CHAPTER 15

2. The distance between wave crests is the wavelength of the wave.

$$\lambda = v/f = 343\,\text{m/s}/262\text{ Hz} = \boxed{1.31\text{ m}}$$

6. To find the time for a pulse to travel from one end of the cord to the other, the velocity of the pulse on the cord must be known. For a cord under tension, we have Eq. 15-2, $v = \sqrt{F_T/\mu}$.

$$v = \frac{\Delta x}{\Delta t} = \sqrt{\frac{F_T}{\mu}} \rightarrow \Delta t = \frac{\Delta x}{\sqrt{\frac{F_T}{\mu}}} = \frac{8.0\,\text{m}}{\sqrt{\frac{140\,\text{N}}{(0.65\,\text{kg})/(8.0\,\text{m})}}} = \boxed{0.19\,\text{s}}$$

15. From Eq. 15-7, if the speed, medium density, and frequency of the two waves are the same, then the intensity is proportional to the square of the amplitude.

$$I_2/I_1 = E_2/E_1 = A_2^2/A_1^2 = 3 \rightarrow A_2/A_1 = \sqrt{3} = \boxed{1.73}$$

The more energetic wave has the larger amplitude.

24. The traveling wave is given by $D = 0.22\sin(5.6x + 34t)$.

(*a*) The wavelength is found from the coefficient of *x*.

$$5.6\,\text{m}^{-1} = \frac{2\pi}{\lambda} \rightarrow \lambda = \frac{2\pi}{5.6\,\text{m}^{-1}} = 1.122\,\text{m} \approx \boxed{1.1\,\text{m}}$$

(*b*) The frequency is found from the coefficient of *t*.

$$34\,\text{s}^{-1} = 2\pi f \rightarrow f = \frac{34\,\text{s}^{-1}}{2\pi} = 5.411\,\text{Hz} \approx \boxed{5.4\,\text{Hz}}$$

(*c*) The velocity is the ratio of the coefficients of *t* and *x*.

$$v = \lambda f = \frac{2\pi}{5.6\,\text{m}^{-1}}\frac{34\,\text{s}^{-1}}{2\pi} = 6.071\,\text{m/s} \approx \boxed{6.1\,\text{m/s}}$$

Because both coefficients are positive, the velocity is in the $\boxed{\text{negative } x \text{ direction}}$.

(*d*) The amplitude is the coefficient of the sine function, and so is $\boxed{0.22\,\text{m}}$.

(*e*) The particles on the cord move in simple harmonic motion with the same frequency as the wave. From Chapter 14, $v_{max} = D\omega = 2\pi fD$.

$$v_{max} = 2\pi fD = 2\pi\left(\frac{34\,\text{s}^{-1}}{2\pi}\right)(0.22\,\text{m}) = \boxed{7.5\,\text{m/s}}$$

The minimum speed is when a particle is at a turning point of its motion, at which time the speed is 0.

$$v_{min} = \boxed{0}$$

$\boxed{49.}$ Since $f_n = nf_1$, two successive overtones differ by the fundamental frequency, as shown below.

$$\Delta f = f_{n+1} - f_n = (n+1)f_1 - nf_1 = f_1 = 320\,\text{Hz} - 240\,\text{Hz} = \boxed{80\,\text{Hz}}$$

CHAPTER 16

15. $\beta = 10\log\frac{I}{I_0} = 10\log\frac{2.0\times10^{-6}\ \mathrm{W/m^2}}{1.0\times10^{-12}\ \mathrm{W/m^2}} = \boxed{63\ \mathrm{dB}}$

18. Compare the two power output ratings using the definition of decibels.

$$\beta = 10\log\frac{P_{150}}{P_{100}} = 10\log\frac{150\,\mathrm{W}}{100\,\mathrm{W}} = \boxed{1.8\,\mathrm{dB}}$$

This would barely be perceptible.

