

••7 A transverse sinusoidal wave is moving along a string in the positive direction of an  $x$  axis with a speed of 80 m/s. At  $t = 0$ , the string particle at  $x = 0$  has a transverse displacement of 4.0 cm from its equilibrium position and is not moving. The maximum transverse speed of the string particle at  $x = 0$  is 16 m/s. (a) What is the frequency of the wave? (b) What is the wavelength of the wave? If  $y(x, t) = y_m \sin(kx \pm \omega t + \phi)$  is the form of the wave equation, what are (c)  $y_m$ , (d)  $k$ , (e)  $\omega$ , (f)  $\phi$ , and (g) the correct choice of sign in front of  $\omega$ ?

•15 **SSM WWW** A stretched string has a mass per unit length of 5.00 g/cm and a tension of 10.0 N. A sinusoidal wave on this string has an amplitude of 0.12 mm and a frequency of 100 Hz and is traveling in the negative direction of an  $x$  axis. If the wave equation is of the form  $y(x, t) = y_m \sin(kx \pm \omega t)$ , what are (a)  $y_m$ , (b)  $k$ , (c)  $\omega$ , and (d) the correct choice of sign in front of  $\omega$ ?

•19 **SSM** What is the speed of a transverse wave in a rope of length 2.00 m and mass 60.0 g under a tension of 500 N?

•31 **SSM** Two identical traveling waves, moving in the same direction, are out of phase by  $\pi/2$  rad. What is the amplitude of the resultant wave in terms of the common amplitude  $y_m$  of the two combining waves?

•43 **SSM WWW** What are (a) the lowest frequency, (b) the second lowest frequency, and (c) the third lowest frequency for standing waves on a wire that is 10.0 m long, has a mass of 100 g, and is stretched under a tension of 250 N?

•45 **SSM ILW** A string that is stretched between fixed supports separated by 75.0 cm has resonant frequencies of 420 and 315 Hz with no intermediate resonant frequencies. What are (a) the lowest resonant frequency and (b) the wave speed?

•48 ~~SSM~~ If a transmission line in a cold climate collects ice, the increased diameter tends to cause vortex formation in a passing wind. The air pressure variations in the vortices tend to cause the line to oscillate (*gallop*), especially if the frequency of the variations matches a resonant frequency of the line. In long lines, the resonant frequencies are so close that almost any wind speed can set up a resonant mode vigorous enough to pull down support towers or cause the line to *short out* with an adjacent line. If a transmission line has a length of 347 m, a linear density of 3.35 kg/m, and a tension of 65.2 MN, what are (a) the frequency of the fundamental mode and (b) the frequency difference between successive modes?

88 ~~SSM~~ **Body armor.** When a high-speed projectile such as a bullet or bomb fragment strikes modern body armor, the fabric of the armor stops the projectile and prevents penetration by quickly spreading the projectile's energy over a large area. This spreading is done by longitudinal and transverse pulses that move *radially* from the impact point, where the projectile pushes a cone-shaped dent into the fabric. The longitudinal pulse, racing along the fibers of the fabric at speed  $v_l$  ahead of the denting, causes the fibers to thin and stretch, with material flowing radially inward into the dent. One such radial fiber is shown in Fig. 16-47a. Part of the projectile's energy goes into this motion and stretching. The transverse pulse, moving at a slower speed  $v_t$ , is due to the denting. As the projectile increases the dent's depth, the dent increases in radius, causing the material in the fibers to move in the same direction as the projectile (perpendicular to the transverse pulse's direction of travel). The rest of the projectile's energy goes into this motion. All the energy that does not eventually go into permanently deforming the fibers ends up as thermal energy.

Figure 16-47b is a graph of speed  $v$  versus time  $t$  for a bullet of mass 10.2 g fired from a .38 Special revolver directly into body armor. The scales of the vertical and horizontal axes are set by  $v_s = 300$  m/s and  $t_s = 40.0$   $\mu$ s. Take  $v_l = 2000$  m/s, and assume that the half-angle  $\theta$  of the conical dent is  $60^\circ$ . At the end of the collision, what are the radii of (a) the thinned region and (b) the dent (assuming that the person wearing the armor remains stationary)?

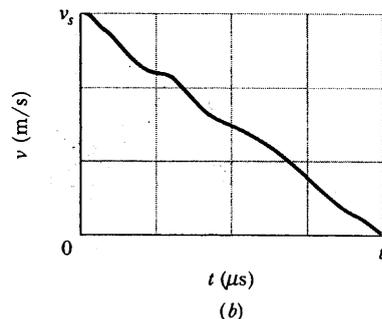
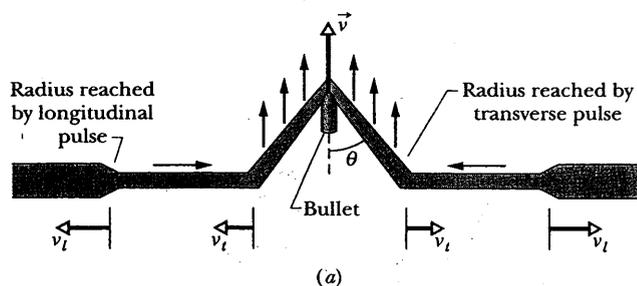


Fig. 16-47 Problem 88.