Grade 8

Cluster 2: Optics

Overview

In this cluster, students broaden their understanding of how light is produced, transmitted, and detected. Students identify colours as different wavelengths of light, and explore why objects appear to have colour. Various types of electromagnetic radiation are compared. The potential positive and negative impacts of technological devices that use electromagnetic radiation are discussed. Students explore the principles and properties of reflection and refraction, and their application in everyday situations. Students investigate the characteristics of concave and convex mirrors and lenses. They enhance their understanding of how these devices function in a variety of optical tools. Students also demonstrate the formation of images using lenses and compare the function of the human eye to that of a camera lens.

PRESCRIBED LEARNING OUTCOMES

Students will...

8-2-01 Use appropriate vocabulary related to their investigations of optics.

Include: spectrum, additive theory; subtractive theory; frequency; wavelength; refraction; concave and convex mirrors and lenses; terms related to types of light sources, types of electromagnetic radiation, and the law of reflection.

GLO: C6, D3

SUGGESTIONS FOR INSTRUCTION

Teacher Notes

Prior Knowledge

Students have had previous experiences related to this cluster in Grade 4, Cluster 2: Light.

➢ Introduce, explain, use, and reinforce vocabulary throughout this cluster.

➢ **Three-Point Approach**

Have students use the Three-Point Approach (Simons, 1991) to write a definition of a term in their own words, represent it with a picture/diagram, and give an example or synonym.

(For a BLM of the Three-Point Approach for Words and Concepts, see *SYSTH*, Attachment 10.2, or *Success*, p. 6.101.)

Suggestions for Assessment

Suggested Learning Resources

PRESCRIBED LEARNING OUTCOMES

Students will...

8-2-02 Differentiate between incandescent and luminescent sources of light.

Include: fluorescent, phosphorescent, chemiluminscent, bioluminescent.

GLO: D3, D4, E1

8-0-5a ➲ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-7f ➲ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

SUGGESTIONS FOR INSTRUCTION

➢ Incandescent Versus Luminescent Light Sources

Part A: Observing Light Sources

Provide students with samples of

- *incandescent light* sources such as a candle and a lamp with an incandescent bulb
- *luminescent light* sources such as a fluorescent light and a glow stick

Have students observe the two types of light sources, noting distinctions and relationships between them. Ask students to fill out a Concept Relationship Frame (Matchullis and Mueller, 1994), including examples. Students should leave spaces beside the examples to classify them as fluorescent, phosphorescent, chemiluminescent, or bioluminescent after completing Part B below.

(For a BLM of a Concept Relationship Frame, see *SYSTH*, Attachment 11.1, or *Success*, p. 6.104.)

Part B: Identifying Types of Luminescent Light

Have pairs of students identify which of the following terms and definitions best suits each example cited in their Concept Relationship Frame (begun in Part A above) and explain why. Have two sets of pairs compare and discuss their answers and reach a consensus. Following a class discussion, ask students to return to their Concept Relationship Frame and identify the type of luminescent light each example represents.

Terms and Definitions

Luminescent light is divided into four categories:

- *Fluorescent light* gives off light only while it is supplied with electrical energy. Generally, fluorescent bulbs are in the shape of a tube. The electricity reacts with the chemicals within the tube. Because fluorescent bulbs are highly energy efficient, smaller tube bulbs have been manufactured to be used in home lighting.
- *Phosphorescent light* continues to give off light even after the initial source of energy is taken away.
- *Chemiluminescent light* occurs when a chemical reaction between substances gives off light without creating heat.
- *Bioluminescent light* is a form of chemiluminescence that occurs in living organisms.

SUGGESTIONS FOR ASSESSMENT

Extended Response

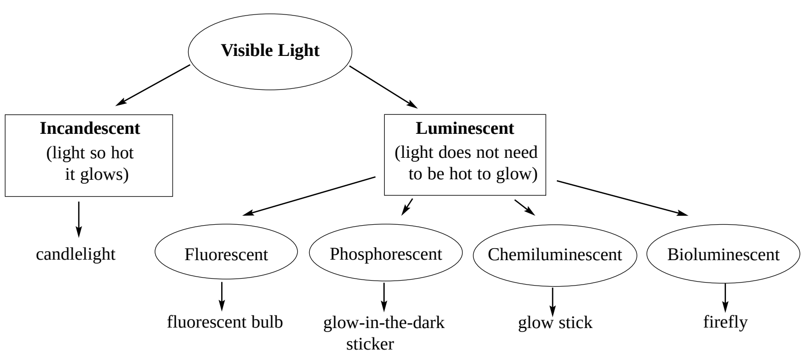
Provide students with the following:

Light Concept Map

Create a concept map to show the relationships among the following terms: *visible light*, *incandescent*, *luminescent*, *fluorescent*, *phosphorescent*, *chemiluminescent*, *bioluminescent*, *hot*, *not hot*, *candlelight*, *glow stick*, *fluorescent bulb*, *glow-in-the-dark sticker,* and *firefly.*

Look for:
- visible light is divided into two types: incandescent (hot) and luminescent (not hot)
- incandescent light is described as a light source that burns so hot it glows, whereas luminescent light is not hot
- luminescent light is divided into four types: fluorescent, phosphorescent, chemiluminescent, and bioluminescent
- examples of each type of incandescent and luminescent light are given

Example:



SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 8 (Section 5.1)

Sciencepower 8 (Section 7.1)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-2-03 Demonstrate that light is a form of energy, that light travels in a straight line, and can be separated into the visible light spectrum.

GLO: A1, C1, C2, D4

8-0-4e ➲ Demonstrate work habits that ensure personal safety, the safety of others, and consideration for the environment. Include: keeping an uncluttered workspace; putting equipment away after use; handling glassware with care; wearing goggles when required; disposing of materials safely and responsibly. GLO: C1

8-0-5a ➲ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5c Select and use tools to observe, measure, and construct. Include: microscope, concave and convex mirrors and lenses, chemical indicators. GLO: C2, C3, C5

8-0-5f ➲ Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 8, 3.3.1; Math: SP-III.2.8)

8-0-7f ➲ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

(continued)

SUGGESTIONS FOR INSTRUCTION

➢ Activating Prior Knowledge

Have students fill out a Knowledge Chart (Matchullis and Mueller, 1994) indicating what they know about light energy. Ensure that students revisit the chart throughout the study of this cluster or as a culminating learning activity at the end of the cluster.

(For a BLM of a Knowledge Chart, see *SYSTH*, Attachment 9.2, or *Success*, p. 6.96.)

➢ Light Is a Form of Energy

Remind students that *energy* is the ability to make things move or produce a change in materials.

Place a radiometer on an overhead projector and have students observe the motion of the vanes within the radiometer. (Radiometers are commonly found in Senior Years science labs. The black vanes and white vanes of the radiometer begin moving as light energy is absorbed by the black side of the vanes.) Ask students to describe in their science notebooks how the radiometer proves that light is a form of energy.

