properties using SPOT (**S**ize, **P**osition, **O**rientation, **T**ype):

- The image size is equal to the object size.
- The image distance is equal to the object distance.
- The image is upright.
- The image is virtual.

Teachers could extend this topic of plane mirrors to situations including combinations of plane mirrors, such as, three way wardrobes mirrors (360^{o} mirrors) and fun house mirrors. It is not expected that students would be able to draw ray diagrams to model these situations.

- use mirrors effectively and accurately for investigating the characteristics of images formed (209-3)
  - differentiate between real and virtual images

Students' understanding of the difference between real and virtual images should be limited to the location of the image on a ray diagram. If the image is in "front" of the mirror (reflected rays converge in front of mirror) the image is real. If the image is "behind" the mirror (reflected rays are extrapolated and converge behind the mirror) the image is virtual.

Reflection - Plane Mirrors

Suggested Assessment Strategies

Journal

- Write a journal entry to show what you have learned about the laws of reflection. (209-2, 210-11)

Performance

- Create and perform a rap that explains the law of reflection. (308-9)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST p. 178

ST pp. 188-189

TR 2.35-2.36

TR AC 7

Reflection - Plane Mirrors (continued)

Outcomes

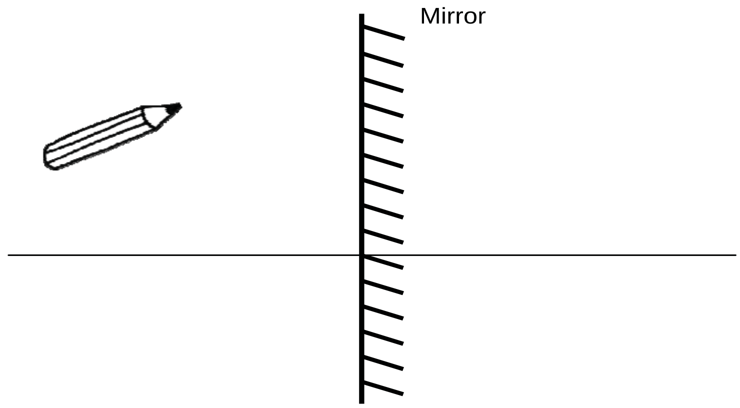
Students will be expected to

- use mirrors effectively and accurately for investigating the characteristics of images formed (209-3) **(continued)**
  - describe the image properties in plane mirrors. Include:
    - (i) size
    - (ii) position
    - (iii) orientation
    - (iv) type
  - construct ray diagrams of images in plane mirrors

Elaborations—Strategies for Learning and Teaching

Teachers should ensure students are able to:

- recognize and label a ray diagram,
- draw a ray diagram with a given template (see below)
- explain observations of an image using a ray diagram (use **S**POT method: **S**ize, **P**osition, **O**rientation, and **T**ype).



In a plane mirror:

- Image size is equal to object size.
- Image distance is equal to object distance.
- The image is upright.
- The image is virtual.

Teachers should ensure students have sufficient hands-on practice using mirrors as well as drawing ray diagrams that they are able to locate an image and give a general description (using a ray diagram) when given an object's location.

As enrichment, teachers could challenge students to construct a periscope or design and build a "classroom" surveillance system using a number of small, plane mirrors. Alternatively, students could explore how combinations of mirrors are used in fun house applications to produce different types of images. These types of problem-solving activities would require students to use the laws of reflection in the given context and practice many of the skills-related outcomes. Teachers could have students address these problems in a general sense or in a very detailed manner using ray diagrams to explain these more complex phenomena. Students could work in pairs or in small groups to plan, design and problem-solve. Students could defend their plans/designs/models by presenting their ideas to other groups, to the class as a whole, or by preparing a detailed poster or written report. Teachers could note whether the students share responsibilities for difficulties encountered during the activity as an indicator for the attitudinal outcome on working collaboratively.

