Science at Work

Optician Tuan Trieu travelled to the Philippines in 2008 with the Third World Eye Care Society. It was not his first trip to the Philippines. Tuan landed in the Philippines as a refugee in 1976 after fleeing Vietnam and before coming to Canada.

Canadians in Science

The Third World Eye Care Society (TWECS) is a group of Canadian optometrists, opticians, and other volunteers. TWECS collects used eyeglasses from Canadians and provides free eye exams and eyeglasses to people in developing countries. As a volunteer with TWECS, Tuan Trieu has helped restore the vision of hundreds of people. Tuan has travelled with TWECS to the Philippines and to his birthplace, Vietnam.

When he is not volunteering with TWECS, Tuan is an optician in Edmonton. Opticians measure and fit people with prescription eyeglasses and contact lenses.

In Tuan Trieu's Words

A student interested in becoming an optician should have a good understanding of optics and should like working with people. I enjoy working as an optician because it is challenging. It is rewarding to be able to help people see more clearly.

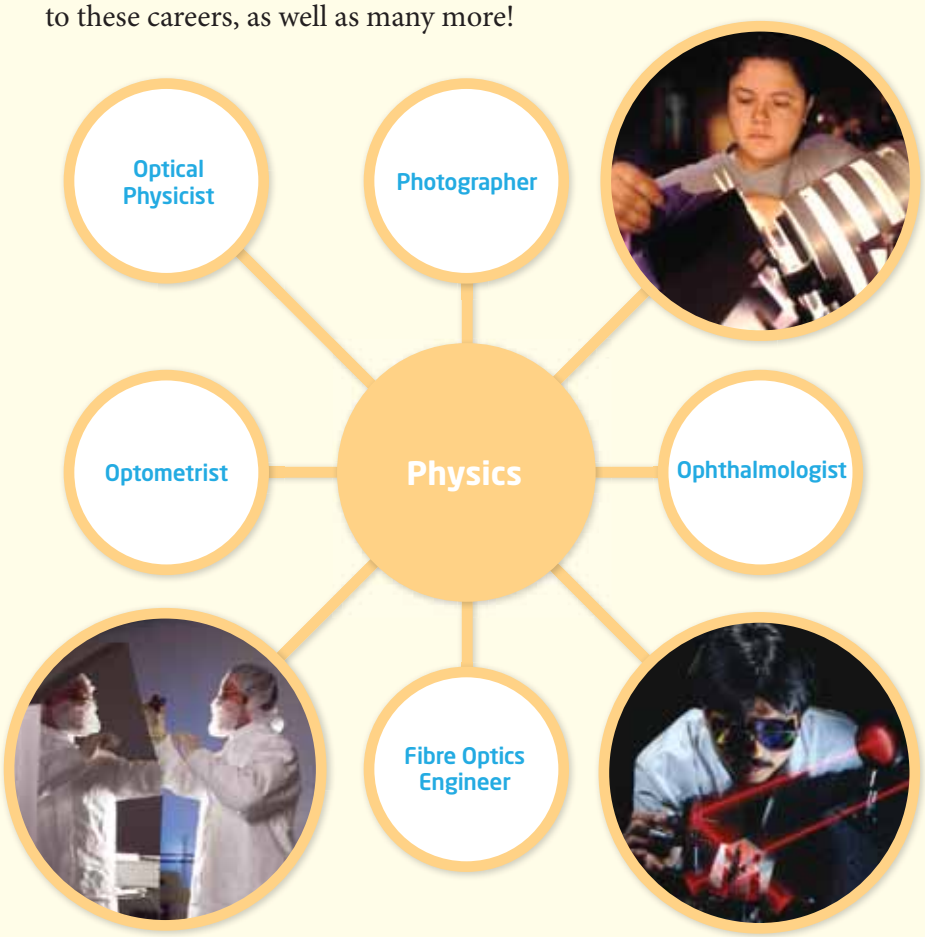
The most challenging part of a TWECS mission is finding the right prescriptions for the patients. We know the used eyeglasses we give the patients are not as perfect as they would be if optometrists prescribed them. However, we have no choice but to find as close a prescription as possible among the used glasses we have for patients.

The most satisfying moments of our missions come when we can improve a person's vision from complete blurriness to 20/20 vision and then see the smile that results.

TWECS has sent volunteer teams to Tanzania, Peru, Cambodia, Mexico, India, Malawi, Bolivia, and other countries. This organization has helped restore the vision of more than 30 000 people.

