EXERCISES

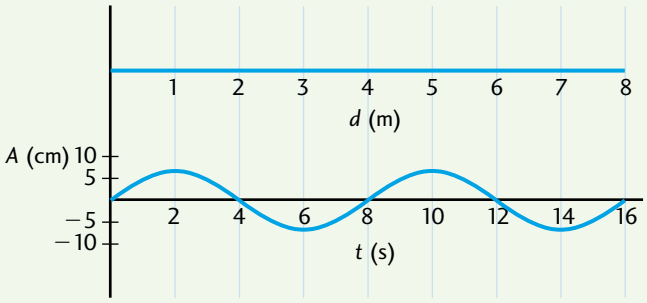
Conceptual Questions

1. Relate the motion of a spring vibrating back and forth to the motion of a light wave.
2. Speculate as to what happens to the magnetic field when the electric field of an electromagnetic wave decreases.
3. Why is "visible light" a relative term?
4. Illustrate reflection of light using wavefronts.
5. Why can't you put metallic objects in a microwave oven?
6. In an arcade shooting gallery, a row of ducks moves back and forth across the target area. In any direction, the speed is constant. Explain why this motion isn't simple harmonic motion.
7. Galileo stated that simple harmonic motion is uniform circular motion viewed edge-on. Explain this statement (you may use diagrams to help in the explanation).
8. Explain refraction in terms of electron oscillators and speed changes.
9. Newton postulated that the refraction of light, as it passed from air to a more optically dense medium, was caused by gravity. In his opinion, light was a particle that was drawn toward the masses in the denser medium. Which aspect of his theory of refraction is correct and which aspect is incorrect for light entering the medium at an angle?
10. For an object to be invisible, what has to be true about its refractive index?
11. What can you tell about optical densities, using a laser?
12. Explain dispersion in terms of refraction.
13. Why is the prism shape optimal for creating dispersion?
14. Can sound waves be polarized? Explain.
15. What is the difference between a polarizer and an analyzer? What happens to light if the light path is reversed and it enters the analyzer first?
16. Your friend plays a trick on you by rotating the polarizing filters in your circular sunglasses 90°. What effects will you experience?
17. Does the effectiveness of Polaroid sunglasses vary throughout the day? Explain.
18. Are Polaroid sunglasses effective on circularly polarized light?
19. How could you use the scattering effect of light to measure the pollution count in the air?
20. Summarize the wave effects of polarization, scattering, and refraction.

Problems

10.2 Fundamental Wave Concepts

Fig.10.58



21. Copy the diagram of a wave into your notebook (Figure 10.58). From measurements and information taken directly from the diagram, find the
    a) wavelength.
    b) amplitude.
    c) period.
    d) frequency.
    e) the speed of the wave.

22. A plastic fish at the end of a spring is pulled down and released. If the fish moves up and down 10 times in 3.2 s, find the period and frequency of oscillation.

23. What is the period and frequency of a person's heart if it beats 72 times in one minute?

24. An electric shaver blade vibrates at 60 Hz. What is its period of vibration?

25. A piston moves up and down in a car engine 150 times per minute (150 rpm). Find
a) the frequency in Hz (rps).
b) the period of vibration.

26. In the olden days, there were three rotational "speeds" used in playing vinyl records, namely, 78 rpm, 45 rpm, and $33\frac{1}{3}$ rpm. Convert each of these values to Hz and then find the period of rotation.

27. Find the displacement of a spring with a maximum amplitude of $A = 1$ from equilibrium for phase angles of
a) 10°. b) 95°. c) $\frac{3\pi}{4}$ rad. d) 2π rad.

28. For the SHM displacement of a spring, $x = A\cos\theta$, the velocity of the wave varies directly as $(-\sin\theta)$. Sketch the velocity and displacement curves, drawing the velocity wave under the displacement wave. Discuss how the two curves are related in terms of the motion of the spring (compare maximum displacement and velocity).

29. The acceleration of the spring varies directly as $(-\cos\theta)$. Draw this wave under the two waves you drew in problem 28. Discuss what the object is doing in terms of its acceleration and the motion of the spring (e.g., is it speeding up, changing direction, or slowing down?).

Problems 30–33 pertain to Lab 10.1

30. Calculate the period for the following objects:
a) A pendulum of length 2.1 m with a mass of 1.3 kg at the end of it.
b) A bungee cord jumper of mass 100 kg, *swinging* from a cord 80 m long.
c) A pendant of mass 30 g, on a chain 15 cm in length.

31. Repeat problem 30, only pretend that you are on
a) the Moon, where the gravitational field constant is 1.6 m/s^2.
b) Jupiter, where the gravitational field constant is 24.6 m/s^2.