21. From Example 16-4, we see that a sound level decrease of 3 dB corresponds to a halving of intensity. Thus, if two engines are shut down, the intensity will be cut in half, and the sound level will be 127 dB. Then, if one more engine is shut down, the intensity will be cut in half again, and the sound level will drop by 3 more dB, to a final value of $\boxed{124\ \mathrm{dB}}$.

24. (*a*) The energy absorbed per second is the power of the wave, which is the intensity times the area.

$$50\ \mathrm{dB} = 10\log\frac{I}{I_0} \quad\rightarrow\quad I = 10^5 I_0 = 10^5\left(1.0\times10^{-12}\ \mathrm{W/m^2}\right) = 1.0\times10^{-7}\ \mathrm{W/m^2}$$

$$P = IA = \left(1.0\times10^{-7}\ \mathrm{W/m^2}\right)\left(5.0\times10^{-5}\,\mathrm{m^2}\right) = \boxed{5.0\times10^{-12}\,\mathrm{W}}$$

(*b*) $1\ \mathrm{J}\left(\frac{1\ \mathrm{s}}{5.0\times10^{-12}\ \mathrm{J}}\right)\left(\frac{1\ \mathrm{yr}}{3.16\times10^7\,\mathrm{s}}\right) = \boxed{6.3\times10^3\,\mathrm{yr}}$

28. (*a*) The intensity is proportional to the square of the amplitude, so if the amplitude is 2.5 times greater, the intensity will $\boxed{\text{increase by a factor of } 6.25 \approx 6.3}$.

(*b*) $\beta = 10\log I/I_0 = 10\log 6.25 = \boxed{8\,\mathrm{dB}}$

62. The moving object can be treated as a moving "observer" for calculating the frequency it receives and reflects. The bat (the source) is stationary.

$$f'_{\text{object}} = f_{\text{bat}}\left(1 - \frac{v_{\text{object}}}{v_{\text{snd}}}\right)$$

Then the object can be treated as a moving source emitting the frequency f'_{object}, and the bat as a stationary observer.

$$f''_{\text{bat}} = \frac{f'_{\text{object}}}{\left(1 + \frac{v_{\text{object}}}{v_{\text{snd}}}\right)} = f_{\text{bat}}\frac{\left(1 - \frac{v_{\text{object}}}{v_{\text{snd}}}\right)}{\left(1 + \frac{v_{\text{object}}}{v_{\text{snd}}}\right)} = f_{\text{bat}}\frac{\left(v_{\text{snd}} - v_{\text{object}}\right)}{\left(v_{\text{snd}} + v_{\text{object}}\right)}$$

$$= \left(5.00 \times 10^{4}\,\text{Hz}\right)\frac{343\,\text{m/s} - 30.0\,\text{m/s}}{343\,\text{m/s} + 30.0\,\text{m/s}} = \boxed{4.20 \times 10^{4}\,\text{Hz}}$$

66. The wall can be treated as a stationary "observer" for calculating the frequency it receives. The bat is flying toward the wall.

$$f'_{\text{wall}} = f_{\text{bat}}\frac{1}{\left(1 - \frac{v_{\text{bat}}}{v_{\text{snd}}}\right)}$$

Then the wall can be treated as a stationary source emitting the frequency f'_{wall}, and the bat as a moving observer, flying toward the wall.

$$f''_{\text{bat}} = f'_{\text{wall}}\left(1 + \frac{v_{\text{bat}}}{v_{\text{snd}}}\right) = f_{\text{bat}}\frac{1}{\left(1 - \frac{v_{\text{bat}}}{v_{\text{snd}}}\right)}\left(1 + \frac{v_{\text{bat}}}{v_{\text{snd}}}\right) = f_{\text{bat}}\frac{\left(v_{\text{snd}} + v_{\text{bat}}\right)}{\left(v_{\text{snd}} - v_{\text{bat}}\right)}$$

$$= \left(3.00 \times 10^{4}\,\text{Hz}\right)\frac{343\,\text{m/s} + 7.0\,\text{m/s}}{343\,\text{m/s} - 7.0\,\text{m/s}} = \boxed{3.13 \times 10^{4}\,\text{Hz}}$$