Reflection - Plane Mirrors (continued)

Suggested Assessment Strategies

Paper and Pencil

- Create a diagram to summarize the image characteristics in a plane mirror. (209-3)

Performance

- Write a song that describes the size and orientation of an image in a plane mirror. (209-3)
- Create a poster that shows the size and orientation of an image in a plane mirror. (209-3)

Journal

- Explain to the imaginary friend in the mirror why he or she isn't a real image. (209-3)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 190, 201, 207

Reflection - Curved Mirrors

Outcomes

Students will be expected to

- use mirrors effectively and accurately for investigating the characteristics of images formed (209-3)

(continued)

- define focal point
- define principal axis

- describe how two incident rays reflect on concave mirrors. Include:
  (i) rays traveling parallel to the principal axis
  (ii) rays traveling through the focal point

Elaborations—Strategies for Learning and Teaching

Teachers could have students complete investigation 5-3B as a reinforcement of real and virtual images and to introduce concave mirrors.

Teachers could have students investigate curved mirror reflection using a ray box and concave mirror. To do this, teachers could have students draw a large "T" on a piece of paper and place the concave mirror, upright, on the top of the "T". Shine a beam of light from the ray box parallel with the "T". Place two dots in the middle of the incident and reflected light beams. Remove the ray box and connect the dots. The lines formed will trace the path of the incident and reflected light rays. Repeat this process to obtain at least two more incident ray/reflected ray combinations. Extrapolate each of the reflected rays behind the mirror. Through this activity students should observe a pattern of reflection whereby the point of intersection of these lines identifies the focal point. After such an activity, teachers should lead students to develop operational definitions of focal point and principal axis.

Teachers could demonstrate image formation in curved mirrors using large mirrors. Teachers could provide students with hand-held mirrors, allowing them to observe the properties of the images formed when they position the mirror differently.

Students should be able to recognize that:

(i) incident rays parallel to the mirror's principal axis are reflected through the focal point; and
(ii) incident rays going through the focal point are reflected parallel to the mirror's principal axis.

Knowledge of both properties is necessary for constructing ray diagrams showing image formation.

Teachers could use overlapping transparencies and coloured markers to represent each incident and reflected ray.

Teachers should provide students with templates which include the principal axis, sketch of mirror, and focal point for all ray diagrams

Reflection - Curved Mirrors

Suggested Assessment Strategies

Paper and pencil

- Define focal point, focal length, and principal axis. (308-9)

Performance

- Create a song or jingle that explains the differences between focal point and principal axis. (308-9)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST p. 198

ST p. 198

BLM 2-29

Reflection - Curved Mirrors (continued)

Outcomes

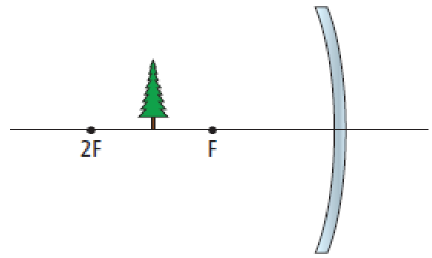
Students will be expected to

- use mirrors effectively and accurately for investigating the characteristics of images formed (209-3)
  (continued)

  - construct ray diagrams showing the formation of images in concave mirrors where the object is at different positions. Include:
    (i) object between focal point and mirror
    (ii) object between focal point and two times the focal length
    (iii) object beyond two times the focal length

  - use ray diagrams to describe the characteristics of images formed using concave mirrors. Include:
    (i) size
    (ii) position
    (iii) orientation
    (iv) type

Elaborations—Strategies for Learning and Teaching



Observe the image of an object placed between the focal point and two times the focal point in a concave mirror. Students should observe that the image is inverted and larger than the object. Students will then justify what they observed using a ray diagram. In order to do so, teachers could have students draw a large "T" on a piece of paper. Place the concave mirror, upright, on the top of the "T". Students will place an object (for example, a paper clip) on the principal axis. Shine a beam of light from the ray box parallel with the principal axis such that the beam of light just touches the top of the object. Place two dots in the middle of the incident and reflected light beams. Remove the ray box and connect the dots forming lines that represent the incident and reflected light rays. Identify the focal point. Repeat this process with a beam of light just touching the top of the object in line with the focal point. Place two dots in the middle of the incident and reflected light beams. Remove the ray box and connect the dots forming lines that represent the incident and reflected light rays. Students can now draw the image using the intersection of the two reflected rays. Finally, students can compare the characteristics of the image they have drawn with their initial observations. This procedure can then be repeated with the object between the focal point and the mirror as well as beyond two times the focal length.