Optics at Work

The study of light and geometric optics contributes to these careers, as well as many more!



Lighting Technician

Lighting technicians set up and operate lighting for television, film, and stage productions. They use light fixtures, mirrors, filters, and electronics to create different lighting effects.

Photonics Engineering Technologist

Photonics is the generation, transmission, manipulation, and detection of light. Photonics engineering technologists work in a variety of industries, producing technologies such as light sensors, laser technologies, CDs and DVDs, barcode scanners, and digital cameras.

Optics Technician

Optics technicians make lenses for cameras, eyeglasses, microscopes, binoculars, and telescopes. They also create prisms for the aerospace industry. In order to design and manufacture the lenses and prisms needed, optics technicians must have a good knowledge of mathematics and computers.

Go to **scienceontario** to find out more

Over to You

1. Why might TWECS not be able to provide an exact prescription to someone they help in a developing country?
2. If you wear eyeglasses, find out where you can donate your old eyeglasses. Or plan a campaign to get students at your school involved in donating used eyeglasses to a service organization such as TWECS.
3. Photonics is a growing field with many different applications. Choose one application of photonics and conduct research to find out more about the science behind the application.
4. Research a career involving light and geometric optics that interests you. If you wish, you may choose a career from the list above. **What essential skills would you need for this career?**

Work
Learning
Life

Unit 4 Projects

Inquiry Project

Design a Light Tunnel

Bringing natural light into a windowless room can be challenging. One way to do this is to construct a light tunnel that redirects light using the properties of lenses and mirrors. For this project, you will take the role of a lighting designer. You have been hired by clients to design a light tunnel that will bring natural light from the roof of their home into a windowless room.

Inquiry Question

How can mirrors, lenses, and other materials be used to direct natural light through a light tunnel into a windowless room?

Initiate and Plan

1. Make a table to summarize information about light that you will need to consider for this task, such as reflection, refraction, mirrors, and lenses.
2. Design a light tunnel that will
   - allow sunlight through a flat roof, direct the light from the roof through an attic, and disperse the light into the windowless room at the end of the tunnel
   - function morning, afternoon, and evening (sunlight will strike the tunnel at different angles at different times of the day)
   - bend at least three times, with one bend greater than 45°
   - maximize light dispersion into the windowless room
3. Gather materials you can use to create a model of your light tunnel. For example, you may want to use
   - a laser pointer to simulate sunlight
   - acetate, plastic wrap, or a small pane of glass to simulate a window on top of the roof
   - cardboard, paper-towel tubes, shoe boxes, or 2 L soft-drink bottles to make the tunnel
   - empty potato chip bags or another material to simulate a reflective surface on the inside of the tunnel
   - tape
   - mirrors and lenses in various shapes and sizes
4. Make sketches to plan your model, before you begin to assemble it.

Perform and Record

5. Construct your model to meet the design criteria given in step 2.
6. Draw two well-labelled ray diagrams, showing at least three light rays, to simulate morning and afternoon conditions as the Sun changes position in the sky.

Analyze and Interpret

1. Identify the challenges you had when designing your light tunnel.
2. Which optics components did you find most useful when designing your light tunnel?

Communicate Your Findings

3. Assemble your design brief for your clients. Include your ray diagrams, as well as an explanation of how light will be directed through each section of your light tunnel.

Assessment Criteria

Once you complete your project, ask yourself these questions. Did you...

- K/U summarize information about reflection, refraction, mirrors, and lenses, as related to this task?
- T/I select appropriate materials to create a model of your light tunnel?
- T/I use the materials in a safe and effective way?
- T/I design your model to meet the criteria provided?
- A identify the challenges you faced when designing your light tunnel?
- A identify the optics components that were most useful in the design of your light tunnel?
- C use appropriate scientific conventions in the ray diagrams for your design brief?
- C use appropriate scientific terminology, for both your audience and your purpose, in the explanation for your design brief?

An Issue to Analyze

LEDs Brighten Up the Darkness

In Canada and many other developed countries, an electrical grid that supplies electricity is taken for granted. In countries with rugged terrain or insufficient development, however, electrical energy is unavailable or very expensive. Consequently, artificial light is produced by burning expensive and difficult-to-obtain fossil fuels in generators, or by burning candles. Fortunately, new light-producing technologies, such as light-emitting diodes (LEDs) require much less electricity to generate light. This feature of LEDs makes them particularly suitable for use in remote or developing communities within the world. Research and analyze the costs and benefits of using LED technology in a remote or developing community.

