11–9 Wave Energy

46. (II) What is the ratio of (*a*) the intensities, and (*b*) the amplitudes, of an earthquake P wave passing through the Earth and detected at two points 10 km and 20 km from the source.

47. (II) The intensity of an earthquake wave passing through the Earth is measured to be $2.0 \times 10^6\ \text{J/m}^2\cdot\text{s}$ at a distance of 48 km from the source. (*a*) What was its intensity when it passed a point only 1.0 km from the source? (*b*) At what rate did energy pass through an area of $5.0\ \text{m}^2$ at 1.0 km?

* 11–10 Intensity Related to *A* and *f*

*** 48.** (I) Two earthquake waves of the same frequency travel through the same portion of the Earth, but one is carrying twice the energy. What is the ratio of the amplitudes of the two waves?

*** 49.** (I) Two waves traveling along a stretched string have the same frequency, but one transports three times the power of the other. What is the ratio of the amplitudes of the two waves?

*** 50.** (II) A bug on the surface of a pond is observed to move up and down a total vertical distance of 6.0 cm, from the lowest to the highest point, as a wave passes. If the ripples decrease to 4.5 cm, by what factor does the bug's maximum KE change?

11–12 Interference

51. (I) The two pulses shown in Fig. 11–52 are moving toward each other. (*a*) Sketch the shape of the string at the moment they directly overlap. (*b*) Sketch the shape of the string a few moments later. (*c*) In Fig. 11–36a, at the moment the pulses pass each other, the string is straight. What has happened to the energy at this moment?

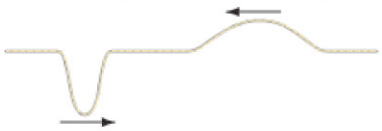

FIGURE 11–52 Problem 51.

11–13 Standing Waves; Resonance

52. (I) If a violin string vibrates at 440 Hz as its fundamental frequency, what are the frequencies of the first four harmonics?

53. (I) A violin string vibrates at 294 Hz when unfingered. At what frequency will it vibrate if it is fingered one-third of the way down from the end? (That is, only two-thirds of the string vibrates as a standing wave.)

54. (I) A particular string resonates in four loops at a frequency of 280 Hz. Name at least three other frequencies at which it will resonate.

55. (II) The velocity of waves on a string is 92 m/s. If the frequency of standing waves is 475 Hz, how far apart are two adjacent nodes?

56. (II) If two successive overtones of a vibrating string are 280 Hz and 350 Hz, what is the frequency of the fundamental?

57. (II) A guitar string is 90 cm long and has a mass of 3.6 g. The distance from the bridge to the support post is $L = 62$ cm, and the string is under a tension of 520 N. What are the frequencies of the fundamental and first two overtones?

58. (II) A particular guitar string is supposed to vibrate at 200 Hz, but it is measured to vibrate at 205 Hz. By what percent should the tension in the string be changed to correct the frequency?

59. (II) One end of a horizontal string is attached to a small-amplitude mechanical 60-Hz vibrator. The string's mass per unit length is 3.9×10^{-4} kg/m. The string passes over a pulley, a distance $L = 1.50$ m away, and weights are hung from this end, Fig. 11–53. What mass m must be hung from this end of the string to produce (*a*) one loop, (*b*) two loops, and (*c*) five loops of a standing wave? Assume the string at the vibrator is a node, which is nearly true.

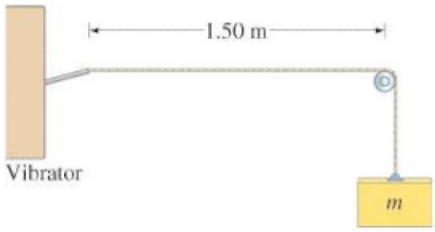

FIGURE 11–53 Problems 59 and 60.

60. (II) In Problem 59, the length of the string may be adjusted by moving the pulley. If the hanging mass m is fixed at 0.080 kg, how many different standing wave patterns may be achieved by varying L between 10 cm and 1.5 m?

61. (II) When you slosh the water back and forth in a tub at just the right frequency, the water alternately rises and falls at each end, remaining relatively calm at the center. Suppose the frequency to produce such a standing wave in a 65-cm-wide tub is 0.85 Hz. What is the speed of the water wave?

* 11–14 Refraction

*** 62.** (I) An earthquake P wave traveling at 8.0 km/s strikes a boundary within the Earth between two kinds of material. If it approaches the boundary at an incident angle of 47° and the angle of refraction is 35°, what is the speed in the second medium?

*** 63.** (I) Water waves approach an underwater "shelf" where the velocity changes from 2.8 m/s to 2.1 m/s. If the incident wave crests make a 34° angle with the shelf, what will be the angle of refraction?

*** 64.** (II) A sound wave is traveling in warm air when it hits a layer of cold, dense air. If the sound wave hits the cold air interface at an angle of 25°, what is the angle of refraction? Assume that the cold air temperature is −10°C and the warm air temperature is +10°C. The speed of sound as a function of temperature can be approximated by $v = (331 + 0.60\,T)$ m/s, where T is in °C.

*** 65.** (III) A longitudinal earthquake wave strikes a boundary between two types of rock at a 38° angle. As the wave crosses the boundary, the specific gravity of the rock changes from 3.6 to 2.8. Assuming that the elastic modulus is the same for both types of rock, determine the angle of refraction.

* 11–15 Diffraction

*** 66.** (II) A satellite dish is about 0.5 m in diameter. According to the user's manual, the dish has to be pointed in the direction of the satellite, but an error of about 2° is allowed without loss of reception. Estimate the wavelength of the electromagnetic waves received by the dish.