11.3
Use Eq. (11.1) to solve for λ, with $v = 1498\,\text{m/s}$ and $f = 440\,\text{Hz}$:

$$\lambda = \frac{v}{f} = \frac{1498\,\text{m/s}}{440\,\text{Hz}} = 3.40\,\text{m}\,.$$

11.5
For a periodic wave of wavelength λ, wave speed v and frequency f, Eq. (11.1) holds true: $v = f\lambda$. Rewrite this as $f = v/\lambda$ and multiply both sides by 2π to obtain $2\pi f = 2\pi v/\lambda = (2\pi/\lambda)v$. But $2\pi f = \omega$ (the angular frequency of the wave), so $\omega = (2\pi/\lambda)v$.

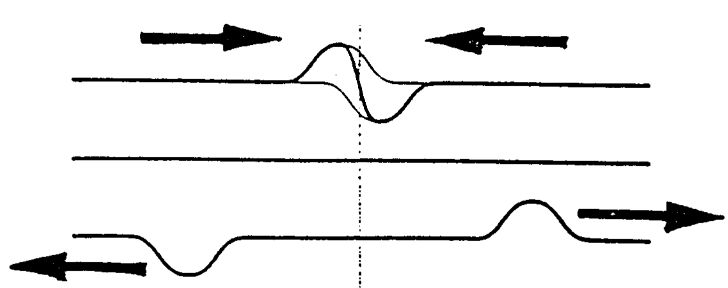
11.17
In order not to be masked by the next group of chirps, a wavetrain must make it from the bat to the object (which is located a distance x away) and get reflected back to the bat in a time interval no longer than $\Delta t = 70\,\text{ms}$. Thus if the speed of the wavetrain is v, then for the round-trip the total distance $2x$ must satisfy $2x/v \leq \Delta t$, or

$$x_{\text{max}} = \frac{1}{2}\,v\Delta t = \frac{1}{2}(330\,\text{m/s})(70 \times 10^{-3}\,\text{s}) = 12\,\text{m}\,.$$

11.29
Use Eq. (11.4), $v = \sqrt{F_T/\mu}$, to find F_T. Here $v = 129\,\text{m/s}$ and $\mu = 64.9 \times 10^{-3}\,\text{kg/m}$ is th linear mass-density. Thus

$$F_T = v^2\mu = (129\,\text{m/s})^2(64.9 \times 10^{-3}\,\text{kg/m}) = 1.08 \times 10^3\,\text{N}\,.$$

11.31
Similar to the previous problem, suppose that the picture in the text (Fig. P31) was taken at $t = 0$. In the following sequence, the top figure depicts the situation a little before $t = 2\,\text{s}$, the middle one is the picture at exactly $t = 2\,\text{s}$ (when the two peaks coincide), while the bottom one is at $t = 4\,\text{s}$.



11.35

If the amplitude of a harmonic wave is A and its frequency is f, then each particle in the medium carrying the wave is in a simple harmonic motion with the same frequency and amplitude. According to Eq. (10.17) the maximum acceleration of each particle in the wave is then $a_{max} = [-\omega^2 A\cos\omega t]_{max} = \omega^2 A = (2\pi f)^2 A$. In this case, the waveform is $y = 0.040\sin(2\pi x)$ which, when compared with the standard form in Eq. (11.2), $y = A\sin(2\pi x/\lambda)$, yields $A = 0.040\,\text{m}$ and $\lambda = 1.0\,\text{m}$. Thus

$$a_{max} = (2\pi f)^2 A = \left(\frac{2\pi v}{\lambda}\right)^2 A = \left[\frac{2\pi(2.0\,\text{m/s})}{1.0\,\text{m}}\right]^2 (0.040\,\text{m}) = 6.3\,\text{m/s}^2\,,$$

where we used $f = v/\lambda$.

11.37

The wave speed v is obtained from Eq. (11.4):

$$v = \sqrt{\frac{F_T}{\mu}} = \sqrt{\frac{25.0\,\text{N}}{2.50\times 10^{-3}\,\text{kg/m}}} = 100\,\text{m/s};$$

the angular speed ω is given by $\omega = 2\pi f = 2\pi(50.0\,\text{Hz}) = 314\,\text{rad/s}$; the period is $T = 1/f = 1/50.0\,\text{Hz} = 0.0200\,\text{s}$; and the wavelength is $\lambda = v/f = (100\,\text{m/s})/50.0\,\text{Hz} = 2.00\,\text{m}$.

11.47

Solve for Y from Eq. (11.7), $v = \sqrt{Y/\rho}$:

$$Y = \rho v^2 = (19.3\times 10^3\,\text{kg/m}^3)(4319\,\text{m/s})^2 = 3.60\times 10^{11}\,\text{Pa} = 360\,\text{GPa}\,.$$

11.61

As the needle moves through the groove it encounters a total of 1.5×10^3 wiggle-wavelengths each second, producing a sound of frequency $f = 1.5\times 10^3\,\text{Hz} = 1.5\,\text{kHz}$. Since the needle traverses $0.50\,\text{m}$ during each second, there must be 1.5×10^3 wiggle-wavelengths in $0.50\,\text{m}$. Thus the wiggle-wavelength is $\lambda = 0.50\,\text{m}/(1.5\times 10^3) = 3.3\times 10^{-4}\,\text{m} = 0.33\,\text{mm}$.

11.63

The period T of the middle-C is $T = 1/f = 1/261.6\,\text{Hz} = 3.823\times 10^{-3}\,\text{s} = 3.823\,\text{ms}$. Thus the contact time for the note is $\frac{1}{2}(3.823\,\text{m/s}) = 1.911\,\text{ms}$, or, to two significant figures, $1.9\,\text{ms}$.