➢ Pinhole Camera

1. Have students build a pinhole camera out of an empty shoe box or tissue box, following these directions:
   - Cut out one end of the box and place wax paper on the newly opened end.
   - On the other end, cut out a 4 cm^2 hole and then cover it with smooth tinfoil. (If students are using a tissue box, the top opening should be covered with cardboard. Students could also use two cylindrical chip containers taped together end to end.)
   - Create a tiny hole in the centre of the tinfoil using the point of a pin.
2. Before students look at a lit candle or an object with their pinhole camera, have them predict what the image will look like on the wax paper of their cameras.
3. Ask students to aim their cameras toward a candle. They can stand two to three metres away from the candle and look at (not through) the wax paper end. If the classroom has a window through which trees or buildings are visible, turn off the lights in the room and have students aim the cameras at the window. Students can then draw the object they see on the wax paper and compare it to what they predicted they would see. (The image will appear upside down.)

(continued)

Suggestions for Assessment

Suggested Learning Resources

Nelson Science & Technology 8 (Section 5.2)

Sciencepower 8 (Sections 7.1, 9.1)

Addison Wesley Science & Technology 8: *Optics* (Sections 1.0, 6.3)

The Electromagnetic Spectrum (Video)

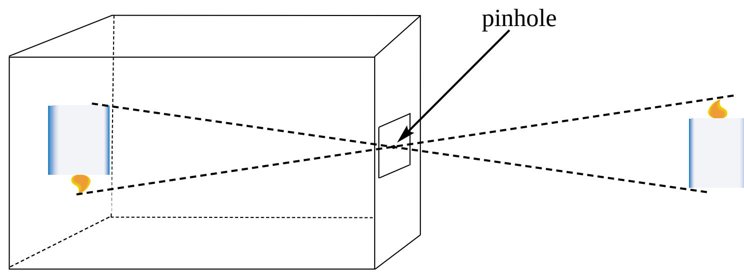
Prescribed Learning Outcomes
Students will...
8-2-03 *(continued)*

Suggestions for Instruction

(continued)

4. Have students draw the camera and the object in their science notebooks. Remind students that light travels in straight lines. Have them draw lines in their illustrations to show how the light is travelling to create the image they saw.

   Example:



➢ **Visible Light: A Spectrum of Colours**

Have students, using a powerful flashlight, shine a white ray of light through a prism and observe the colours of light that appear. Inform students that these colours make up what is called the *visible light spectrum*, and the separating of white light into a spectrum is called *dispersion*. Have students record the colours of the spectrum in their science notebooks.

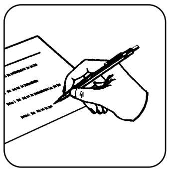
Discuss with students the concept of mnemonics as a tool for remembering ideas (e.g., using the first letter of a term as the first letter of a word in a catchy phrase). Have students create a mnemonic that will assist them in remembering the order of colours in a spectrum.

Teacher Notes

Background Information

The colours that make up the visible light spectrum are: red, orange, yellow, green, blue, (indigo), and violet. There has been some recent debate in the science community with respect to the inclusion of the colour indigo. Some texts may include it, while others may not.

SUGGESTIONS FOR ASSESSMENT



Extended Response

Provide students with the following:

Light

You have been asked to prove to a younger student that the following statements are true. Write a position paper clearly indicating what proof you have to offer. (Use recent learning experiences, as well as any other examples you can think of.)

1. Light is a form of energy.
2. Light travels in a straight line.
3. Light can be seperated into different colours.

Look for:

- explanations are clearly stated
- examples (proof) are provided

SUGGESTED LEARNING RESOURCES

PRESCRIBED LEARNING OUTCOMES

Students will...

8-2-04 Explain, using the additive theory, how colours are produced, and identify applications of this theory in daily life.

GLO: A1, A2, B1

8-0-5a ⊂ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5f ⊂ Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 8, 3.3.1; Math: SP-III.2.8)

8-0-6b ⊂ Interpret patterns and trends in data, and infer and explain relationships. GLO: A1, A2, C2, C5

8-0-7a ⊂ Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 8, 3.3.4)

8-0-7h ⊂ Identify and evaluate potential applications of investigation results. GLO: C4

(continued)

SUGGESTIONS FOR INSTRUCTION

➢ Additive Theory of Colour

Use explicit instruction to introduce to students the *additive theory of colour.* Have students experiment with colour combinations to determine what colours of light can be produced using only the three primary additive colours and light rays:

- Using three ray boxes/flashlights (one with a red gel or transparency film on it, one with a blue transparency on it, and one with a green transparency on it), shine different combinations of light onto a light-coloured surface.
- Record information on a chart, listing the colour combinations and the subsequent new colour created. (An overhead projector may be used instead of light boxes.)

  Example:

Additive Colour Combinations

Primary Additive Colours	**Secondary or Resulting Additive Colours**
blue + red + green	white
blue + red	magenta
blue + green	cyan
green + red	yellow

The following websites allow students to manipulate primary additive colours to demonstrate the resulting colour mixes, or secondary colours.

<*http://micro.magnet.fsu.edu/primer/java/light/primaryadd.html*>
<*http://mc2.cchem.berkeley.edu/Java/emission/Java%20classes/emission.html*>

Have students answer the following questions in their science notebooks:

1. The three initial colours used are called the primary additive colours. What are they? (blue, red, and green)
2. What secondary colours were created when only two of the primary colours were blended? (magenta, cyan, yellow)
3. What colour was created when all three primary colours were combined? (white)

(continued)

Suggestions for Assessment

Teacher Notes

Background Information

Visible white light is made up of a spectrum of colours; however, colours of light can also be perceived in other ways. The illusion of a particular colour of light can be created by combining specific coloured light rays. This adding of colours to create a second colour is called the *additive theory of colour.*

The primary additive colours are blue, red, and green. The secondary (or resulting) colours produced when two of the primary colours are mixed are magenta, cyan, and yellow. When all three primary colours of light are combined, they produce white light.

Suggested Learning Resources

Nelson Science & Technology 8 (Section 5.18)

Sciencepower 8 (Section 9.1)

Addison Wesley Science & Technology 8: *Optics* (Sections 5.2-5.3)

The Electromagnetic Spectrum (Video)

PRESCRIBED LEARNING OUTCOMES
Students will...
8-2-04 *(continued)*

SUGGESTIONS FOR INSTRUCTION

(continued)

4. A colour television screen utilizes the three primary additive colours and the additive theory of colour to create the illusion of an array of colours. Each primary colour is in a separate row of lit dots. What combination of lit dots would be needed to create the colour of snow on television? (blue, red, and green)
5. Stage lighting also uses the concept of the additive theory of colour. Spotlights covered with gels or transparency film of the three primary colours may shine toward a light-coloured background. If a director wanted to create the illusion of a bright sunny day that progresses into a beautiful sunset and then into a restful evening, what types of colour combinations would be used and why? (The bright part of day may be represented by using all three colours to create a white light, or by combining red and green to create a yellow light. As the Sun sets, blue and red may be used to create a magenta sunset. Finally, blue and green may be used to create cyan, giving the illusion of evening.)