Note: the textbook illustrates a third ray through the optical centre. This ray is not required to construct an accurate ray diagram.

Students should observe that images in concave mirrors vary depending on the object's location. Using SPOT, the following characteristics may be observed:

- The image is smaller or larger than the object.
- The image distance is smaller or larger than the object.
- The image is upright or inverted
- The image is real or or virtual

Note: Students should be able to identify SPOT characteristics from a specific ray diagram but are not expected to memorize them.

Students should have opportunities to observe the reflecting patterns of light off concave mirrors. This could be completed prior to introducing ray diagrams for curved mirrors.

Reflection - Curved Mirrors (continued)

Suggested Assessment Strategies

Performance

- In groups, design pictures to represent different types of mirrors, viewing objects and image characteristics. Place magnets on the back of the pictures. Create matching games where the pictures can be switched around to match the mirror type with image characteristics. (209-3)
- Develop a comic strip that explains how images are reflected in concave mirrors. (308-9)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 198-202

BLM 2-29, 2-32

ST pp. 200-202

Reflection - Curved Mirrors (continued)

Outcomes

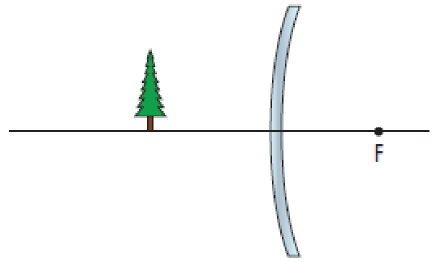
Students will be expected to

- use mirrors effectively and accurately for investigating the characteristics of images formed (209-3)
  (continued)

- describe how incident rays reflect on convex mirrors. Include:
  (i) rays traveling parallel to the principal axis
  (ii) rays traveling through the focal point
- construct ray diagrams showing the formation of images in convex mirrors

- use ray diagrams to describe the characteristics of images formed using convex mirrors. Include:
  (i) size
  (ii) position
  (iii) orientation
  (iv) type

Elaborations—Strategies for Learning and Teaching



Teachers should ensure students recognize that the focal point in a convex mirror is behind the mirror.

Observing the image of an object in a convex mirror. To address this outcome, students should observe objects using convex mirrors, noting the image characteristics. Students should observe that the images are always upright and smaller than the object. Next, students can confirm their observations using a ray diagram (a template such as the one shown below must be given). In order to do so, teachers should have students draw a large "T" on a piece of paper. Place the convex mirror, upright, on the top of the "T". Students will place an object (for example, a paper clip) on the principal axis. Shine a beam of light from the ray box parallel with the principal axis such that the beam of light just touches the top of the object. Place two dots in the middle of the incident and reflected light beams. Remove the ray box and connect the dots forming lines that represent the incident and reflected light rays. Identify the focal point. Repeat this process with a beam of light just touching the top of the object in line with the focal point. Place two dots in the middle of the incident and reflected light beams. Remove the ray box and connect the dots forming lines that represent the incident and reflected light rays. Students can now draw the image using the intersection of the two reflected rays. Finally, students can compare the characteristics of the image they have drawn with their initial observations.

Note: the textbook illustrates a third ray through the optical centre. This ray is not required to construct an accurate ray diagram.

Teachers should provide students with opportunities to observe images in a convex mirror

Using ray diagrams, students should be able to identify the following SPOT image characteristics for convex mirrors:

- The image is smaller than the object.
- The image distance is smaller than the object distance.
- The image is upright.
- The image is virtual.

Reflection - Curved Mirrors (continued)

Suggested Assessment Strategies

Performance

- Create a skit that explains how an image is formed in a curved mirror. (209-3)
- Create a comic strip which uses the formation of images in curved mirrors as the main topic. (209-3)
- Write a poem, rap, or song to explain the difference between real and virtual images. (209-3)

Presentation

- Devise a way of explaining how images form in curved mirrors and share with the class. (209-3)
- Write a song that describes the size and orientation of an image in different mirrors (plane, concave, convex). (209-3)
- Create a poster that shows how the size and orientation of images differ for different types of mirrors. (209-3)

