

## Chapter 29 Reflection and Refraction

### Exercises

#### 29.1 Reflection (page 579)

1. What usually happens when a wave reaches a boundary between two media?

Some or all of the wave bounces back into the first medium.

2. The return of a wave back to its original medium is called reflection.

3. Explain what happens when a spring is attached to a wall and you send a pulse along the spring's length.

The wall is very rigid compared to the spring. So, all the wave energy is reflected back along the spring rather than transmitted into the wall.

4. Is the following sentence true or false? Shiny metals, such as aluminum and silver, reflect almost all the frequencies of visible light.

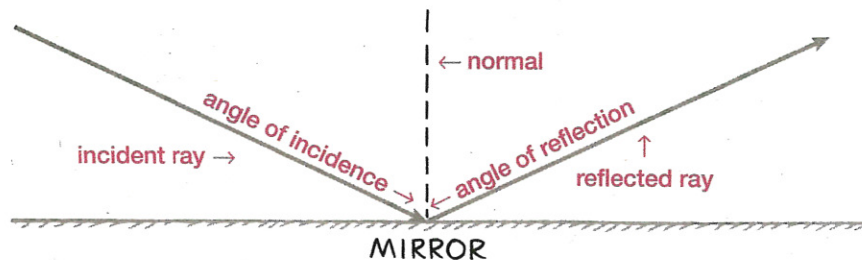
true

5. When light strikes glass perpendicularly, much of its energy is

transmitted

#### 29.2 The Law of Reflection (page 580)

6. On the diagram below, label the following: *normal*, *incident ray*, *angle of incidence*, *reflected ray*, and *angle of reflection*.



Match each phrase with the correct term or terms.

Phrase	Terms
<u>d</u> 7. a line perpendicular to a surface	a. angle of reflection
<u>b</u> 8. the angle between the incident ray and the normal	b. angle of incidence
<u>a</u> 9. the angle between the reflected ray and the normal	c. law of reflection
<u>c</u> 10. the relationship between the angle of incidence and angle of reflection	d. normal

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## 29.3 Mirrors (pages 580–581)

11. A virtual image is an image that appears to be in a location where light does not really reach.

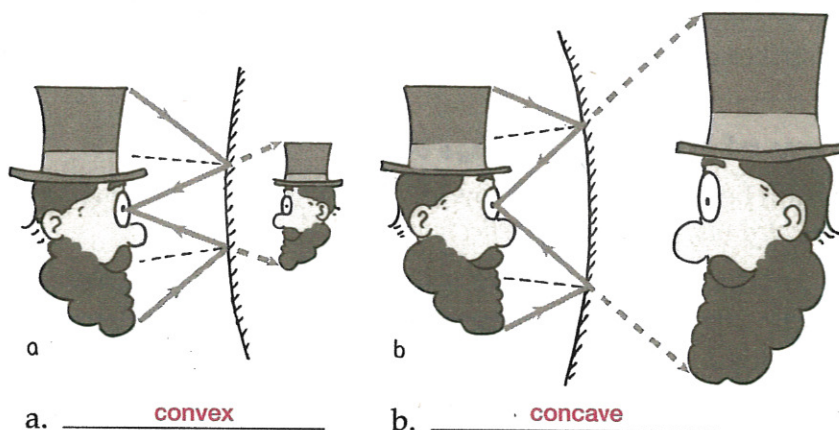
12. Can your eye tell the difference between an object and its virtual image? Explain.

No, your eye cannot tell the difference because light enters your eye in exactly the same manner as it would without the mirror as if there really were an object where you see the image.

13. The virtual image formed by a convex mirror (a mirror that curves outward) is smaller and closer to the mirror than the object is.

14. When an object is close to a concave mirror (a mirror that curves inward), the virtual image is larger and farther away than the object is.

15. Identify which mirror is concave and which mirror is convex.



## 29.4 Diffuse Reflection (pages 582–583)

16. What is diffuse reflection? the reflection of light from a rough surface

17. Explain why light is reflected in many directions when striking a rough surface.

Each ray obeys the law of reflection and the many different angles that incident light rays encounter at the rough surface cause reflection in many directions.

18. Is the following sentence true or false? If the differences in elevations in a surface are small (less than about one-eighth the wavelength of the light that falls on it), the surface is considered polished. true

19. An open-mesh parabolic dish acts like a diffuse reflector for visible light waves but like a polished reflector for long-wavelength radio waves.

20. What determines whether a surface is a diffuse reflector or a polished reflector?

the wavelength of the waves it reflects



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**29.5 Reflection of Sound (pages 583–584)**

21. Is the following sentence true or false? The fraction of sound energy reflected from a surface is less when the surface is rigid and smooth, and more when the surface is soft and irregular. false
22. Sound energy not reflected is absorbed or transmitted.
23. Acoustics is the study of reflective properties of surfaces and sound.
24. Define reverberations.  
Reverberations are multiple reflections of sound waves.
25. What properties of sound must be considered when designing an auditorium or concert hall?  
There must be a balance between wave reverberation and absorption.
26. Explain why being able to see a reflection of a musical instrument means, you will also be able to hear it.  
Because both sound and light obey the same law of reflection, sound from the instrument will follow the line of sight to the reflector and then to you.