Suggestions for Assessment

Extended Response

Provide students with the following:

Light Colour Combinations

White light can be created by combining two complementary colours such as blue and yellow. The yellow contains the green and red that would complete the colour combination that creates white light. Explain why the following light colour combinations are able to create white light.

1. red + cyan = white
2. green + magenta = white

Look for:

1. Blue, green, and red are needed to create white light. Cyan is made of blue and green light. Therefore, all three primary colours are present to create white light.
2. Blue, green, and red are needed to create white light. Magenta is made of red and blue light. Therefore, all primary colours are present to create white light.

Suggested Learning Resources

PRESCRIBED LEARNING OUTCOMES

Students will...

8-2-05 Explain how the human eye detects colour, and how the ability to perceive colour may vary from person to person.

GLO: A2, E1

8-0-2a ➲ Access information, using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 8, 3.2.2)

8-0-2b Develop and use criteria for evaluating information sources. Include: distinguish between fact and opinion. GLO: C6, C8 (ELA Grade 8, 3.2.2, 3.2.3; TFS 2.2.2)

8-0-2c Make notes in point form, summarizing major ideas and supporting details and referencing sources. GLO: C6 (ELA Grade 8, 3.3.2)

8-0-7f ➲ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

8-0-7h ➲ Identify and evaluate potential applications of investigation results. GLO: C4

SUGGESTIONS FOR INSTRUCTION

Teacher Notes

Background Information

The retina of the human eye has *cone cells* that perceive colour. Some cone cells are sensitive to red, some to green, and some to blue.

➢ The Human Eye and the Perception of Colour

To enable students to broaden their understanding of the ability to perceive colour, have them

- use a variety of resources to obtain information on how the eye perceives colour and on the nature and causes of colour-blindness
- summarize this information in their science notebooks
- use this information and the additive theory of colour to identify the colour of the cone cells that would need to be activated for them to see the flame of a burning candle
- identify the colour that is perceived (red + green = yellow)

➢ What Colour Is It?

Darken the classroom and show students three different coloured objects (e.g., blue, red, and green balls). Have students note what colour they perceive each object to be. Slowly add more light to the classroom and, with each addition of light, have students record the colour of the objects. When the lighting has returned to normal, have students identify what affected their perception of the colour of each object. (The amount of light present affected the perception of colour.)

➢ Colour-Blindness

Have students use the Think-Pair-Share strategy (McTighe and Lyman, 1992) to identify some situations where perception of colour is important, and where adaptive skills would have to be learned to cope with the challenge of colour-blindness (e.g., memorizing the order of lights on a traffic light, having clothes colour-coordinated).

Suggestions for Assessment

Evaluating Testimonies

Provide students with the following:

Evaluating Testimonies

Two witnesses were called to the stand to testify in a criminal case. Which of the following testimonies has a greater degree of validity, and why?

- *Witness A:* I saw two people running through the park around 10:00 p.m. The first one who ran by was wearing a bright red sweater. The second one wore a lime green sweater. It was dark and cloudy and there was no moon. The lights in the park were out due to a power failure.
- *Witness B:* I saw a person running through the park at approximately 10:00 p.m. Then a minute later another person ran by. I was unable to tell the colour of their clothes, although both wore sweaters. Both sweaters appeared dark but different shades. It was dark and cloudy and there was no moon. The lights in the park were out due to a power failure.

Scoring Rubric

Score	Criteria
4	The response is correct, complete, and detailed, indicating that Witness B's testimony has greater validity because light is needed to detect shades of colours. It contains examples and/or elaboration to support the answer (according to both witnesses the area was dark because of the time of day, weather conditions, and power failure; therefore, Witness A should not have been able to detect the correct colour of the sweaters worn). It includes evidence of higher-order thinking.
3	The response is correct and complete, indicating that Witness B's testimony has greater validity because light is needed to detect shades of colours. It contains examples and/or elaboration to support the answer.
2	The response is generally correct and complete. It may contain minor errors. It contains examples and/or elaboration to support the answer.
1	The response is partially correct but is incomplete and/or contains major errors. It contains no examples or elaboration to support the answer.

Suggested Learning Resources

Nelson Science & Technology 8 (Section 5.18)

Sciencepower 8 (Section 9.1)

Addison Wesley Science & Technology 8: *Optics* (Section 5.3)

The Electromagnetic Spectrum (Video)

Prescribed Learning Outcomes

Students will...

8-2-06 Demonstrate, using the subtractive theory, how colours are produced, and identify applications of this theory in daily life.

GLO: A2, B1

8-0-4c ➲ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 8, 5.2.2)

8-0-5a ➲ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-7f ➲ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

8-0-7h ➲ Identify and evaluate potential applications of investigation results. GLO: C4

(continued)

Suggestions for Instruction

➢ **What Colour Is It?**

Investigate the mixing of pigments (magenta, cyan, and yellow) from paints or highlighter pens. Have students

- determine what colour results from mixing any two of the pigments, and from mixing all three
- record their information on a chart

Example:

Creating Colours

Colour Combinations	Resulting Colours
magenta + cyan	blue
magenta + yellow	red
yellow + cyan	green
magenta + cyan + yellow	black

Have students use a Compare and Contrast Frame (Matchullis and Mueller, 1994) to compare this method of creating new colours with the additive theory of colour (the mixing of coloured light).

(For a BLM of a Compare and Contrast Frame, see *SYSTH*, Attachment 10.4, or *Success*, p. 6.103.)

Example:

- Both methods mix primary colours to create secondary colours.
- One method uses coloured lights, whereas the other uses coloured pigments.

➢ **Subtractive Theory of Colour**

1. Use explicit instruction to introduce the *subtractive theory of colour* and to relate this theory to the previous learning activity. Demonstrate the subtractive theory by shining a blue light on a blue object, on a red object, and on a green object in a dark classroom. Ask students to state what colour each object is. (They should readily see the blue as blue but they will identify the other two as black.) Turn on the classroom lights and have students attempt to explain why they identified the red and green objects as black. (Only the blue object reflects blue light. The red and green absorb the blue. Since there was no red or green light available, the red and green objects absorbed the blue, thereby creating black.)

(continued)

Suggestions for Assessment

Teacher Notes

Background Information

If objects do not give off their own light, they are seen because light reflects off them. White light is actually made up of a spectrum of colours. Some substances only allow certain colours to be absorbed and whatever is not absorbed is reflected, thus determining the perceived colour of the object. The colour of the object is thus determined by subtracting all the colours that have been absorbed. This is referred to as the *subtractive theory of colour*.

The chemical that absorbs certain colours of light, but reflects others, is a *pigment*.

- The primary pigment colours are: yellow, cyan, and magenta (these are also the secondary light colours).
- The secondary pigment colours produced when two primary pigments are mixed are: red, green, and blue (the primary light colours).

