Physics 100A – Summer 2016
Chapter 14

Solutions are provided only for problems from your textbook. The other problems already have so much guidance and notes that you should be able to understand where you have gone wrong.

Problems

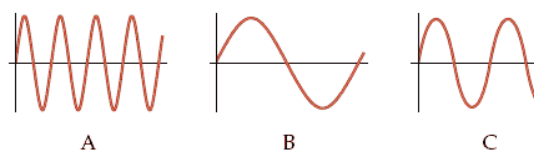
2. **Picture the Problem**: A surfer measures the frequency and length of the waves that pass her. From this information we wish to calculate the wave speed.

   Strategy: Use equation 14-1 to write the wave speed as the product of the wavelength and frequency.

   Solution: Multiply wavelength by frequency: $v = \lambda f = (34 \text{ m})(14 \text{ /min})\left(\frac{1 \text{ min}}{60 \text{ sec}}\right) = \boxed{7.9 \text{ m/s}}$

   Insight: The wave speed can increase by either an increase in wavelength or an increase in frequency.

12. **Picture the Problem**: The three waves, A, B, and C, shown in the figure at right propagate on strings with equal tensions and equal mass per length.

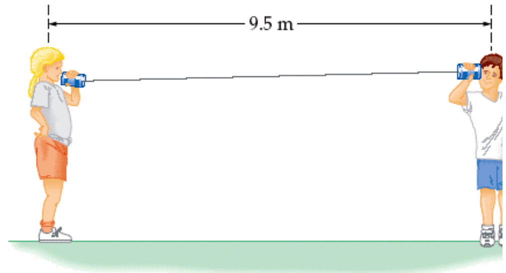


   Strategy: Use $v = \lambda f$ (equation 14-1) and the principles of wave propagation to determine the requested rankings.

   Solution: 1. (a) With equal tensions and equal mass per length, waves on the three strings have the same speed, $v = \lambda f$. The wave with the longest wavelength therefore has the lowest frequency. The ranking for frequency is $\boxed{B < C < A}$.
   2. (b) Wavelength is simply the distance from crest to crest. Therefore the ranking for wavelength is $\boxed{A < C < B}$.
   3. (c) As stated in part (a) the wave speeds are the same. Therefore the ranking for speed is $\boxed{A = B = C}$.
   Insight: If these were sound waves, the ranking for sound pitch would be the same as for frequency: B < C < A.

14. **Picture the Problem**: The image shows two people talking on a tin can telephone. The

cans are connected by a 9.5-meter-long string weighing 32 grams.



Strategy: Set the time equal to the distance divided by the velocity, where the velocity is given by equation 14-2. The linear mass density is the total mass divided by the length.

Solution: 1. Set the time equal to the distance divided by velocity:

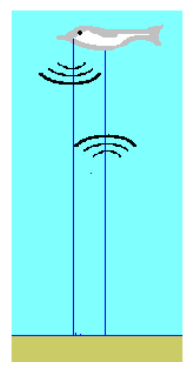
$$t = \frac{d}{v} = d\sqrt{\frac{\mu}{F}}$$

2. Substitute $\mu = m/d$ and insert numerical values:

$$t = d\sqrt{\frac{m/d}{F}} = \sqrt{\frac{md}{F}} = \sqrt{\frac{(0.032\text{ kg})(9.5\text{ m})}{8.6\text{ N}}} = \boxed{0.1}$$

Insight: The message travels the same distance in the air in 0.028 seconds, about 7 times faster.

27. **Picture the Problem**: The dolphin sends a signal to the ocean floor and hears its echo.



Strategy: The sound wave of the click must travel to the ocean floor and back before it is heard. So the distance traveled is twice the distance to the floor. Divide this distance by the speed of sound in water to calculate the time. Calculate the wavelength from equation 14-1.

Solution: 1. (a) Divide the distance
by the speed of sound in water:

$$t = \frac{2d}{v} = \frac{2(75\text{ m})}{1530\text{ m/s}} = \boxed{0.098\text{ s}}$$

2. (b) Solve equation 14-1 for the wavelength:

$$\lambda = \frac{v}{f} = \frac{1530\text{ m/s}}{55\text{ kHz}} = 28\times10^{-3}\text{ m} = \boxed{28\text{ n}}$$

Insight: In air the wavelength would be 6.2 mm. The wavelength is longer in the water because the wave travels faster in water, while the frequency is the same.

38. **Picture the Problem**: We are given the sound intensity of one hog caller and are asked to calculate how many hog callers are needed to increase the intensity level by 10 dB.

Strategy: Multiply the intensity in equation 14-8 by N callers, setting the intensity level to 120 dB and solve for N.

