Physics 203 – Principles of Physics III
Homework Chapter 15 and 16
Assignment #4
March 27, 2008

15-5: a) λ_{max} = (344 m/s)/(20.0 Hz) = 17.2 m, λ_{min} = (344 m/s)/(20,000 Hz) = 1.72 cm.

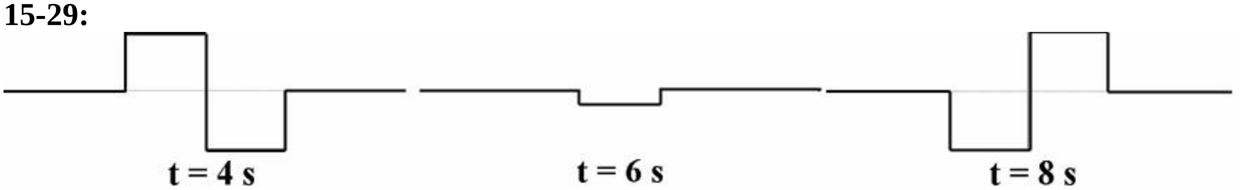
b) λ_{max} = (1480 m/s)/(20.0 Hz) = 74.0 m, λ_{min} = (1480 m/s)/(20,000 Hz) = 74.0 mm.

15-11: Reading from the graph:
a) A = 4.0 mm
b) T = 0.040 s
c) Remember that the graph is of amplitude versus time. For a wave in the positive x direction, what you observe for the red line at a given instant happens later for the blue line. Consider the red line at zero going positive at t = 0. The displacement at 0.090 m, the blue line, is zero going positive at a time of 0.025 s. In other words, the part of the wave represented by the point where the red curve crosses the origin corresponds to the point where the blue curve crosses the time axis (y = 0) at t = 0.025 s, and in this time the wave has traveled 0.090 m. Thus, the wave speed is $v = \frac{0.090\,\text{m}}{0.025\,\text{s}} = 3.6\,{}^{\text{m}}\!/\!{}_{\text{s}}$ and the wavelength is ? = vT = (3.6 m/s)(0.040 s) = 0.14 m.
d) In this case, for a wave traveling in the negative direction, what happens for the blue line happens later for the red line. The blue line crosses the y axis at t = .025 s. The red line crosses the y axis at t = 0.04 s. Thus, $v = \frac{0.090\,\text{m}}{0.015\,\text{s}} = 6.0\,{}^{\text{m}}\!/\!{}_{\text{s}}$ and the wavelength is ? = vT = (6.0 m/s)(0.04 s) = 0.24 m.
e) No; there could be many wavelengths between the places where y(t) is measured.

15-17: Denoting the suspended mass by M and the string mass by m, the time for the pulse to reach the other end is

$$t = \frac{L}{v} = \frac{L}{\sqrt{F/\mu}} = \frac{L}{\sqrt{Mg/(m/L)}} = \sqrt{\frac{mL}{Mg}} = \sqrt{\frac{(0.800\,\text{kg})(14.0\,\text{m})}{(7.50\,\text{kg})(9.80\,\text{m/s}^2)}} = 0.390\,\text{s}.$$

15-29:



15.37: a) In the fundamental mode,

$$\lambda = 2L = 1.60\ \text{m and so } v = f\lambda = (60.0\ \text{Hz})(1.60\ \text{m}) = 96.0\ \text{m/s}.$$

b) $F = v^2\mu = v^2\, m/L = (96.0\ \text{m/s})^2\,(0.0400\ \text{kg})/(0.800\ \text{m}) = 461\ \text{N}.$

c) $$\begin{aligned} v_{\max}^{\text{trans}} &= \omega A = 2\pi f A = 2\pi(60\ \text{Hz})(.003\,\text{m}) = 1.13\,\text{m/s} \\ a_{\max}^{\text{trans}} &= \omega^2 A = (2\pi f)^2 A = 426\,\text{m/s}^2 \end{aligned}$$

15-55: a,b) (1): The curve appears to be horizontal, and $v_y = 0$. As the wave moves, the point will begin to move downward, and $a_y < 0$.