Filters contain pigments and absorb some colours of light. For example, a blue filter absorbs red and green light and transmits blue. Students can investigate the effect of coloured light on pigments, but this is not required to meet the learning outcomes.

Suggested Learning Resources

Nelson Science & Technology 8 (Section 5.21)

Sciencepower 8 (Section 9.1)

Addison Wesley Science & Technology 8: *Optics* (Section 5.3)

Prescribed Learning Outcomes
Students will...
8-2-06 *(continued)*

Suggestions for Instruction

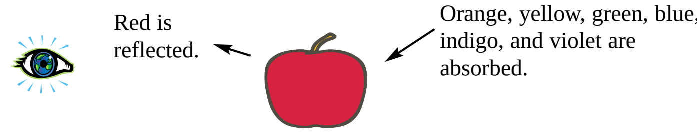
(continued)

2. Based on this information, have students use the terms *reflected* and *absorbed* to explain, in their science notebooks, why a red apple appears red in daylight. Ask them to include the colours that had to be subtracted/absorbed and draw a diagram depicting this phenomenon.

Example:

Why a Red Apple Appears Red in Daylight

A red apple only reflects red. The rest of the light spectrum is absorbed by the pigments in the skin of the apple. In order for the colour red to be seen, orange, yellow, green, blue, indigo, and violet are subtracted from the white light, leaving the red.



3. Have students add to their Compare and Contrast Frame (started in the previous learning activity) to include the primary and secondary colours for both the additive and subtractive theory of colour.

➢ Consolidating Knowledge

Have students answer the following questions in their science notebooks:

1. What is the resulting colour when yellow and cyan pigments are mixed? (green)
2. What primary pigments need to be mixed to create the secondary pigment blue? (magenta and cyan)
3. Why is black not a colour? (Black results when *no* colour is reflected.)
4. How are the primary pigment colours related to the secondary light colours? (They are the same.)

➢ Applications of the Subtractive Theory of Colour

Have students investigate the workings of a colour printer or invite a photographer to the class to explore the subtractive theory of colour at work in printers and/or photography.

Suggestions for Assessment

Restricted Response

Provide students with the following:

Subtractive Theory of Colour

Circle the best answer to each of the following questions:

1. White light contains all the colours of the spectrum. According to the *subtractive theory of colour*, which colour is not being absorbed by a red apple?
   a. blue
   b. green
   c. magenta
   d. red
2. A white T-shirt
   a. absorbs all colours in the spectrum
   b. reflects all colours in the spectrum
   c. reflects only one colour and absorbs the rest
   d. absorbs only one colour and reflects the rest
3. What two pigment colours are needed to create the secondary pigment colour red?
   a. magenta and cyan
   b. magenta and yellow
   c. yellow and cyan
   d. blue and green
4. When combined, the three primary pigment colours create
   a. black
   b. white
   c. brown
   d. purple
5. A cyan filter absorbs which of the following colours?
   a. blue
   b. green
   c. red
   d. yellow

Look for: 1. d 2. b 3. b 4. a 5. c

Suggested Learning Resources

Prescribed Learning Outcomes

Students will...

8-2-07 Compare and contrast various types of electromagnetic radiation, with respect to relative energy, frequency, wavelength, and human perception.

Include: radio waves, microwaves, infrared, radiation, visible light, ultraviolet radiation, X-rays, gamma rays.

GLO: D4, E1

8-0-2a Ͼ Access information, using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 8, 3.2.2)

8-0-2b Develop and use criteria for evaluating information sources. Include: distinguish between fact and opinion. GLO: C6, C8 (ELA Grade 8, 3.2.2, 3.2.3; TFS 2.2.2)

8-0-2c Make notes in point form, summarizing major ideas and supporting details and referencing sources. GLO: C6 (ELA Grade 8, 3.3.2)

8-0-7g Ͼ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 8, 4.4.1)

Suggestions for Instruction

➢ Introducing Waves

Introduce students to the concepts of *electromagnetic radiation* and the *electromagnetic spectrum*. Demonstrate how energy travels in waves by having students observe a still surface of water that is touched by a vibrating rod.

Have students describe what they saw and gain practical experience with determining wavelengths by completing “Waves” (BLM 8-B).

Teacher Notes

Background Information

Electromagnetic radiation describes a stream of massless particles, each travelling in a wave-like pattern at the speed of light, and containing a certain amount of energy. The *electromagnetic spectrum* is the term used to describe the whole range of different types of electromagnetic radiation, each with its own wavelength, frequency, and amount of energy. Types of electromagnetic radiation include: radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

➢ The Electromagnetic Spectrum

Have students examine and represent various types of electromagnetic radiation, following these steps:

- Use print and/or electronic resources to identify and describe the various forms of electromagnetic radiation that make up the electromagnetic spectrum.
- For each type of radiation, include information on relative energy, wavelength, frequency, and human perception.
- Present information in a poster format that graphically illustrates the spectrum from long to short wavelength, with each type of radiation labelled in the appropriate location on the spectrum, along with associated details.

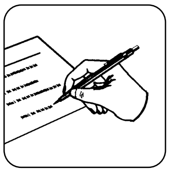
The following websites, for example, provide information regarding the electromagnetic spectrum:

<http://imagine.gsfc.nasa.gov/docs/science/>

<http://imagers.gsfc.nasa.gov/ems/waves3.html>

<http://radar.ou.edu/OK1/meteorology/Radiation.html>

SUGGESTIONS FOR ASSESSMENT



Extended Response:

Using a Concept Relationship Frame (Matchullis and Muller, 1994), have students compare and contrast two forms of electromagnetic radiant energy. (For a BLM of a Concept Relationship Frame, see *SYSTH*, Attachment 11.1, or *Success*, p. 6.104.)

Scoring Rubric	
Score	**Criteria**
4	The student describes both forms of electromagnetic radiation in terms of relative energy, frequency, wavelength, and human perception, and includes a summary statement that uses appropriate terminology and succinctly captures main ideas.
3	The student describes both forms of electromagnetic radiation in terms of relative energy, frequency, wavelength, and human perception, and includes a summary statement that uses appropriate terminology.
2	The student describes both forms of electromagnetic radiation, addressing at least three aspects of each, and provides a basic summary statement.
1	The student describes both forms of electromagnetic radiation, addressing at least two aspects of each.

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 8 (Sections 5.15-5.16)

Sciencepower 8 (Sections 9.2-9.3)

Addison Wesley Science & Technology 8: *Optics* (Sections 6.1-6.2)

The Electromagnetic Spectrum (Video)

Prescribed Learning Outcomes

Students will...

8-2-08 Provide examples of technologies that use electromagnetic radiation, and describe potential positive and negative impacts of their uses.

