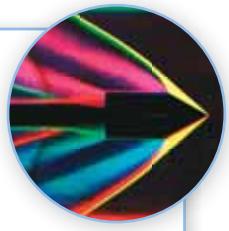
Chapter 11 Summary



11.1 Refraction of Light

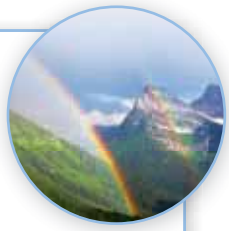
Key Concepts

- Light rays refract when they cross a boundary between media in which the speeds of light are different.
- If a light ray goes from a medium in which its speed is higher (such as air) into a medium in which its speed is lower (such as water), the refracted ray bends toward the normal.
- If a light ray goes from a medium in which its speed is lower (such as water) into a medium in which its speed is higher (such as air), the refracted ray bends away from the normal.
- The index of refraction of a medium is the ratio of the speed of light in a vacuum to the speed of light in the medium. A ratio greater than 1 results.
- Dispersion is the separation of the various colours of light when white light crosses the boundary between different media at an angle.
- The speed of each wavelength of light is different in any given medium. The speed of all wavelengths of light is 3.00×10^8 m/s in a vacuum.

11.2 Partial Refraction and Total Internal Reflection

Key Concepts

- When light strikes a boundary between two transparent media that have different indices of refraction, some light reflects off the boundary and some light refracts through the boundary. This phenomenon is called partial reflection and refraction.
- At a small angle of incidence, more light refracts than reflects. As the angle of incidence increases, more and more light reflects than refracts.
- When light travels from a medium with a higher index of refraction to a medium with a lower index of refraction, the angle of refraction is larger than the angle of incidence. Therefore, an angle of incidence that results in a 90° angle of refraction is eventually reached. This angle of incidence is called the critical angle.
- When the angle of incidence is larger than the critical angle, no refraction occurs. All the light is reflected from the boundary. This phenomenon is called total internal reflection.
- Total internal reflection has many practical applications, such as binoculars, retroreflectors, and optical fibres in telecommunications and in surgical instruments.



11.3 Optical Phenomena in Nature

Key Concepts

- A rainbow is formed by the refraction and total internal reflection of light and the resulting dispersion of the light by spherical water droplets in the sky.
- As a result of the refraction of light at the surface of water, objects under the water are not where they appear to be when you are looking at them from above the water. The level at which they appear to be is called their apparent depth.
- Shimmering is the apparent movement of objects seen through air that is unevenly heated and moving.
- A mirage is the appearance of water or another object that is not really there. A mirage is caused by light being continuously refracted by layers of air that are at extremely different temperatures.

Chapter 11 Review

Make Your Own Summary

Summarize the key concepts of this chapter using a graphic organizer. The Chapter Summary on the previous page will help you identify the key concepts. Refer to Study Toolkit 4 on pages 565–566 to help you decide which graphic organizer to use.

Reviewing Key Terms

1. The ratio of the speed of light in a vacuum to the speed of light in a medium is the _____ of the medium. (11.1)

2. _____ is the separation of white light into its colours. (11.1)

3. The angle of incidence for which the angle of refraction is 90° is called the _____. (11.2)

4. _____ is the apparent movement of objects seen through hot air over objects and surfaces. (11.3)

5. When you think that you are seeing an object but it is not really there, you are seeing a _____. (11.3)

Knowledge and Understanding K/U

6. Explain what happens to a light ray when it goes from air into water at an angle.

7. The speed of each colour (wavelength) of light is different in any given medium. How, then, can a specific index of refraction be reported for a certain substance, such as quartz?

8. Draw a simple diagram of a light ray travelling from one medium into another. Include the following labels: incident ray, normal, refracted ray, angle of incidence, angle of refraction.

9. How would you predict whether an angle of refraction is larger or smaller than the angle of incidence?

10. What information must be included in a table that lists indices of refraction? Why must this information be present?

11. When light crosses the boundary between two substances that have different indices of refraction, what determines the amount of refraction that will occur compared with the amount of reflection?

12. A light ray is travelling from a medium with a larger index of refraction to a medium with a smaller index of refraction. Describe what happens as the angle of incidence gets larger and larger. Include the concept of the critical angle in your discussion.