11.93

For the first system the sound-level is $\beta_1 = 10\log_{10}(I_1/I_0)$, while for the second one (the one with grater acoustic power output) $\beta_2 = 10\log_{10}(I_2/I_0)$. The difference in their sound-levels is then

$$\begin{aligned}\Delta\beta &= 10\log_{10}\left(\frac{I_2}{I_0}\right) - 10\log_{10}\left(\frac{I_1}{I_0}\right) = 10\log_{10}\left[\left(\frac{I_2}{I_0}\right)\Big/\left(\frac{I_1}{I_0}\right)\right] \\ &= 10\log_{10}\left(\frac{I_2}{I_1}\right) = 10\log_{10}\left(\frac{10I_1}{I_1}\right) \\ &= 10\log_{10}(10) = 10\,\text{dB}\,.\end{aligned}$$

Note that we used the identity $\log_a x - \log_a y = \log_a(x/y)$.

11.95

The sound-level β is related to the intensity I by Eq. (11.10): $\beta = 10\log_{10}(I/I_0)$. Since the two systems have the same intensity at the location of the microphone, they must also have the same sound-level. The difference in their sound-levels is therefore 0 dB.

11.99

Apply the result of the previous problem: $I = 10^{\beta/10}I_0$. In this case $\beta = 77\,\text{dB}$, so

$$I = 10^{\beta/10}I_0 = (10^{77/10})(10^{-12}\,\text{W/m}^2) = 5.0 \times 10^{-5}\,\text{W/m}^2\,.$$

11.103

At $R = 5.0\,\text{m}$ from the source

$$\beta = 10\log_{10}\left(\frac{I}{I_0}\right) = 10\log_{10}\left(\frac{56\times 10^{-5}\,\text{W/m}^2}{10^{-12}\,\text{W/m}^2}\right) = 87\,\text{dB}\,.$$

Since $I \propto R^{-2}$ for spherical waves, At $R' = 20.0\,\text{m}$ from the printer the intensity drops to $I' = I(R/R')^2 = I(5.0\,\text{m}/20.0\,\text{m})^2 = 0.0625\,I$, and the sound-level changes by

$$\Delta\beta = 10\log_{10}\left(\frac{I'}{I}\right) = 10\log_{10}\left(\frac{0.0625\,I}{I}\right) = -12\,\text{dB}\,,$$

so the sound-level there is $\beta' = \beta + \Delta\beta = 87\,\text{dB} + (-12\,\text{dB}) = 75\,\text{dB}$.

11.109

The sound intensity I varies as the square of the acoustic pressure P: $I \propto P^2$. Thus $I/I_0 = (P/P_0)^2$, where $P_0 = 2\times 10^{-5}\,\text{Pa}$ corresponds to an intensity of I_0. Thus from Eq. (11.10)

$$\beta = 10\log_{10}\left(\frac{I}{I_0}\right) = 10\log_{10}\left(\frac{P}{P_0}\right)^2 = 20\log_{10}\left(\frac{P}{P_0}\right)\,.$$

11.115

According to the problem statement the period of the beats is $T_{\text{beat}} = 0.99\,\text{s}$, so the beat frequency is $f_{\text{beat}} = 1/T_{\text{beat}} = 1/0.99\,\text{s} = 1.0\,\text{Hz}$, which is the same as Δf, the difference in frequency between the two tuning forks which produce the beats.

11.119

First, find the speed v of the wave on the piano string of length L and mass m under tension F_T using Eq. (11.4), $v = \sqrt{F_T/\mu}$, where μ is the linear mass-density of the string:

$$v = \sqrt{\frac{F_T}{\mu}} = \sqrt{\frac{100\,\text{N}}{2.5\times 10^{-3}\,\text{kg}/1.00\,\text{m}}} = 2.0\times 10^2\,\text{m/s}\,.$$

Also, the wavelength λ_1 of the fundamental mode is given by Eq. (11.14), with $N = 1$: $\lambda_1 = 2L/1 = 2(1.00\,\text{m})/1 = 2.00\,\text{m}$. Thus the corresponding frequency f_1 is

$$f_1 = \frac{v}{\lambda_1} = \frac{2.0\times 10^2\,\text{m/s}}{2.00\,\text{m}} = 1.0\times 10^2\,\text{Hz} = 0.10\,\text{kHz}\,.$$

11.130

Similar to the previous problem, it is clear that the wavelength λ_1 of the fundamental mode will not change as a result of temperature change, since λ_1 depends only on the length of the tube, which is assumed to be a constant. Thus $f_1 = v/\lambda_1 \propto v$. At 0 °C the speed of sound is $v = 331.5\,\text{m/s}$, while at 40 °C it becomes $v' = 331.5\,\text{m/s} + (0.60\,\text{m/s-°C})(40\,\text{°C}) = 355.5\,\text{m/s}$. Thus the frequency f' at 40 °C satisfies $f_1'/f_1 = v'/v$, or

$$f_1' = f_1\left(\frac{v'}{v}\right) = (200\,\text{Hz})\left(\frac{355.5\,\text{m/s}}{331.5\,\text{m/s}}\right) = 214\,\text{Hz},$$

which is higher than f_1 (at 0 °C) by 14 Hz.

11.145

The beat frequency, f_{beat}; is the difference between f_s, the source frequency; and f_o, the observed frequency of the reflected signal. According to Eq. (11.23) $f_o = f_s(v + v_t)/(v - v_t)$, where v_t is the speed of the target approaching the observer. So the beat frequency is

$$f_{\text{beat}} = f_o - f_s = f_s\left(\frac{v + v_t}{v - v_t}\right) - f_s = \frac{2v_t f_s}{v - v_t}.$$