## Chapter 12

1. Assume the temperature to be 20ºC so sound travels at 343 m/s. The time for the sound to travel to the cliff at the other end of the lake is half the time it takes to hit the cliff and travel back.

2. Find the speed of sound in seawater using Table 12-1 on page 323 and do this problem like #1.

3. Use $v = \lambda f$. Find the speed of sound in air at 20oC from Table 12-1 and solve for $\lambda$.

4. a) Use Table 12-1 on page 341 to find speed of sound in seawater. You're given the distance, find the time it takes for sound to travel that far.
   b) Find the time it takes for sound to travel that far in air and compare the two answers

5. This is similar to the bowling ball problem (#15) in chapter 2. 3.5 s = the time to fall plus the time for sound to return, or 3.5s = $\sqrt{\frac{2h}{g}} + \frac{h}{v_s}$. Solve for h. You'll need the quadratic.

8. Use equation 12-1 on page 350 for intensity level (dB) and rearrange it for intensity ($W/m^2$). You're given intensity level and you know the intensity of silence ($I_o$) is $1x10^{-12}$ $W/m^2$. Solve for intensity at each level given and compare the two answers.

9. Use equation 12-1 on page 350 for intensity level. You're given the intensity and you know the intensity of silence (see Homework Hint for problem #9). Solve for dB.

14. a) The energy per second is the same thing as power, in Watts. Find the intensity level of the sound (measured in $W/m^2$), and then multiply by the area of the eardrum to get the number of Watts.
    b) Your answer to part (a) is in J/s. You're given energy in Joules. Divide J by J/s to get time.

16. The sound wave travels out in a spherical path from its source, and decreases in intensity as the wave "stretches" to a larger and larger surface area.
    a) List your variables and find the intensity of sound at 130 dB. The units are $W/m^2$. Multiply by the surface area of the sphere with a 2.5 m radius to the power output.
    b) Calculate the intensity of 90 dB. Using Intensity = $W/m^2$ and your value for power in part (b), calculate the radius of the surface area of the spherical sound wave that produced the 90 dB sound from the loudspeaker.

24. This problem will take two steps.

i) The wavelength of a fundamental frequency is always twice the length of the string. You're given the length of the string and the frequency, find the velocity of the wave using equation 11-12 page 325. Convert the length of the string to meters.

ii) Rearrange equation 11-13 for velocity of a wave and solve for tension force. Convert the mass to kilograms. Substitute the variables given and solve for tension.

25. **For open pipes**, the wavelengths change by ½ L for each subsequent overtone. If the wavelength of the fundamental frequency is2X the length of the pipe, the wavelength of the first overtone will be 2/2L, the second will be 2/3L, the third will be 2/4 L and so on.

**For closed pipes**, The wavelengths change by ¼ L for each subsequent overtone. The fundamental frequency starts at $\lambda = 4L$ instead of the 2L for an open pipe. If the wavelength of the fundamental frequency is 4/1 X the length of the pipe, the wavelength of the first overtone will be 4/3L, the second will be 4/5L, the third will be 4/7L and so on.

26. a) The empty soda bottle acts as a closed pipe, which is ¼ the wavelength of the fundamental sound heard.

b) If the bottle is 1/3 full of soda, it is a closed pipe $^1/_3$ the length of the bottle in part (a). Solve for the frequency of the sound.

27. $f = \dfrac{v}{2L}$ for the fundamental frequency of an open pipe. Rearrange the equation for length, use the speed of sound in air at 20$^o$C and the frequencies given. Solve for length.

30. a) Calculate the speed of sound in air at 21$^o$C. The length an open organ pipe is half the wavelength of the sound.

b) You were given the frequency in part (a). Calculate the speed of sound at 21$^o$C and then the wavelength using $v = \lambda f$ or $\lambda = 2L$.

c) It is air that is resonating inside the pipe to make the sound; $\lambda$ and $f$ will remain the same outside the pipe.

33. a) For an open pipe, $\lambda = 2L$. Find the speed of sound in air at 20$^o$C to solve for $\lambda$ and then L.

b) Find the speed of sound in helium using Table 12-1. Then use $\lambda = 2L$ and $v = \lambda f$ to find the fundamental frequency.

35. a) For an open tube, the difference between successive harmonic frequencies is equal to the fundamental frequency.
b) $v = \lambda f$

43. We know $v = f\lambda$ and $v = \sqrt{\frac{F_T}{m/L}}$. Therefore, $f\lambda = v = \sqrt{\frac{F_T}{m/L}}$.

It is the same string, so neither the wavelength nor the m/L will change. We can now say $f$ is proportional to $\sqrt{F_T}$ and $f_1/\sqrt{F_{T1}} = f_2/\sqrt{F_{T2}}$. Through simple algebraic wizardry we get: $f_2 = f_1 \sqrt{F_{T2}} / \sqrt{F_{T1}}$

Now we know $F_{T2}$ = 1.5% less than $F_{T1}$, so $F_{T2} = 0.985\ F_{T1}$. Substitute $0.985\ F_{T1}$ for $F_{T2}$ and solve for $f_2$.

46. a) The difference in the distances between the two speakers corresponds to ½ λ of the lowest frequency heard (see class notes for day 20 of second semester). Assume sound travels at 343 m/s and solve for $f$.
b) Destructive interference will occur at all ½ wavelengths: 3/2 λ, 5/2 λ, 7/2 λ, etc.

49. Use equations 12-2a and 12-2b to find the answers in both cases.

50. Use equations 12-3a and 12-3b to find the answers in both cases.

53. Use the Doppler equation found on page 367 for the sound source that is moving away.

52. Use the Doppler equation for the sound source moving toward the observer to solve for $f$. Then subtract the two frequencies to get $f_B$.

51. This asks you to solve 6 Doppler problems. The first two use the same velocity; first coming toward you and second moving away. The next 4 involve 2 faster speeds moving toward you and then away. Solve all 6 and compare your results to answer the questions in the problem.

68. The intensity of a 0 dB (1 mosquito) sound is $1\text{x } 10^{-12}$ W/m$^2$. The intensity of 1000 mosquitoes will be 1000 x $1\text{x } 10^{-12}$ W/m$^2$. Use this information to solve for the intensity level of 1000 mosquitoes.

76. This is a closed tube situation.

Using the distances given, you can figure out the length of 1/2 wavelength and then 1 wavelength.

The sound is travelingin air, use the velocity of sound in air = 343 m/s and solve for frequency.