(2): As the wave moves in the +x-direction (to the right in Fig. (19-39)), the particle will move upward, $v_y > 0$. The portion of the curve to the left of the point is steeper, so $a_y > 0$.

(3): The point is moving down, and will increase its speed as the wave moves; $v_y < 0$, $a_y < 0$.

(4): The curve appears to be horizontal, and $v_y = 0$. As the wave moves, the point will move away from the x-axis, and $a_y > 0$.

(5): The point is moving downward, and will increase its speed as the wave moves; $v_y < 0$, $a_y < 0$.

(6): The particle is moving upward, but the curve that represents the wave appears to have no curvature, so $v_y > 0$ and $a_y = 0$.

c) The accelerations, which are related to the curvatures, will not change. The transverse velocities will all change sign.

Q17 At point A nothing is heard. At point B one hears a sonic boom, i.e. the superposition of waves coming from various points of the flight all arriving at the same time. At point C one just hears a jet passing.

16.7: Use $v_{\text{water}} = 1482\ \text{m/s}$ at $20°\text{C}$, as given in Table (16.1) The sound wave travels in water for the same time as the wave travels a distance $22.0\ \text{m} - 1.20\ \text{m} = 20.8\ \text{m}$ in air, and so the depth of the diver is

$$(20.8\ \text{m})\frac{v_{\text{water}}}{v_{\text{air}}} = (20.8\ \text{m})\frac{1482\ \text{m/s}}{344\ \text{m/s}} = 89.6\ \text{m}.$$

This is the depth of the diver; the distance from the horn is $90.8\ \text{m}$.

16.25: a) Refer to Fig. (16.18). i) The fundamental has a displacement node at $\frac{L}{2} = 0.600\ \text{m}$, the first overtone mode has displacement nodes at $\frac{L}{4} = 0.300\ \text{m}$ and $\frac{3L}{4} = 0.900\ \text{m}$ and the second overtone mode has displacement nodes at $\frac{L}{6} = 0.200\ \text{m}, \frac{L}{2} = 0.600\ \text{m}$ and $\frac{5L}{6} = 1.000\ \text{m}$. ii) Fundamental: $0, L = 1.200\ \text{m}.$ First : $0, \frac{L}{2} = 0.600\ \text{m}, L = 1.200\ \text{m}.$ Second : $0, \frac{L}{3} = 0.400\ \text{m}, \frac{2L}{3} = 0.800\ \text{m}, L = 1.200\ \text{m}.$

b) Refer to Fig. (16.19); distances are measured from the right end of the pipe in the figure. Pressure nodes at: Fundamental: $L = 1.200\ \text{m}$. First overtone: $L/3 = 0.400\ \text{m}$, $L = 1.200\ \text{m}$. Second overtone: $L/5 = 0.240\ \text{m}$, $3L/5 = 0.720\ \text{m}$, $L = 1.200\ \text{m}$. Displacement nodes at Fundamental: 0. First overtone: 0, $2L/3 = 0.800\ \text{m}$. Second overtone: 0, $2L/5 = 0.480\ \text{m}$, $4L/5 = 0.960\ \text{m}$

16.29: a) For a stopped pipe, the wavelength of the fundamental standing wave is $4L = 0.56\ \text{m}$, and so the frequency is $f_1 = (344\ \text{m/s})/(0.56\ \text{m}) = 0.614\ \text{kHz}$.
b) The length of the column is half of the original length, and so the frequency of the fundamental mode is twice the result of part (a), or 1.23 kHz.