Examples: satellite dish, x-ray machine, light telescopes, motion sensors, microwave ovens…

GLO: A5, B1 D4

8-0-1a ➲ Formulate specific questions that lead to investigations. Include: rephrase questions to a testable form; focus research questions. GLO: A1, C2 (ELA Grade 8, 3.1.2; Math: SP-I.1.8)

8-0-2a ➲ Access information, using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 8, 3.2.2)

8-0-2b Develop and use criteria for evaluating information sources. Include: distinguish between fact and opinion. GLO: C6, C8 (ELA Grade 8, 3.2.2, 3.2.3; TFS 2.2.2)

8-0-2c Make notes in point form, summarizing major ideas and supporting details and referencing sources. GLO: C6 (ELA Grade 8, 3.3.2)

8-0-7f ➲ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

8-0-7h ➲ Identify and evaluate potential applications of investigation results. GLO: C4

Suggestions for Instruction

➢ **Inquiry Project**

Using a Sample Inquiry Plan for Grade 8 (see *5-8 ELA*, Grade 8, pp. 184-185), have pairs of students research and develop a short written report (or an oral presentation) identifying

- a technology that uses electromagnetic radiation
- the type of electromagnetic radiation it uses
- the potential positive and negative effects of its use

Begin as a class by brainstorming technologies that use electromagnetic radiation and have students record the examples in the first box located on the Sample Inquiry Plan. Have each pair research a different type of technology, if possible, and work through the plan.

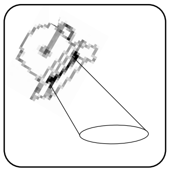
Provide direction with respect to type of audience. Lead a class discussion on evaluating information sources for accuracy, currency, usefulness, sufficiency (enough), and reliability (authority), and have students create criteria defining what is a good resource.

(For strategies to aid students in using a variety of information sources, determining the usefulness of information, constructing meaning, recording information, referencing, and evaluating sources, refer to *5-8 ELA*, learning outcomes 3.2.2-3.2.5 and 3.3.2-3.3.3.)

Possible Internet Sites:

- The website How Stuff Works provides information on how radio waves work and their many applications, ranging from baby monitors to deep space radio communications.
  <http://www.howstuffworks.com/radio-spectrum.htm>
- The fact sheet entitled "Are Electromagnetic Fields Hazardous to Your Health?" from Ohio State University contains information on electromagnetic radiation and its potential negative effects, as well as precautions to take.
  <http://www.ag.ohio-state.edu/~ohioline/cd-fact/0185.html>
- Washington State Department of Health has an informative site on Microwave Oven Radiation Safety.
  <http://198.187.0.42/ehp/rp/rp-oven.htm#microwaves>
- The article "Hung up on Mobile Phones" by an associate professor at the Department of Public Health and Community, University of Sydney, examines the issue of safety with electromagnetic radiation, particularly with cell phones.
  <http://www.studentbmj.com/back_issues/0999/editorials/307.html>

SUGGESTIONS FOR ASSESSMENT



Inquiry Project Oral Presentation

Provide students with the following tool for peer assessment of the oral presentations:

Peer Assessment of Research Report Presentation

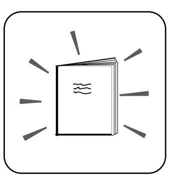
Presenters: ____________________

Technology: ____________________

Assessor: ____________________

Rating Scale					
Criteria	**Poor**		**Good**		**Excellent**
The speaker					
• spoke so that everyone could hear	1	2	3	4	5
• described the technology	1	2	3	4	5
• identified the type of radiation used by the technology	1	2	3	4	5
• described possible positive and/or negative effects of its use	1	2	3	4	5
• used visuals	1	2	3	4	5
• kept the interest of the group	1	2	3	4	5

Constructive comment:



Written Report of Inquiry Project

When assessing students' inquiry projects, look for indications of the following:

Rating Scale					
Criteria	**Poor**		**Good**		**Excellent**
The report					
• describes the technology	1	2	3	4	5
• identifies the type of radiation used by the technology	1	2	3	4	5
• describes possible positive and/or negative effects of its use	1	2	3	4	5
• includes pictures and/or diagrams	1	2	3	4	5
• is neat and legible	1	2	3	4	5

Constructive comment:

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 8 (Section 5.16)

Sciencepower 8 (Sections 9.2-9.3)

Addison Wesley Science & Technology 8: *Optics* (Section 6.2)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-2-09 Conduct experiments to determine the laws of reflection, and provide examples of the use of reflection in daily life.

Include: the angle of reflection is the same as the angle of incidence; the incident beam, the normal, and the reflected beam are all on the same plane.

GLO: A2, C1, C2, D4

8-0-1a ➲ Formulate specific questions that lead to investigations. Include: rephrase questions to a testable form; focus research questions. GLO: A1, C2 (ELA Grade 8, 3.1.2; Math: SP-I.1.8)

8-0-3a ➲ Formulate a prediction/hypothesis that identifies a cause and effect relationship between the dependent and independent variables. GLO: A2, C2 (Math: SP-I.1.8)

8-0-3c ➲ Create a written plan to answer a specific question. Include: apparatus, materials, safety considerations, steps to follow, and variables to control. GLO: C2 (ELA Grade 8, 3.1.4)

8-0-4a ➲ Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability. GLO: C2

8-0-5a ➲ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5c Select and use tools to observe, measure, and construct. Include: microscope, concave and convex mirrors and lenses, chemical indicators. GLO: C2, C3, C5

8-0-5e ➲ Estimate and measure accurately using SI and other standard units. Include: determining volume by displacement of water. GLO: C2, C5 (Math: SS-IV.1.6, SS-III.1.5, Math: SS-III.1.6, SS-I.1.5)

8-0-6b ➲ Interpret patterns and trends in data, and infer and explain relationships. GLO: A1, A2, C2, C5

8-0-7a ➲ Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 8, 3.3.4)

8-0-7h ➲ Identify and evaluate potential applications of investigation results. GLO: C4

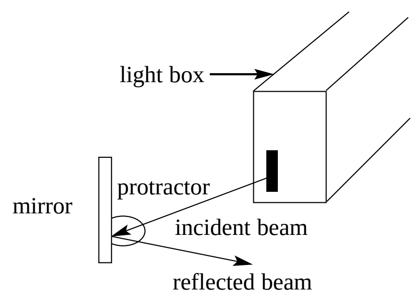
SUGGESTIONS FOR INSTRUCTION

➢ **Laws of Reflection Experiment**

Use explicit instruction to introduce students to the first *law of reflection*, which states that the incident beam (ray), the normal, and the reflected beam (ray) are all on the same plane (all occur on the same flat surface). As a result, the reflected beam will not bounce off in many directions but will follow a clear and predictable path.

Provide students with a commercial light box (or have them construct a light box), a flat/plane mirror, and a protractor. Have students plan and implement an experiment to determine the relationship between the angle of an incoming beam of light (incident beam) and the angle of an outgoing beam (reflected beam).