Solution: 1. Write the intensity level for *N* callers:

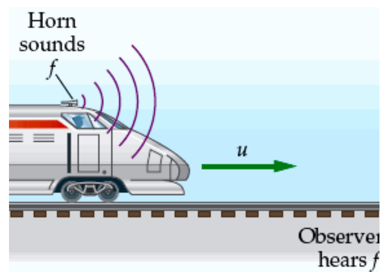
$$\beta = 10\log\left(\frac{NI}{I_0}\right) = 10\log(N) + 10\log\left(\frac{I}{I_0}\right)$$

2. Insert the intensity levels and solve for *N*:

$$120 = 10\log(N) + 110$$
$$10 = 10\log(N)$$
$$N = 10^{10/10} = \boxed{10 \text{ callers}}$$

Insight: Increasing the intensity level by 10 dB increases the intensity by a factor of 10. Therefore 10 callers, each with intensity level 110 dB, would produce a net intensity level of 120 db. 100 callers (10 × 10 callers) would be needed to produce an intensity level of 130 dB (120 dB + 10 dB).

45. **Picture the Problem**: The train, a moving source, sounds its horn. We wish to calculate the frequency heard by a person standing near the tracks.



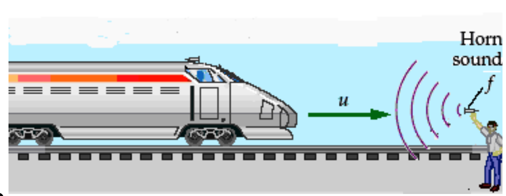
Strategy: Solve equation 14-10 for the observed frequency, using the negative sign because the train is moving toward the observer.

Solution: Insert the given data into equation 14-10:

$$f' = \left(\frac{1}{1-u/v}\right) f = \left[\frac{1}{1-(31.8 \text{ m/s})/(343 \text{ m/s})}\right](1$$
$$= \boxed{1.50\times10^2 \text{ Hz}}$$

Insight: If the train were moving away from the observer, he would hear a frequency of 124 Hz.

46. **Picture the Problem**: A stationary person sounds a 136-Hz horn as a train approaches him at 31.8 m/s. We want to know at what frequency a passenger on the train hears the horn.



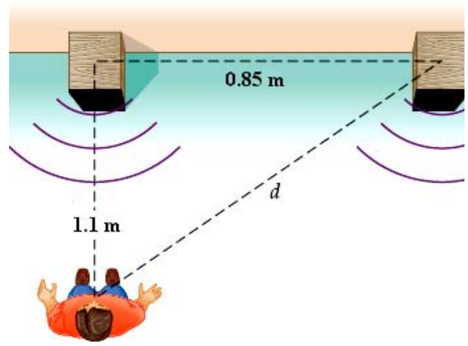
Strategy: This problem has a stationary source and an approaching observer, the passenger. Use equation 14-9 (with a plus sign) for the observed frequency.

Solution: Insert the given data into equation 14-9:

$$f' = (1 + u/v)\, f$$
$$= \left[1 + (31.8 \text{ m/s}/343 \text{ m/s})\right](136 \text{ Hz}) = \boxed{149 \text{ Hz}}$$

Insight: The frequency is slightly lower than the frequency found in problem 45, where the source was moving.

61. **Picture the Problem**: The image shows two speakers 0.85 meters apart. You are standing 1.1 meters in front of one of the speakers. We want to calculate the lowest frequency from the speakers which will produce constructive interference at your location.



Strategy: Use the Pythagorean Theorem to calculate your distance from the second speaker. Subtract from this distance your distance to the close speaker to find the difference in distances. Set this difference equal to one wavelength and solve equation 14.1 for the frequency.

Solution: 1. Solve Pythagorean Theorem for the distance *d*:

$$d = \sqrt{(0.85\text{ m})^2 + (1.1\text{ m})^2} = 1.39\text{ m}$$

2. Subtract the distance to the close speaker:

$$\lambda = \Delta d = 1.39\text{ m} - 1.1\text{ m} = 0.29\text{ m}$$

3. Solve equation 14.1 for the frequency:

$$f = \frac{v}{\lambda} = \frac{343\text{ m/s}}{0.290\text{ m}} = \boxed{1.2\text{ kHz}}$$

Insight: Constructive interference occurs whenever the difference in distances to the two speakers is an integer multiple of the wavelength.

$\boxed{75.}$ **Picture the Problem**: The figure shows a standing wave inside an organ pipe 2.75 m long. We want to calculate the frequency of the wave and the fundamental frequency of the pipe.

Strategy: The pipe has a node at one end and an antinode at the other, so it is closed at one end. The wave corresponds to the third harmonic because there is one node inside the pipe. Use equation 14-14 to calculate the frequency of this harmonic, setting $n = 3$. Then calculate the fundamental frequency using $n = 1$.

Solution: 1. (a) Solve equation 14-14 with $n = 3$:

$$f_3 = \frac{3v}{4L} = \frac{3(343\text{ m/s})}{4(2.75\text{ m})} = \boxed{93.5\text{ Hz}}$$

2. (b) Solve equation 14-14 with $n = 1$:

$$f_1 = \frac{v}{4L} = \frac{343\text{ m/s}}{4(2.75\text{ m})} = \boxed{31.2\text{ Hz}}$$

Insight: The next harmonic possible on this pipe is the fifth harmonic, whose frequency is 156 Hz.