Paper and Pencil

- Create a 3-circle Venn diagram to compare image characteristics in plane, concave and convex mirrors. (209-3)
- Create a table to highlight and contrast the characteristics of images formed by concave and convex mirrors. (308-9)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST. pp 204-205

BLM 2-30, 2-31, 2-32, 2-34

ST p. 205

Refraction

Outcomes

Students will be expected to

- identify questions to investigate involving refraction arising from practical problems and issues. (208-2) Include:
  - (i) bent stick effect
  - (ii) apparent position of a fish under water

Elaborations—Strategies for Learning and Teaching

To begin this topic, teachers could have students recall the demonstration performed at the beginning of the unit using the large beaker of water and popsicle stick. Alternatively, teachers could have students complete an activity in which the position of a coin in an opaque cup apparently changes when water is added to the cup. Teachers could use their school's flex camera to perform this activity as a whole class demonstration.

Teachers should relate what has already been covered in the study of reflection and virtual images to this topic to ensure students understand that the location of an object's image depends upon how the human brain interprets the light rays entering our eye. That is, the human brain does not interpret that these light rays become bent or refracted as they travelled from water to air. As a result, the apparent position of the object is different from its actual position. Teachers could use diagrams to explain how these examples of refraction occur. At this point, the details of such a diagram do not have to be presented (e.g. why the light rays bend in the direction they do). This can be presented once refraction has been studied further.

- describe qualitatively how visible light is refracted (308-10)

Teachers could introduce the terms associated with refraction through the use of a demonstration in which a beam of light from a ray box is shone upon a prism. Teachers may want to carefully adjust the angle at which the incident ray shines upon the surface of the prism so that dispersion of light is minimized. The incident rays and refracted rays can be marked with dots and the surface of the prism can be traced. Once the ray box is moved, the diagrams can be completed by appropriately connecting the dots. Students could then measure and compare the angles of incidence and refraction. By performing such a demonstration, the teacher can easily present how the angle of refraction changes with the incident angle. In order for the entire class to more easily view such a demonstration, teachers may want to use an overhead projector or the school's flex camera.

A laser could be used in place of the ray box as it will not cause dispersion.

Refraction

Suggested Assessment Strategies

Paper and Pencil

- Explain how the refraction of light causes us to see a stick as being bent in water. (208-2, 308-10)
- Describe the effect of light refraction on objects (or images) seen by the human eye and why this effect occurs. (308-10)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 179-182

ST pp. 149-151, 179-182

Refraction (continued)

Outcomes

Students will be expected to

- describe qualitatively how visible light is refracted (308-10)

(continued)

- define the process of light refraction. Include:
  - (i) incident ray
  - (ii) refracted ray
  - (iii) angle of incidence
  - (iv) angle of refraction

- indicate that the speed of light decreases as it travels from one medium to another of greater density
- indicate that the speed of light increases as it travels from one medium to another of lesser density

Elaborations—Strategies for Learning and Teaching

Teachers could use diagrams, relating to the observations made in the activity/demonstration as they define and help students develop an understanding of these terms.

Light slows down as it travels through other media such as through water or glass from air. A possible analogy for refraction is a car travelling on the highway. If the car runs onto a sandy shoulder, it will veer and slow down. This models the refraction of light caused by travelling through a denser medium. Teachers could roll a wheel and axle setup (e.g. from a toy vehicle) from a bare surface onto a rougher surface, to simulate light traveling from one medium to another of different density. If the wheel and axle hits straight on, it will slow down but does not bend. If the wheels hit at an angle, one wheel will slow down before the other, and the direction of the wheels will change. This is analogous to the refraction of light as it passes from one medium to another of different density.

Videos and simulations are available online to illustrate this concept.

Refraction (continued)

Suggested Assessment Strategies

Paper and pencil

- Create a table or mind map to distinguish between the terms incident ray, refraction ray, angle of incidence, angle or refraction. (308-10)

Performance

- Create a song, rap, poem, or jingle that describes the characteristics of the terms incident ray, refracted ray, angle of the incidence, angle or refraction. (308-10)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 179-181

ST pp. 149-151, 179-181

BLM 2-23

Refraction (continued)

Outcomes

Students will be expected to

- estimate angles of incidence and refraction. (209-2) Include:
  - (i) as light moves from a less dense medium to a more dense medium
  - (ii) as light moves from a more dense medium to a less dense medium

Elaborations—Strategies for Learning and Teaching

Teachers could revisit the ray box and prism demonstration completed during the introduction of the terms associated with refraction. Teachers could change the angle of incidence and have students observe the affect on the angle of refraction. Students could measure both the angle of incidence and angle of refraction each time. While they work through such an activity, teachers should ensure students observe how the difference in a medium's density affects the relationship between angle of incidence and angle of refraction.