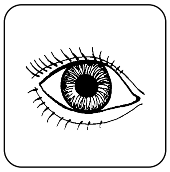
Example of possible set-up:



Ask students to record their observations as labelled beam diagrams, indicating measurements of the angles and including the following terms: *incident beam, reflected beam, angle of incidence, angle of reflection,* and *normal.* (The angle of incidence occurs between the incident beam and the normal, which is an imaginary line located at a 90° angle from the reflective surface, and the angle of reflection is between the reflected beam and the normal.)

Based on the data gathered, have students draw a conclusion that represents the *second law of reflection.* (The angle of incidence is equal to the angle of reflection.) Have students identify examples of the use of reflection in daily life. (cosmetology, rearview mirrors in cars, security mirrors, reflectors on jackets or bicycles, single-lens reflex cameras)

Suggestions for Assessment

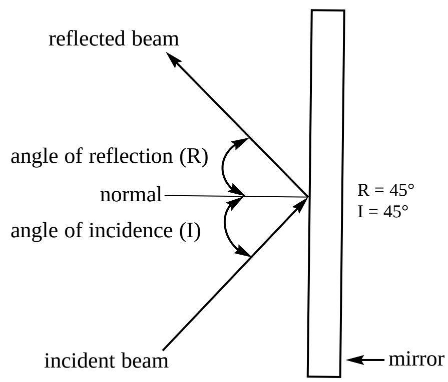


When assessing the Laws of Reflection experiment, refer to "Conducting a Fair Test: Observation Checklist" (BLM 8-Q).

Teacher Notes

For instructions on constructing a light box, refer to Grade 4, Cluster 2: Light. Use of a commercial light box is recommended to ensure that clear light beams are obtained for this learning activity and others.

Background Information - Laws of Reflection



Suggested Learning Resources

Nelson Science & Technology 8 (Sections 5.3-5.4)

Sciencepower 8 (Section 7.2)

Addison Wesley Science & Technology 8: *Optics* (Sections 2.0-2.2)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-2-10 Conduct experiments to compare the refraction of light through substances of different densities.

GLO: C1, C2, D4

8-0-1a ➲ Formulate specific questions that lead to investigations. Include: rephrase questions to a testable form; focus research questions. GLO: A1, C2 (ELA Grade 8, 3.1.2; Math: SP-I.1.8)

8-0-1b ➲ Select and justify a method to be used in finding the answer to a specific question. GLO: C2 (ELA Grade 8, 3.2.3; Math: SP-II.1.8)

8-0-3a ➲ Formulate a prediction/hypothesis that identifies a cause and effect relationship between the dependent and independent variables. GLO: A2, C2 (Math: SP-I.1.8)

8-0-3b Identify the independent and dependent variables in an experiment. GLO: A2, C2

8-0-3c ➲ Create a written plan to answer a specific question. Include: apparatus, materials, safety considerations, steps to follow, and variables to control. GLO: C2 (ELA Grade 8, 3.1.4)

8-0-4a ➲ Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability. GLO: C2

8-0-4c ➲ Work cooperatively with team members to carry out a plan, and troubleshoot problems as they arise. GLO: C7 (ELA Grade 8, 5.2.2)

8-0-5a ➲ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5c Select and use tools to observe, measure, and construct. Include: microscope, concave and convex mirrors and lenses, chemical indicators. GLO: C2, C3, C5

8-0-5e ➲ Estimate and measure accurately using SI and other standard units. Include: determining volume by displacement of water. GLO: C2, C5 (Math: SS-IV.1.6, SS-III.1.5, Math: SS-III.1.6, SS-I.1.5)

8-0-5f ➲ Record, compile, and display observations and data, using an appropriate format. GLO: C2, C6 (ELA Grade 8, 3.3.1; Math: SP-III.2.8)

8-0-6f ➲ Identify how the original plan evolved and justify the changes. GLO: C2, C3 (ELA Grade 8, 3.3.4)

8-0-7a ➲ Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 8, 3.3.4)

8-0-7c ➲ Identify a new prediction/hypothesis based on investigation results. GLO: A1, C2 (ELA Grade 8, 3.3.4)

SUGGESTIONS FOR INSTRUCTION

➢ Comparing Refraction through Substances of Different Densities

Have students plan and carry out an experiment to compare the *refraction of light* through substances of different densities (e.g., water, vegetable oil, shampoo, transparent acrylic), then identify the relative densities of the substances for students or have students identify them. For this experiment, students use their knowledge of angle of incidence and angle of refraction to develop a testable question, an hypothesis (that predicts a relationship between the dependent and independent variable), and record of procedures. They also make observations and draw conclusions.

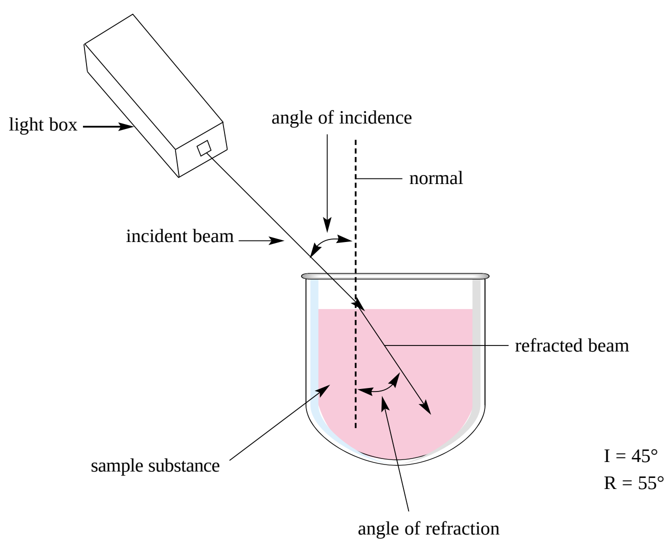
Note: this learning experience links to Grade 8, Cluster 3: Fluids, learning outcome 8-3-06.

Example:

- *Testable question:* What is the effect of the density (independent variable) of a substance on the size of the angle of refraction (dependent variable)?
- *Hypothesis/prediction:* The higher the density of a substance, the greater the size of the angle of refraction.

Have students draw labelled refraction beam diagrams for each substance tested, including the angle measurements.

Example:



Suggestions for Assessment

When assessing the Comparing Refraction through Substances of Different Densities, refer to "Experiment Report: Assessment" (BLM 8-S).

Refraction

Provide students with the following:

Refraction

You are cleaning out a large fish tank and you need to remove the fish inside the tank before emptying the water. When you place your net into the water, the fish are not where they appear to be. Why not? Include a labelled diagram with your explanation.

Scoring Rubric

Score	Criteria
4	The response is correct, complete, and detailed. It indicates that the light reflected off the fish has to travel through mediums of different densities, thus causing the light rays to refract (bend) and giving the appearance that the fish is in a different place than it actually is. The response contains example and/or elaboration to support the answer and includes an accurately drawn and labelled diagram. It includes evidence of higher-order thinking.
3	The response is correct and complete. It indicates that the light reflected off the fish has to travel through mediums of different densities, thus causing the light rays to refract (bend) and giving the appearance that the fish is in a different place than it actually is. The response contains examples and/or elaboration to support the answer and includes an accurately drawn and labelled diagram.
2	The response is generally correct and complete. It may contain minor errors. It contains examples and/or elaboration to support the answer and includes a labelled diagram which may contain a minor error or omission.
1	The response is partially correct but is incomplete and/or contains major errors. It contains no examples or elaboration to support the answer. The diagram is missing or contains major errors or omissions.