16.31: a) For constructive interference, the path difference $d = 2.00\ \text{m}$ must be equal to an integer multiple of the wavelength, so $?_{\text{n}} = d/n$,

$$f_n = \frac{v}{?_{\text{n}}} = \frac{vn}{d} = n\left(\frac{v}{d}\right) = n\frac{344\ \text{m/s}}{2.00\ \text{m}} = n(172\ \text{Hz}).$$

Therefore, the lowest frequency is 172 Hz.
b) Repeating the above with the path difference an odd multiple of half a wavelength, $f_n = (n + \frac{1}{2})(172\ \text{Hz})$. Therefore, the lowest frequency is $86\ \text{Hz}\ (\text{n} = 0)$.

16.37: a) A frequency of $\frac{1}{2}(108\ \text{Hz} + 112\ \text{Hz}) = 110\ \text{Hz}$ will be heard, with a beat frequency of 112 Hz–108 Hz = 4 beats per second.
b) The maximum amplitude is the sum of the amplitudes of the individual waves, $2(1.5\times10^{-8}\ \text{m}) = 3.0\times10^{-8}\ \text{m}$. The minimum amplitude is the difference, zero.

16.45: a) $v_{\text{L}} = 18.0\ \text{m/s}$, $v_{\text{S}} = -30.0\ \text{m/s}$, and Eq. (16.29) gives $f_{\text{L}} = \left(\frac{362}{314}\right)(262\ \text{Hz})$ $= 302\ \text{Hz}$. b) $v_{\text{L}} = -18.0\ \text{m/s}$, $v_{\text{S}} = 30.0\ \text{m/s}$ and $f_{\text{L}} = 228\ \text{Hz}$.

16.49: a) Combining Eq. (16.14) and Eq. (16.15),

$$p_{\max} = \sqrt{2\,?vI_0 10^{(ß/10)}} = \sqrt{2(1.20\ \text{kg/m}^3)(344\ \text{m/s})(10^{-12}\ \text{W/m}^2)10^{5.20}}$$
$$= 1.144\times10^{-2}\ \text{Pa},$$

or $= 1.14\times10^{-2}\ \text{Pa}$, to three figures.
b) From Eq. (16.5), and as in Example 16.1,

$$A = \frac{p_{\max}}{Bk} = \frac{p_{\max}v}{B2pf} = \frac{(1.144\times10^{-2}\ \text{Pa})\,(344\ \text{m/s})}{2p(1.42\times10^5\ \text{Pa})(587\ \text{Hz})} = 7.51\times10^{-9}\ \text{m}.$$

c) The distance is proportional to the reciprocal of the square root of the intensity, and hence to 10 raised to half of the sound intensity levels divided by 10. Specifically,

$(5.00\ \text{m})10^{(5.20-3.00)/2} = 62.9\ \text{m}.$

16.74: a) (See also Example 16.19 and Problem 16.66.) The wall will receive and reflect pulses at a frequency $\frac{v}{v-v_{\text{w}}} f_0$, and the woman will hear this reflected wave at a frequency

$$\frac{v+v_{\text{w}}}{v} \cdot \frac{v}{v-v_{\text{w}}} f_0 = \frac{v+v_{\text{w}}}{v-v_{\text{w}}} f_0;$$

The beat frequency is

$$f_{\text{beat}} = f_0\left(\frac{v+v_{\text{w}}}{v-v_{\text{w}}} - 1\right) = f_0\left(\frac{2v_{\text{w}}}{v-v_{\text{w}}}\right).$$

b) In this case, the sound reflected from the wall will have a lower frequency, and using $f_0(v-v_{\text{w}})/(v+v_{\text{w}})$ as the detected frequency (see Example 21-12; v_{w} is replaced by $-v_{\text{w}}$ in the calculation of part (a)),

$$f_{\text{beat}} = f_0\left(1 - \frac{v-v_{\text{w}}}{v+v_{\text{w}}}\right) = f_0\left(\frac{2v_{\text{w}}}{v+v_{\text{w}}}\right).$$