32. Calculate the period for the following:
a) A spring with constant $k = 23.4$ N/m, with a 0.30-kg mass hanging from it.
b) A spring pulled down 20 cm from equilibrium, with a spring constant of 20 N/m, and a 0.40-kg mass hanging from it.
c) A spring on the Moon ($g = 1.6$ m/s^2), with a spring constant of 2.0 N/cm, pulled down 1.0 m, with a 0.21-kg mass hanging from it.

33. a) Calculate the spring constant for a spring with a hanging mass of 402 g and a frequency of 12 Hz.
b) How much force is required to pull the spring down 35 cm?

10.3 Electromagnetic Theory

34. For the following wavelengths of light, calculate the corresponding frequency.
a) Red: 650 nm
b) Orange: 600 nm
c) Yellow: 580 nm
d) Green: 520 nm
e) Blue: 475 nm
f) Violet: 400 nm

Note that these wavelengths are representative values: each colour has a range of frequencies associated with it.

35. Calculate the time it would take light leaving Earth to reach
a) the Sun (1.49×10^{11} m away).

b) the Moon (3.8×10^8 m away).
c) Pluto (5.8×10^{12} m away).
d) Mercury (9.1×10^{10} m away).
Convert the times to minutes and hours as well.

36. Find the distance light travels in one year. This distance is referred to as a light year.

37. If we see light coming from a galaxy 100 light years away, how long ago did the light leave the galaxy?

38. A light bulb is turned on at one end of a football stadium. How much time elapses before the light reaches you? Assume a distance of 160 m.

39. Calculate the time it would take light to travel around the world once ($r_{Earth} = 6.38 \times 10^6$ m).

40. UV light is invisible to the human eye, unless we use special sensors. Given the range of wavelengths of UV light (4×10^{-7} m to about 8×10^{-8} m), calculate the corresponding frequencies.

41. British Columbia is about a 50-h drive from Southern Ontario. Assume a distance of 4000 km. How much faster would it be to travel this distance at the speed of light?

10.4 Electromagnetic Wave Phenomena: Refraction

42. For the following angles, find the sine of the angle.
a) 30°
b) 60°
c) 45°
d) 12.6°
e) 74.4°
f) 0°
g) 90°

43. For the following inverse sine values ($\sin^{-1}$), find the corresponding angle.
a) 0.342
b) 0.643
c) 0.700
d) 0.333
e) 1.00

44. Calculate the speed of light in a material with a refractive index of 0.90. Comment.

45. Find the angle of refraction for light travelling from air to a medium ($n = 1.98$), if the angle of incidence in air is 2.0 times the angle of refraction.

46. Calculate the index of refraction for a substance where the angle of incidence in a material with $n = 1.5$ is 30° and the angle of refraction is 50°. Comment.

47. Sketch a light ray passing through a rectangular piece of glass. The exiting ray should be parallel to the incident ray. Draw the wavefronts.

48. Calculate the speed of light in
a) diamond ($n = 2.42$).
b) crown glass ($n = 1.52$).
c) water ($n = 1.33$).
d) ice ($n = 1.30$).

49. Calculate the relative index of refraction for light travelling from the material to air for the substances listed in problem 48.

50. Given that the refractive index of water is 1.33, how long does it take light to travel from one shore of a lake to the opposite shore if the lake is 12 km long?

10.5 Electromagnetic Wave Phenomena: Polarization

51. A beam of light is reflected from a surface that has an index of refraction of 1.42. If the reflected beam is 100% polarized, what is the angle of
a) incidence?
b) refraction?
c) reflection?

52. What should be the Sun's angle of elevation over a lake in order for Polaroid sunglasses to be the most effective?

53. What percentage of light intensity is transmitted through a polarizer–analyzer combination if the angle between their axes is
    a) 30°?
    b) 50°?
    c) 70°?

54. Describe the image you would see through a doubly refracting crystal. What would you see if another crystal was placed on top of the first crystal and rotated?

55. How can you determine if light is polarized, unpolarized, or partially polarized?

56. Calculate the angle at which light reflected off water is 100% polarized.

57. Calculate Brewster's angle for the following combination of mediums:
    a) Air–water ($n_{water} = 1.33$)
    b) Air–glass ($n_{glass} = 1.50$)
    c) Glass–water
    d) Ice–water ($n_{ice} = 1.30$)

58. What is the refractive index of a medium that has a Brewster's angle of 60°?

59. Two Polaroids are crossed such that no light is transmitted. Now a third Polaroid is placed *in between* and *at an angle to* the first two Polaroids. Why is light once again transmitted?

60. Calculate the percentage of light travelling through two crossed polarizing filters if the angle between the polarizing directions is
    a) 10°.
    b) 30°.
    c) 70°.
    d) 85°.

61. At what angle should two polarizing filters be positioned to reduce the intensity of light by 60%?

62. Three polarizing filters are placed on top of one another. If the angle between the first two filters is 60° and the angle between the first and third filter is 70°, find the percentage of light exiting the last polarizing filter.