13. The colours of light can be separated with a prism. What property of light makes this possible?

14. Use a Venn diagram to show the similarities and differences between sundogs and rainbows.

15. Imagine that you are standing in the shallow end of a swimming pool. You look ahead, at the bottom of the pool, and see a coin. Describe the difference between where the coin appears to be and where it actually is.

Thinking and Investigation T/I

16. A clear plastic cube, with exactly the same index of refraction as water, is placed in a container of water. Would you be able to see the plastic cube in the water if you looked at it from an angle? Explain why or why not.

17. Complete the following calculations. Refer to **Table 11.1** on page 454 when necessary.

a. The speed of light in a solid is 1.96×10^8 m/s. Calculate the index of refraction for the solid.

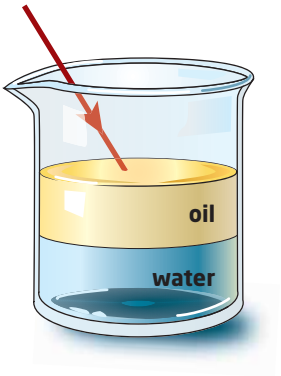
b. Calculate the speed of light in diamond.

c. Calculate the speed of light in ethyl alcohol.

d. The speed of light in a solid is 1.56×10^8 m/s. Calculate the index of refraction, and identify the solid.

18. Why is a small critical angle desirable for optical fibres? What problems could be caused if the critical angle were increased?

19. The following diagram shows a beaker that contains water and cooking oil. The oil has a higher index of refraction than the water. A light ray is about to enter the cooking oil. Copy the diagram, and show the refracted ray in the oil and then in the water. Ignore the reflected rays.



Use this diagram for question 19.

20. Some of the astronauts who landed on the Moon placed retroreflectors there like the one shown below. What properties of light would you have to know and use if you wanted to determine the exact distance between Earth and the Moon?

This retroreflector is on the Moon.

21. Review Investigation 11-D. The method you used to determine the critical angle of water only works for some liquids. Explain how you could determine the critical angle of a flat piece of glass.

Communication C

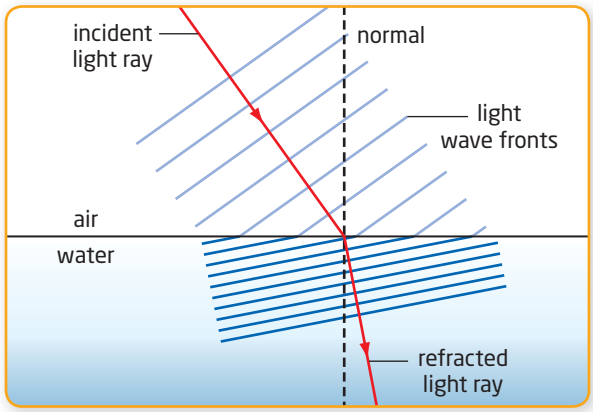
22. BIG IDEAS Society has benefited from the development of a range of optical devices and technologies. Give two examples.

23. Using a sketch, explain how a rearview mirror can be set for daytime driving and nighttime driving.

24. Using a sketch, explain how a retroreflector can reverse the direction of a light ray.

25. Imagine that you and a friend are hiking across a hot desert. Your friend believes that he sees a pool of water and starts to run toward the water. How could you convince your friend not to exert himself unnecessarily? In your explanation, include a description of the different indices of refraction of the layers of air of different temperatures.

26. In the following diagram, wave fronts are travelling across the boundary between air and water. Explain the significance of the change in the distance between the wave fronts where the light passes from air into water. Draw a similar diagram, but have the light approaching the boundary along a normal, so the angle of incidence is zero. Show and explain what happens when the wave fronts are parallel to the boundary as the light crosses the boundary.



27. Review your observations for Activity 11-1, The Re-appearing Coin, on page 447. Based on what you have learned in this chapter, explain your observations.

Application A

28. Identify two careers related to optics from this chapter.

29. Astronomers can learn a lot about stars by studying the wavelengths of light that are emitted by stars. Some of the early instruments that were used to analyze starlight contained prisms. Explain what you think the function of these prisms is.