Teachers could demonstrate by rolling a ball or marble from the floor onto a piece of carpet or mat and, from the carpet onto the floor at different angles. Point out the changes in the direction of the ball at the boundary between the floor and carpet.

Teachers could now revisit the refraction phenomena discussed earlier, including the apparent change in the position of a coin in an opaque cup or the bent stick effect. Teachers can now explain why the incident and refracted light rays were drawn as they were. Students should now develop a better understanding of this phenomena and predict the apparent position of the object in such situations.

Teachers could point out to students that while the relationship between the angles of incidence and refraction is straightforward, the same is not the case for refraction. While students are not expected to learn about Snell's law, teachers could inform students that there is a mathematical relationship, called Snell's law, that exists between the angle of incidence and the angle of refraction.

Refraction (continued)

Suggested Assessment Strategies

Performance

- Develop a song or jingle to help you remember the angle of incidence and refraction as light moves from a more dense to a less dense medium and vice versa. (209-2)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 179-181

Refraction (continued)

Outcomes

Students will be expected to

- conduct an experiment to describe the path of refracted rays through transparent media (208-8)
- design an experiment and identify major variables (208-6)
- work cooperatively and collaboratively with others (211-1)
- identify that a light ray traveling into a medium of greater density will bend towards the normal and a light ray traveling into a medium of lesser density will bend away from the normal (210-6)
- predict the effect of transparent media of varying densities on the angle of refraction of light. (208-5) Include:
  - (i) vegetable oil
  - (ii) water
  - (iii) 30% sugar solution

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity: Follow that Refracted Ray!

The laboratory outcomes 208-5, 208-6, 208-8, 210-6, 211-1 and, in part 308-10 are addressed by completing CORE LAB 5-1D “Follow that Refracted Ray”.

Teachers should direct students to observe and describe how the refracted light bends at the interface and what happens when the angle of incidence is changed.

After students have completed the activity, teachers should clarify that different materials or media have different indices of refraction. The higher the index of refraction, the greater the amount of refraction which occurs. Determining the degree of refraction for a particular substance can be a useful tool in attempting to identify an unknown material. Teachers could relate this to crime scene investigations.

As an extension (or prior to attempting the core lab), students could place a pencil in a beaker containing each transparent liquid to test predictions about what might happen to the appearance of the pencil in the medium as well as how the appearance would change in the different media.

Teachers should note that the refraction of light through various substances is related to physical density.

- The more dense the substance, the more the light refracts toward the normal.
- The less dense the substance, the less the light refracts toward the normal.

Teachers should ensure that students are more focused on the process embedded in the core lab activity and less focused on the exact results of the process. However, students should use a ruler for drawing their resultant rays as this will aid them with viewing and better understanding the exact results of the process.

Refraction (continued)

Suggested Assessment Strategies

Performance

- Create a poster, collage, or multimedia presentation that shows the effects various liquids have on the refraction of light. (208-5, 308-10)

Paper and pencil

- Diagram the bending of a ray towards the normal as the light ray passes from a less dense medium to a more dense medium and from a more dense medium to a less dense medium. (208-5, 210-6)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

Core lab #6: “Follow that Refracted Ray!”

ST pp. 184-185

TR 2.31-2.33

ST pp. 474- 475, 488 (Science Skills)

TR AR 3, 5, 6

TR PS 6, 7, 10

Refraction - Lenses

Outcomes

Students will be expected to

- describe qualitatively how visible light is refracted (308-10)
  - define lens
  - describe two types of lenses. Include:
    - (i) convex
    - (ii) concave
  - provide examples of each type of lens. Include:
    - (i) magnifying glass (convex)
    - (ii) eye glasses (convex)
    - (iii) eye glasses (concave)
  - describe how convex and concave lenses refract light
  - describe how lenses correct near-sightedness and far-sightedness

Elaborations—Strategies for Learning and Teaching

After students have been introduced to the refraction of light and some examples, teachers should present lenses as a common object that takes advantage of this property of light. Teachers could have students brainstorm a list of everyday technologies that make use of lenses. Magnifying glasses and eyeglasses will likely be two technologies with which students have some experience. Teachers could supply students with magnifying glasses so they may observe the effects they have. Similarly, teachers could provide groups of students with a ray box and a selection of different lenses so they may observe the effect the lenses have on light.