Suggested Learning Resources

Nelson Science & Technology 8 (Section 5.10)

Sciencepower 8 (Section 7.3)

Addison Wesley Science & Technology 8: *Optics* (Section 2.3)

PRESCRIBED LEARNING OUTCOMES

Students will...

8-2-11 Explain how reflection and refraction produce natural phenomena.

Examples: sun dogs, rainbows, blue sky...

GLO: D4, D5

8-0-2a ➲ Access information, using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 8, 3.2.2)

8-0-5a ➲ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-7g ➲ Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 8, 4.4.1)

SUGGESTIONS FOR INSTRUCTION

➢ Creating a Phenomenon

Have students work in small groups to create the effect of a sunset, following these steps:

1. Add a teaspoon of powdered milk to a glass of water. Do not stir; let the powder settle on its own.
2. Shine a flashlight straight down into the glass and record the colour you detect. (bluish)
3. Stir the mixture. When the water calms, shine the light through the glass from the side onto a light-coloured wall or a piece of white paper. Record the colour detected. (reddish-orange)

Have students answer the following questions in their science notebooks:

1. What source of light was the flashlight intended to represent? (the Sun)
2. In what position in the sky would the Sun be when the sky is the colour you first detected in the glass? (overhead)
3. In what position in the sky would the Sun be during the second colour? (lower, sunset level)
4. What does the milk solution represent? (dust and sediment particles in the sky)

➢ Word Wall and Poster

Have students use the Think-Pair-Share strategy (McTighe and Lyman, 1992) to generate examples of natural phenomena produced by light. Ask students to create a Word Wall (Cunningham, 1991) with the examples (e.g., sun dogs, rainbows, blue sky, mirage, northern lights, sunsets, harvest moon). (For a discussion of the Word Wall strategy, see *5-8 ELA*, Strategies, pp. 199-201.)

After conducting research, have each student develop a small poster that presents information, both in text and visual form, about how his or her chosen phenomenon is created, including the terms *reflection, refraction,* or *dispersion* where appropriate. To assist students in answering the following questions, have the class participate in a Gallery Walk (Brownlie and Close, 1992) of the various phenomena posters:

1. Which phenomena were created by the refraction of light and what medium caused the refraction?
2. Which phenomena were created by the reflection of light and off what material was light being reflected?
3. Were any phenomena created through any combination of reflection, dispersion, and/or refraction? If so, which?

SUGGESTIONS FOR ASSESSMENT

Natural Phenomena Poster

When assessing students' natural phenomena posters, look for indications of the following:

Rating Scale					
Criteria	**Poor**		**Good**		**Excellent**
The poster					
• describes how a phenomenon is created	1	2	3	4	5
• illustrates the phenomenon with a labelled diagram	1	2	3	4	5
• identifies and explains how the phenomenon is an example of reflection, refraction, or dispersion	1	2	3	4	5
• is aesthetically pleasing	1	2	3	4	5

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 8 (Section 5.14)

Sciencepower 8 (Sections 7.3, 9.1)

Addison Wesley Science & Technology 8: *Optics* (Section 5.1)

The Electromagnetic Spectrum (Video)

Prescribed Learning Outcomes

Students will...

8-2-12 Investigate to determine how light interacts with concave and convex mirrors and lenses, and provide examples of their use in various optical instruments and systems.

GLO: B1, C2, D3, D4

8-0-5a ➲ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-7a ➲ Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 8, 3.3.4)

8-0-7f ➲ Reflect on prior knowledge and experiences to construct new understanding and apply this new knowledge in other contexts. GLO: A2, C4 (ELA Grade 8, 1.2.1)

Suggestions for Instruction

➢ **Lens Investigation**

Provide students with a light box that divides light into several beams (rays). (Divided light beams can be created with materials such as a piece of thick paper with slits, a comb, and so on.) Have pairs or small groups of students use this light box to investigate the effect of different types of lenses on the direction of light beams, following these steps:

- Place a *double concave lens* and then a *double convex lens* in front of the light beams and observe what happens with each lens.
- Record observations on a Three-Point Approach sheet.
  (For a BLM of the Three-Point Approach for Words and Concepts, see *SYSTH*, Attachment 10.2, or *Success*, p. 6.101.)
- Create a definition of each lens, indicating whether light beams converge (come together) or diverge (spread apart).
- Draw a diagram of each lens and show the direction of the light beams after they leave the lens.
- Identify some examples of the use of each lens in optical instruments and systems.

➢ **Investigating Mirrors**

Have students look at themselves using convex and concave mirrors, record their observations, and explain why the images appeared as they did.

Teacher Notes

Background Information

A *convex mirror* produces a small image standing right side up. It reflects back a larger area than a concave mirror does. Convex mirrors are used for security purposes in stores.

A *concave mirror* can reflect in two different ways:

- If the object is close, the mirror will make it appear larger and right side up.
- If the object is farther away, the mirror will make it appear smaller and upside down. Concave mirrors are used for shaving.

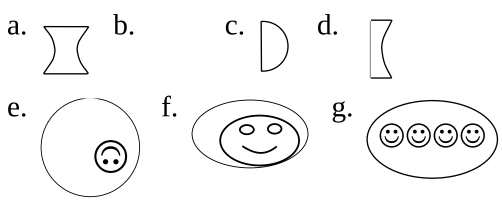
Suggestions for Assessment

Restricted Response

Provide students with the following:

Lenses, Mirrors, and Light Beams

Match the following pictures of lenses and mirrors with the applicable phrases below. Each picture may be used more than once.



1. concave mirror ______________________________
2. double convex lens ___________________________
3. convex mirror ______________________________
4. double concave lens __________________________
5. lenses that cause light beams to diverge __________
6. lenses that cause light beams to converge ________
7. planoconvex lens ____________________________
8. planoconcave lens ___________________________

Look for:

1. e, f   2. b   3. g   4. a   5. a, d   6. b, c   7. c   8. d

Teacher Notes

Background Information

A *convex lens* is thicker in the middle than at its edges and causes light beams to converge (come together)

Examples:

- double convex lens
- planoconvex lens

Convex lenses are used in overhead projectors, cameras, movie projectors, and magnifying glasses.

A *concave lens* is thicker at its edges than in the middle and causes light beams to diverge (spread apart).

Examples:

- double concave lens
- planoconcave lens

Concave lenses are often used in combination with convex lenses.

Suggested Learning Resources

Nelson Science & Technology 8 (Sections 5.8-5.9)

Sciencepower 8 (Sections 8.1, 8.3)

Addison Wesley Science & Technology 8: *Optics* (Sections 2.2, 4.1-4.2)

Prescribed Learning Outcomes

Students will...