Issue

How can LED technology be used to benefit a remote or developing community?

Initiate and Plan

1. Prepare to analyze LED technology from economic, scientific, and social perspectives.

Perform and Record

2. Using human, print, and electronic resources, research responses to the following questions about LED technology:
   - How does LED technology differ from conventional technology?
   - What are the economic costs of using LED lighting technology, compared with the economic costs of using conventional incandescent technology?
   - What scientific challenges prevent the widespread use of LED lighting technology?
   - What are the social implications of LED lighting technology for a remote or developing community?
3. Based on your research, identify the costs and benefits of using LED technology. Organize your research using an appropriate format.

Analyze and Interpret

3. Based on your research, prepare a recommendation that you could present to the town council of a remote or developing community to promote the use of LED technology. Consider responses to the following questions as part of your recommendation:
   - Why is LED technology being used now? Why was it not used in the past?
   - Why are some communities unable to use LEDs for artificial light?
   - What could you (or your school community) do to make it possible for remote or developing communities to use LEDs for artificial lighting?

Communicate Your Findings

2. Select an appropriate format, such as a podcast, poster, or oral presentation, to present your recommendation. Consider both your purpose and your audience.

Assessment Criteria

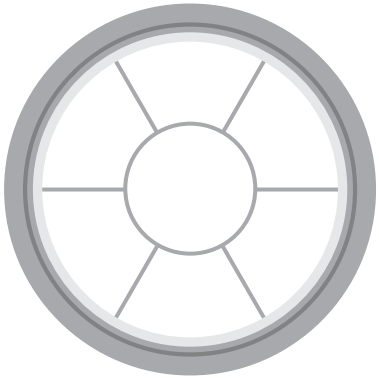
Once you complete your project, ask yourself these questions. Did you...

- K/U compare light generated by conventional technology with light generated by LED technology?
- A research the costs and benefits of LED technology from multiple perspectives?
- C organize your research in an appropriate format, using proper academic documentation?
- C select an appropriate format to present your recommendation?

Unit 4 Review

Connect to the BIG IDEAS

Use this bicycle wheel graphic organizer to connect what you have learned in this unit to the Big Ideas, found on page 397. Draw one bicycle wheel for each Big Idea and write the Big Idea in the centre. Between the spokes of the wheel, briefly describe six examples of that Big Idea.



Knowledge and Understanding K/U

1. Which source produces light as a result of the heating of atoms?

a. fluorescence

b. incandescence

c. bioluminescence

d. chemiluminescence

2. In which of the following mirrors can you always expect an image that is virtual and the same size as the object?

a. spherical

b. convex

c. concave

d. plane

3. Which of the following optical effects is *not* an effect of refraction?

a. fluorescence

b. sun dogs

c. mirage

d. shimmering

4. The major difference between Newton's design for telescopes and the designs of his predecessors was the presence of a(n)

a. objective lens

b. eyepiece lens

c. plane mirror

d. concave mirror

5. Which of the following diseases associated with vision is not the direct result of a change in the shape of the eye lens?

a. cataracts

b. near-sightedness

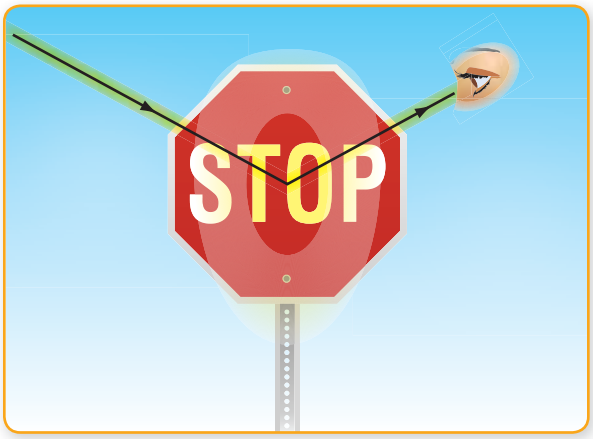
c. far-sightedness

d. presbyopia

6. Explain how the production of light is categorized with reference to the type of energy and atoms involved.

7. How is light produced by an incandescent source? Use a diagram in your explanation.

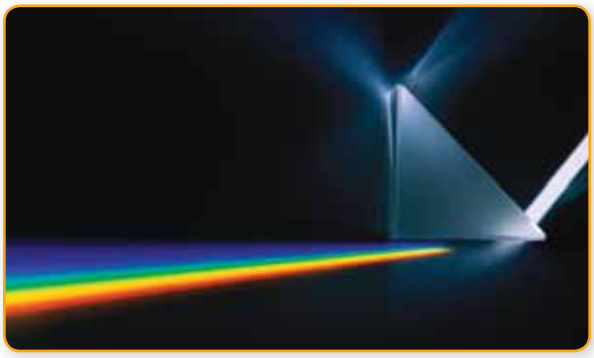
8. Use the diagram below to explain why the image that strikes the retina of an observer's eye is laterally inverted.