Convex lenses should be described as thicker across the middle and thinner at its edges. Students should understand that convex lenses cause light rays to refract toward each other, or converge. Concave lenses should be described as thinner across the middle and thick at its edges. Students should understand that concave lenses cause light rays to refract away from each other, or diverge.

Teachers should ensure that students understand the practical applications of convex and concave lenses. A practical application of convex and concave lenses would include the use of eyeglasses used to correct near-sightedness and far-sightedness. The type of lens needed to correct a vision problem depends on whether the convex, human eye lens converges the light rays to a point in front of or behind the retina. In other words, it depends on whether the eye lens refracts the light too much (near-sighted), or not enough (far-sighted).

A concave lens is used to correct near-sightedness. A convex lens is used to correct far-sightedness. The difference between these lenses is easily identified as concave lenses make a person's eyes and face look smaller, while convex lenses makes the eyes look larger.

Teachers should note that the construction of ray diagrams for lenses is not part of this unit.

Refraction - Lenses

Suggested Assessment Strategies

Performance

- Create a poster, collage or multimedia presentation that describes the benefits lenses have on our society. (210-1)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

ST pp. 214-217

TR 2.50-2.51

ST p. 234

Development of Optical Technologies

Outcomes

Students will be expected to

- describe how optical technologies have developed through systematic trial-and-error processes constrained by the optical properties of the materials (109-5)

Elaborations—Strategies for Learning and Teaching

The **CORE STSE** component of this unit incorporates a broad range of grade 8 science outcomes. More specifically, it targets, in whole or in part, 109-5, 109-10, 111-3, and 112-8. The STSE component, “Fibre Optics” can be found in Appendix A.

In addition to using the Core STSE to address this outcome, teachers could have students investigate and describe the development and evolution of another optical technology such as a microscope, telescope, reading glasses, or contact lenses. Teachers could use this as an opportunity to help students understand that technological advances often follow the development of scientific understandings. For example, the development and use of the various optical technologies depended on the development of a material that would lend itself to the specific application (e.g. the development of contact lenses).

- provide examples of optical technologies that enable scientific research and relate personal activities associated with such technologies (109-10, 111-3)
- provide examples related to optics that illustrate that scientific and technological activities take place individually and in group settings (112-8)

Teachers could have students research the historical development of an application of optics such as the development of telescopes and microscopes. Teachers should ensure students are aware of the scientific research that occurs because of optical technologies as well as how personal activities such as using a telescope or magnifying glass are related to the study of optics. Face shields on hockey helmets, car headlights, flashlights, magnifying glasses, eye glasses, contact lenses, microscopes, telescopes, and cameras can be used as examples.

Teachers should ensure students are aware of scientific and technological activities that involve individuals, such as lens makers, and groups, such as astronomy teams investigating and surveying the universe. Through such discussions, students should develop a better appreciation for the nature of ongoing development of scientific knowledge. For example, the development of optical technologies (from Galileo, to Newton, to the Hubble telescope and laser technologies) is gradually helping us to better understand the complexity of our universe. The knowledge that we have today is by no means stagnant, and will likely change and be extended in the near future. The intermediate student may often struggle with these nature of science topics. Students will learn more about the applications of optical technologies in the grade 9 unit “Space”. This is why the nature of science is best treated on an ongoing basis. As the student learns about the development of optical technologies, this process can be treated as being analogous to the development of knowledge in scientific community.

Development of Optical Technologies

Suggested Assessment Strategies

Portfolio

- Make a list or create a small scrapbook of various reflecting technologies and indicate their particular uses. (109-5)

Resources

www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/index.html

Appendix A

BLM 2-42, 2-43, 2-44

TR AR 3, 7, 8

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