**29.6 Refraction (pages 584–585)**

27. What is refraction?  
Refraction is the bending of a wave as it crosses the boundary between two media at an angle.
28. Circle the letter of each statement that is true about refraction.
- a. When a wave that is traveling at an angle changes its speed upon crossing a boundary between two media, it continues in a straight line.
  - ☒ b. Water waves bend, or refract, when one part of each wave is made to travel slower (or faster) than another part.
  - c. Refraction is the same as reflection.
  - ☒ d. Water waves are refracted as they move from deep water into shallow water.
29. On a wave diagram, it is convenient to draw lines, called wave fronts, which represent the positions of different crests.
30. Is the following sentence true or false? At each point along a wave front, the wave is moving parallel to the wave front. false

**29.7 Refraction of Sound (page 586)**

31. Sound waves are refracted when parts of a wave front travel at different speeds.



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32. How does a sound wave become refracted?

A sound wave is refracted when it travels in uneven winds or when it is traveling through air of uneven temperature.

33. How does a layer of warm air on top of a layer of colder air near the ground affect sound waves?

The higher speeds of the wave fronts in the warmer air cause a bending of the sound waves toward Earth. When this happens, sound can be heard over considerably longer distances.

### 29.8 Refraction of Light (pages 587–588)

34. Changes in the speed of light as it passes from one medium to another, or variations in the temperatures and densities of the same medium, cause \_\_\_\_\_ refraction \_\_\_\_\_.

35. Is the following sentence true or false? The wave fronts of light from the sun look like straight lines because the source of light is so far away.  
true

36. When light rays enter a medium in which their speed decreases, the rays bend toward the \_\_\_\_\_ normal \_\_\_\_\_.

37. Circle the letter of each statement that is true.

- ☒ a. If a laser beam enters a container of water at the left and exits at the right, the path would be the same as if the light entered from the right and exited at the left.
- ☐ b. Light paths are reversible for reflection but not refraction.
- ☒ c. The apparent depth of a glass block is less than the real depth because of refraction.
- ☐ d. A full glass mug appears to hold more colored liquid than it actually does because of reflection.

### 29.9 Atmospheric Refraction (pages 588–590)

38. What is a mirage?

an image caused by the refraction of light in Earth's atmosphere

39. Since molecules in hot air are farther apart, light travels \_\_\_\_\_ faster \_\_\_\_\_ through it than through the cooler air above, resulting in a \_\_\_\_\_ bending \_\_\_\_\_ of the light rays.

40. Is the following sentence true or false? Because of refraction, we see the sun for several minutes after the sunset. true

### 29.10 Dispersion in a Prism (page 590)

41. Light of frequencies closer to the natural frequency of the electron oscillators in a medium travels more \_\_\_\_\_ slowly \_\_\_\_\_ in the medium.

42. Why is the statement in Question 41 true?

Light travels more slowly because there are more interactions with the medium in the process of absorption and reemission.



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43. Is the following sentence true or false? Since the natural frequency of most transparent materials is in the ultraviolet part of the spectrum, visible light of higher frequencies travels more slowly than light of lower frequencies. true

44. What is dispersion?

the separation of light into colors arranged according to their frequency

### 29.11 The Rainbow (pages 591–593)

45. What needs to happen in order for a person to see a rainbow?

The sun must be shining in one part of the sky, and the water droplets in a cloud or in falling rain must be in the opposite part of the sky.

46. Why aren't rainbows completely round?

Rainbows are not completely round because the ground gets in the way of these dispersions of light.

47. Explain why, if each drop of water disperses a full spectrum of colors, an observer can only see a single color from any one drop.

Different colors are bent different amounts. If violet light from a single drop enters your eye, red light from the same drop falls below your eye. To see red light you have to look at a drop higher in the sky.

48. How does a secondary rainbow form?

A secondary rainbow forms when sunlight is doubly reflected within raindrops.

### 29.12 Total Internal Reflection (pages 593–595)

Match each phrase with the correct term or number.

Phrase	Terms and Numbers
<u>b</u> 49. the angle of incidence that results in light being refracted at an angle of $90^\circ$ with respect to the normal	a. $24.6^\circ$
<u>d</u> 50. the complete reflection of light back into its original medium	b. critical angle
<u>c</u> 51. critical angle for glass	c. $43^\circ$
<u>a</u> 52. critical angle for diamond	d. total internal reflection

53. What are optical fibers?

Optical fibers are transparent fibers that pipe light from one place to another.

54. What are two applications for optical fibers?

Mechanics and machinists use them to look at the interiors of engines. Physicians use them to look inside a patient's body. Optical fibers also are used in the communications industry to replace copper cables in switching centers.