SOLUTIONS

Quiz Number 3 PHYSICS 109 October 5, 2001

Please BOX your answers.

1. A pulse travels on a string under tension. The transverse displacement of the string from its equilibrium position is given by $y(x - 150t)$ where $x$ is in meters and $t$ is in seconds.

   a) The pulse $(y)$ is plotted as a function of $x$ for $t = 0$ in the top panel. In the middle and bottom panels, draw the pulse as a function of $x$ for $t = 0.04$ s (2 points) and as a function of $t$ for $x = 0$ (2 points).

   ![Graphs](image)

   b) If the mass per unit length of the string, is 0.01 kg/m, what is the tension in the string? (2 points)

   From above, the wave speed is 150 m/s and $T = \mu v^2 = 225 \text{ N}$. 

Rewrite and sign the Honor Pledge: I pledge my honor that I have not violated the Honor Code during this examination.

Signature

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2. One day, you’re enjoying a soft drink when you blow across the top of the bottle generating a tone. Having just finished Learning Guide 8, you decide to calculate the frequency of the tone you hear. You assume the speed of sound in air is \(v = 340 \, \text{m/s}\) and you estimate your empty soft drink bottle approximates a tube, closed on one end, open on the other, and \(L = 0.20 \, \text{m}\) high. What is the lowest frequency you can get from your soft drink bottle? (2 points)

Lowest frequency means largest wavelength. When the air in the tube is vibrating at resonance, the closed end must be a displacement node, or a pressure antinode, while the open end is approximately a pressure node. To meet these conditions, the standing wave in the tube must contain a quarter of a wavelength plus an integral number of half wavelengths. Since the longest wavelength is desired, \(L = \lambda/4 = v/(4f)\), \(f = v/4L = \boxed{425 \, \text{Hz}}\).

3. You are standing along the side of a road when a speeding ambulance goes by. Before it passed you, you heard the siren at a frequency \(f_1 = 1060 \, \text{Hz}\). After it passes, the frequency of the siren you hear is \(f_2 = 950 \, \text{Hz}\). How fast was the ambulance going? Assume \(v_{\text{sound}} = 340 \, \text{m/s}\) and there is no wind. (2 points)

There are Doppler shifts since the source is moving. Let \(f_0\) be the frequency emitted by the siren and let \(u\) be the speed of the ambulance. Then

\[
\begin{align*}
  f_1 &= \frac{f_0}{1 - u/v}, \\
  f_2 &= \frac{f_0}{1 + u/v}.
\end{align*}
\]

Divide one by the other to get

\[
\frac{f_1}{f_2} = \frac{1 + u/v}{1 - u/v},
\]

and solve for \(u\)

\[
u = v \frac{f_1/f_2 - 1}{f_1/f_2 + 1} = \boxed{18.6 \, \text{m/s}}.
\]