The image that strikes the retina is laterally inverted.

9. Explain the cause(s) of spherical aberration in mirrors. Use a diagram in your explanation.

10. Explain the difference(s) between partial reflection and refraction of white light that encounters a prism, as shown in the photograph below.

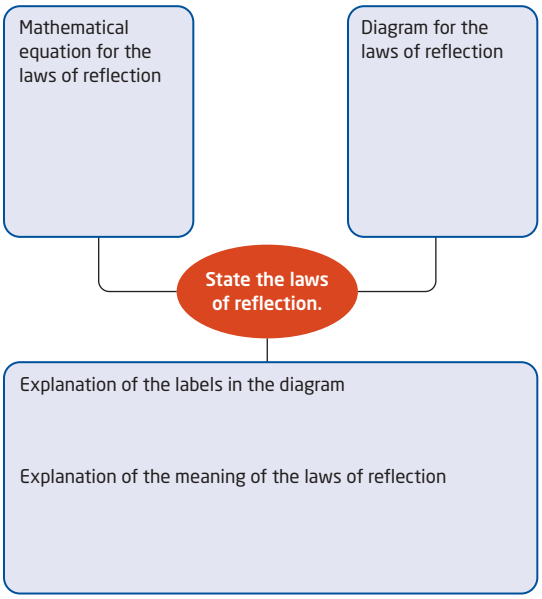


White light entering a prism is partially reflected and refracted.

11. Explain the difference between myopia and hyperopia.

12. In a Venn diagram, illustrate the differences and similarities between a real image and a virtual image.

13. Copy the outline of the concept map shown here in your notebook, and fill in the boxes.

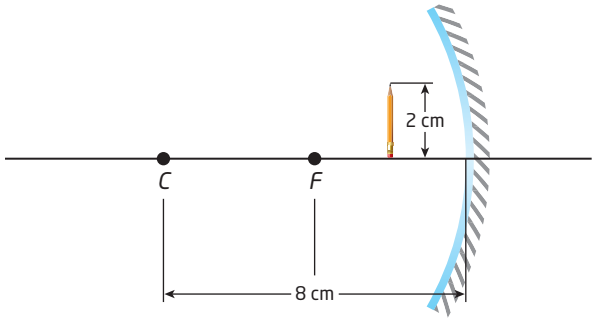


Thinking and Investigation T/I

14. The image of an object in a mirror is farther from the mirror than the object, larger than the object, real, and inverted. Draw a ray diagram that fits these criteria.

15. How would you determine the difference between the focal lengths of a shiny metal soupspoon and a shiny metal teaspoon? Explain your answer.

16. Copy the diagram below into your notebook. Draw a ray diagram, and calculate the focal length of the concave mirror.



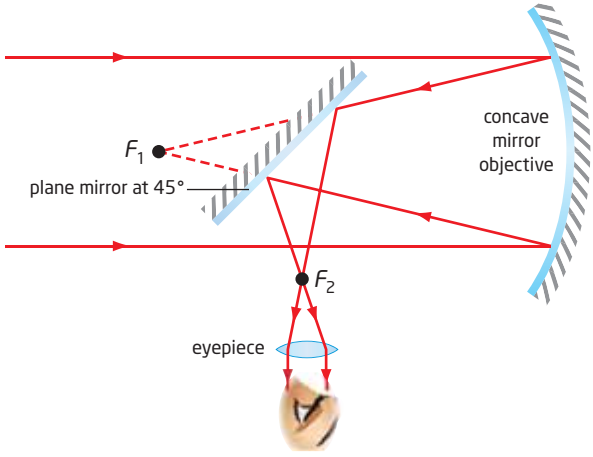
17. Use ray diagrams to explain the difference between real and virtual images in concave spherical mirrors.

18. Use the data in the table below to explain why the speed of light in pure hydrogen is greater than the speed of light in glass.