8-2-13 Demonstrate the formation of images using a double convex lens, and predict the effects of changes in lens position on the size and location of the image.

Examples: magnify or reduce an image by altering the placement of one or more lenses...

GLO: C2, C5, D4

8-0-5a ⊃ Make observations that are relevant to a specific question. GLO: A1, A2, C2

8-0-5c Select and use tools to observe, measure, and construct. Include: microscope, concave and convex mirrors and lenses, chemical indicators. GLO: C2, C3, C5

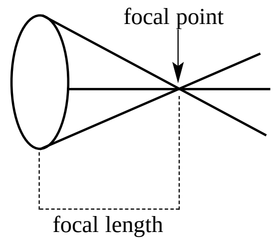
8-0-5e ⊃ Estimate and measure accurately using SI and other standard units. Include: determining volume by displacement of water. GLO: C2, C5 (Math: SS-IV.1.6, SS-III.1.5, Math: SS-III.1.6, SS-I.1.5)

8-0-7a ⊃ Draw a conclusion that explains investigation results. Include: explaining the cause and effect relationship between the dependent and independent variables; identifying alternative explanations for observations; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 8, 3.3.4)

Suggestions for Instruction

➢ **Investigating Focal Points**

Provide students with the following information: The *focal point* is the point where light beams meet. It is the point where an image would appear in focus. The distance from the mid-region of the lens to the focal point is called the *focal length*.



Have students compare the focal length of a planoconvex (flat on one side) lens to that of a double convex lens by light from a light box. Have students record their observations. (The planoconvex lens should have a longer focal length.)

Teacher Notes

A planoconvex lens is used here to provide a comparison in focal lengths and to provide background for the instructional strategies suggested for learning outcome 8-2-14, where students describe how the eye can focus an image.

➢ **Investigating Lenses**

Have students investigate the effects of

- changes in the position of a double convex lens on the size and location of an image
- changes in the number of lenses on the size and location of an image

For this investigation, students need to use a light box and a screen (a large piece of paper) and carefully measure and record the distances involved and the resulting size and location of the focused image.

After students have completed the investigation, have them answer the following questions in their science notebooks:

1. Did the image appear larger or smaller as the distance between the light source and the lens increased? (smaller)
2. Did the image appear larger or smaller as the distance between lenses increased? (larger)
3. If you were attempting to view something very far away, what combination of lenses would you use and how would you set them up? (You would use two double convex lenses placed far apart in order to obtain maximum magnification.)
4. What is an example of an optical device that uses two lenses to view distant objects? (a telescope)

Suggestions for Assessment

Extended Response

Provide students with the following:

Refracting Telescopes

Why are extremely large refracting telescopes used to study distant stars? Include in your explanation the science concepts used to develop this technology.

Scoring Rubric

Score	Criteria
4	The response is correct and complete and thoroughly explains the concept, including references to • the distance of stars and the subsequent small image seen with the unaided eye • the consequent need for the use of two double convex lenses situated a great distance apart • the resultant large size of the telescope The response contains examples and/or elaboration with reference to results of the investigations with lenses and the production of a focused and enlarged image. It includes evidence of higher-order thinking.
3	The response is correct and complete and thoroughly explains the concept, including references to • the distance of stars and the subsequent small image seen with the unaided eye • the consequent need for the use of two double convex lenses situated a great distance apart • the resultant large size of the telescope The response contains examples and/or elaboration with reference to results of the investigations with lenses and the production of a focused and enlarged image.
2	The response is generally correct and complete. It may contain minor errors. It contains examples and/or elaboration to support the answer.
1	The response is partially correct but is incomplete and/or contains major errors. It contains no examples or elaboration to support the answer.

Suggested Learning Resources

Nelson Science & Technology 8 (Sections 5.11-5.12)

Sciencepower 8 (Section 8.2)

Addison Wesley Science & Technology 8: *Optics* (Section 3.2)

Prescribed Learning Outcomes

Students will...

8-2-14 Compare the functional operation of the human eye to that of a camera in focusing an image.

GLO: A5, C4, D1, D4

8-0-2a ➲ Access information, using a variety of sources. *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet…* GLO: C6 (ELA Grade 8, 3.2.2)

8-0-2b Develop and use criteria for evaluating information sources. Include: distinguish between fact and opinion. GLO: C6, C8 (ELA Grade 8, 3.2.2, 3.2.3; TFS 2.2.2)

8-0-2c Make notes in point form, summarizing major ideas and supporting details and referencing sources. GLO: C6 (ELA Grade 8, 3.3.2)

Suggestions for Instruction

➢ Comparing the Eye and the Camera

Have students use various print, multimedia, and Internet resources to

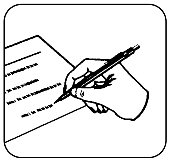
- identify the corresponding parts and functions of the eye and the camera and record these on a chart
- create a labelled diagram of the eye and the camera, colour coordinating similar-functioning components of the eye and the camera

➢ Focusing an Image

Have students, working in pairs, view distant and near objects with a single-lens reflex 35 mm camera (which allows the user to focus manually by pulling out or pushing in the lens) and answer the following questions in their science notebooks:

1. Predict whether the focal length (placement of lens in relationship to the film) would be short or long in order to bring a small distant object into focus. (long)
2. Test your prediction by looking through a single-lens reflex 35 mm camera and trying to focus on your partner. Have your partner note the length of the casing that holds the camera lens. Then look at a small distant object with your camera and record your observations about the length of the lens casing.
3. Was your prediction correct? Why or why not?
4. What does a camera do to produce a focused image of objects at varying distances? (It changes the focal length—the distance between the lens and the focused image on the film.)
5. Unlike the camera, the eye is not able to change focal length. How does the eye focus objects at varying distances? Research to find the answer, if necessary. (The eye can change the shape of its lens by the pull of certain muscles, making it thicker and thinner, allowing it to focus a variety of images.)

SUGGESTIONS FOR ASSESSMENT



Extended Response

Have students use a Compare and Contrast Frame (Matchullis and Mueller, 1994) to compare the major parts and functions of the human eye and the camera. (For a BLM of a Compare and Contrast Frame, see *SYSTH*, Attachment 10.4, or *Success*, p. 6.103.)

Look for:

- the points stated in the example provided for the Comparing the Eye and the Camera learning activity

Teacher Notes

Background Information

The Eye and the Camera

The following chart sumarizes the function of corresponding parts of the eye and the camera.

Function	Eye	Camera
Allows in light	pupil	aperture
Controls the amount of light allowed to enter	iris	iris diaphragm and shutter
Magnifies image	lens	lens
Serves as the focal point where image is received	retina	film
Provides the protective covering of lens	cornea	lens cap

SUGGESTED LEARNING RESOURCES

Nelson Science & Technology 8 (Section 5.13)

Sciencepower 8 (Section 8.2)

Addison Wesley Science & Technology 8: *Optics* (Section 4.1)

Notes