PHYS 145 - Modern Physics - S'08 - Homework #03

17-7 Call the distance between the location of the earthquake and the location of the seismograph L. Then, if v_s is the speed of a longitudinal wave and t_s is the time after the earthquake that the S wave is observed, $L = v_s t_s$. Similarly $L = v_p t_p$. We are given v_s and v_p and the time difference $\Delta t = t_s - t_p$. So,

$$v_s t_s = v_p t_p = v_p (t_s - \Delta t)$$

$$\Rightarrow (v_s - v_p) t_s = - v_p \Delta t$$

$$t_s = \frac{v_p}{v_p - v_s} \Delta t = \frac{8.0 \text{ km/s}}{8.0 \text{ km/s} - 4.5 \text{ km/s}} \cdot 180 \text{ s}$$

$$t_s = 411 \text{ s}.$$

Thus $L = v_s t_s = 4.5 \text{ km/s} \cdot 411 \text{ s} = \boxed{1850 \text{ km}}$ is the distance from the seismograph to the earthquake location.

17-12 a) From figure 17-31 we see that the wave must travel a distance $d = D \sin\theta$, leading to a time difference $\Delta t = d/v = \boxed{\frac{D}{v} \sin\theta}$.

b) Clearly $\boxed{\Delta t = D/v_w}$

c) Since the brain only knows Δt we equate these two expressions:

$$\frac{\cancel{D}}{v} \sin\theta = \frac{\cancel{D}}{v_w}$$

$$\sin\theta = v/v_w$$

From inside back cover of book $v = 343$ m/s

$v_w = 1460$ m/s

$$\Rightarrow \quad \theta = \sin^{-1}\left(\frac{343 \text{ m/s}}{1460 \text{ m/s}}\right)$$

$$\boxed{\theta = 13.6^\circ}$$

17-38 a) Tube is said to be open at both ends, so we can use eqn 17-39 $f = \frac{v}{2L} n$ $n = 1, 2, 3, \ldots$

We are given $L = 2.0$ m, $v = 343$ m/s, and $n = 1$ for the fundamental. So,

$$f = \frac{343 \text{ m/s}}{2 \cdot 2.0 \text{ m}} = \boxed{86 \text{ Hz}}$$

b) 86 Hz is in the audio range on the low end.

c) If the tube is shorter then the frequency out will be higher since $f \propto 1/L$.

17-41 For a pipe open at both ends $f_n = f_1 \cdot n$. $n = 1, 2, 3, \ldots$
For a pipe open at one end $f_n = f_1 \cdot n$ $n = 1, 3, 5, \ldots$
In pipe A the ratio of two successive resonance frequencies is 1.2 which we recognize is $6/5$. Since this fits the pattern for frequencies with the pipe open at both ends, we conclude that pipe A is open at both ends. In pipe B we are told the ratio of frequencies is 1.4 or $14/10$ or $7/5$. This fits in the pattern of sequential odd integers characteristic of a pipe open only at one end.

17-44 The tuning fork will excite a standing wave anytime there is a resonance at 686 Hz. For a tube that is open at one end only the resonant frequencies are given by $f_n = \frac{v}{4L} n$ with $n = 1, 3, 5, \ldots$. The tricky thing here is that L varies. Define L_n to be the length associated with the n^{th} harmonic, then

$$686\ \text{Hz} = \frac{343\ \text{m/s}}{4 \cdot L_n} n$$

$$\Rightarrow L_n = \frac{343\ \text{m/s}}{4 \cdot 686\ \text{Hz}} n = \frac{n}{8}\ \text{m}$$

So standing waves will occur for $L = \frac{1}{8}$ m, $\frac{3}{8}$ m, $5/8$ m, and $7/8$ m for a total of **4 resonances.** The lowest amount of water is when $L = 7/8$ m, so $h_{water} = 1/8$ m. The second least $h_w = 3/8$ m