Indices of Refraction

Substance	Index of Refraction
Hydrogen	1.000 14
Glass (crown)	1.52

19. The objective mirror in the Newtonian telescope in the diagram below has a diameter of 15 cm. Calculate F_1 and F_2.



A Newtonian telescope uses a lens and a concave mirror.

20. Explain why the image formed in a camera is inverted and smaller than the object being photographed. Include a ray diagram.

21. While walking on a beach, you find a clear, colourless rock that may be quartz ($n = 1.46$) or a piece of glass ($n = 1.52$). Explain how you could use variations in the angles of refracted light and the index of refraction to determine whether the rock is glass or quartz.

Communication C

22. BIG IDEAS Light has characteristics and properties that can be manipulated with mirrors and lenses for a range of uses. Using colour ray diagrams, show how the combination of one or more lenses can decrease chromatic aberration in a camera.

23. BIG IDEAS Society has benefited from the development of a range of optical devices and technologies. Use a graphic organizer to compare the causes and treatments of myopia, hyperopia, presbyopia, and astigmatism.

24. Write a public service announcement for a local radio station that might persuade your peers to donate their used eyeglasses to a non-governmental agency that provides used eyeglasses for children in developing countries. Your announcement should be no more than 150 words.

25. Write a paragraph that explains the importance of using fibre optics in medicine.

26. Use a colour ray diagram that shows how each of the different colours of the electromagnetic spectrum is refracted to explain why the sky appears to be red at sunset.

Application A

27. Explain why using compact fluorescent bulbs may be better for the environment than using incandescent bulbs to provide light in your home.

28. Describe how different types of mirrors can be used in the following circumstances.

a. dental office

b. variety store

c. winding roads through a mountainous region

29. In the photograph below, the word AMBULANCE is written backwards. Explain why you think the word is purposely written backwards.

The word AMBULANCE is purposely written backwards.

30. Photovoltaic cells convert solar energy into electrical energy. Explain how the efficiency of photovoltaic cells can be greatly increased by using lenses that focus the Sun's rays on the photovoltaic cells.

31. Identify three sports in which the laws of reflection can be applied. For each sport, describe how these laws are applied.

32. Explain why the diameter of the aperture is important when designing optical instruments. Consider telescopes and cameras. Include references to optical properties, such as aberration and the amount of light transmitted or reflected.

Literacy Test Prep

Read the selection below and answer the questions that follow it.

Liquid Mirror Telescope

A team of researchers at the University of British Columbia, working with teams from Laval University, State University of New York at Stony Brook, and Columbia University, developed and built a reflecting telescope with a liquid mirror. When any liquid is rotated, the surface takes the shape of a perfect parabola. The paraboloid shape focusses all parallel rays to one focal point. A spherical shape can produce spherical aberration.

You might wonder how a mirror precise enough to be used as a telescope can be formed by a liquid. The mirror must be reflective. The researchers use mercury because it is the only metal that is a liquid at room temperature.

The diameter of the liquid mirror for this reflecting telescope is 6 m. Mercury can be very toxic. People who have to handle the mercury must wear protective clothing, gloves, masks, and goggles.

Advantages and Disadvantages of a Liquid Mirror Telescope Compared with a Solid Mirror Telescope

	Advantages	Disadvantages
Liquid mirror telescope	When a liquid rotates, it forms a paraboloid shape, which is desirable for objective mirrors.	Because it is a liquid, it must be parallel to the ground.
Solid mirror telescope	Does not have to be rotating.	Large mirrors can expand and contract in temperature extremes, which affects their reflecting properties.

Multiple Choice

In your notebook, record the best or most correct answer.

33. In which state of matter is mercury found at room temperature?

a. solid
b. liquid
c. gas
d. vapour

34. What causes the mercury in the mirror to take a paraboloid shape?

a. rotation of Earth
b. rotation of the Sun
c. rotation of the telescope
d. rotation of the Moon

35. In the caption of the photograph on the left, "diameter" refers to

a. the depth of the mercury
b. the size of the mechanical supports
c. the size of the opening in the roof
d. the size of the mirror

36. Which institution was not included in the research teams mentioned in the first paragraph?

a. State University of New York
b. University of British Columbia
c. McMaster University
d. Laval University

37. Which of the following is a disadvantage of using a liquid mirror?

a. It has a reflective surface.
b. It must be parallel to the ground.
c. Its reflecting properties are affected by high temperature.
d. Its reflecting properties are affected by low temperature.

Written Answer

38. In a paragraph, explain the advantages and disadvantages of a liquid mirror telescope compared with a telescope that has a solid mirror.