PHYS 201 Winter 2010

Recitation Problems (Week 3)

All problems taken from *University Physics,* Young and Freedman, 12th Ed.

15.3. **IDENTIFY:** $v = f\lambda = \lambda/T$.

SET UP: $1.0\text{ h} = 3600\text{ s}$. The crest to crest distance is λ.

EXECUTE: $v = \dfrac{800\times10^3\text{ m}}{3600\text{ s}} = 220\text{ m/s}$. $v = \dfrac{800\text{ km}}{1.0\text{ h}} = 800\text{ km/h}$.

EVALUATE: Since the wave speed is very high, the wave strikes with very little warning.

15.8. **IDENTIFY:** The general form of the wave function for a wave traveling in the $-x$-direction is given by Eq.(15.8). The time for one complete cycle to pass a point is the period T and the number that pass per second is the frequency f. The speed of a crest is the wave speed v and the maximum speed of a particle in the medium is $v_{max} = \omega A$.

SET UP: Comparison to Eq.(15.8) gives $A = 3.75\text{ cm}$, $k = 0.450\text{ rad/cm}$ and $\omega = 5.40\text{ rad/s}$.

EXECUTE: **(a)** $T = \dfrac{2\pi\text{ rad}}{\omega} = \dfrac{2\pi\text{ rad}}{5.40\text{ rad/s}} = 1.16\text{ s}$. In one cycle a wave crest travels a distance

$\lambda = \dfrac{2\pi\text{ rad}}{k} = \dfrac{2\pi\text{ rad}}{0.450\text{ rad/cm}} = 0.140\text{ m}$.

(b) $k = 0.450\text{ rad/cm}$. $f = 1/T = 0.862\text{ Hz} = 0.862\text{ waves/second}$.

(c) $v = f\lambda = (0.862\text{ Hz})(0.140\text{ m}) = 0.121\text{ m/s}$. $v_{max} = \omega A = (5.40\text{ rad/s})(3.75\text{ cm}) = 0.202\text{ m/s}$.

EVALUATE: The transverse velocity of the particles in the medium (water) is not the same as the velocity of the wave.

15.32. **IDENTIFY:** $y_{net} = y_1 + y_2$. The string never moves at values of x for which $\sin kx = 0$.

SET UP: $\sin(A \pm B) = \sin A\cos B \pm \cos A\sin B$

EXECUTE: **(a)** $y_{net} = A\sin(kx+\omega t) + A\sin(kx-\omega t)$.

$y_{net} = A[\sin(kx)\cos(\omega t) + \cos(kx)\sin(\omega t) + \sin(kx)\cos(\omega t) - \cos(kx)\sin(\omega t)] = 2A\sin(kx)\cos(\omega t)$

(b) $\sin kx = 0$ for $kx = n\pi$, $n = 0, 1, 2, \ldots$. $x = \dfrac{n\pi}{k} = \dfrac{n\pi}{2\pi/\lambda} = \dfrac{n\lambda}{2}$.

EVALUATE: Using $y = A\sin(kx \pm \omega t)$ instead of $y = A\cos(kx \pm \omega t)$ corresponds to a particular choice of phase and corresponds to $y = 0$ at $x = 0$, for all t.

15.33. **IDENTIFY and SET UP:** Nodes occur where $\sin kx = 0$ and antinodes are where $\sin kx = \pm 1$.

EXECUTE: Eq.(15.28): $y = (A_{SW} \sin kx)\sin \omega t$

(a) At a node $y = 0$ for all t. This requires that $\sin kx = 0$ and this occurs for $kx = n\pi$, $n = 0, 1, 2, \ldots$

$$x = n\pi / k = \frac{n\pi}{0.750\pi \text{ rad/m}} = (1.33 \text{ m})n,\ n = 0, 1, 2, \ldots$$

(b) At an antinode $\sin kx = \pm 1$ so y will have maximum amplitude. This occurs when $kx = \left(n + \frac{1}{2}\right)\pi$, $n = 0, 1, 2, \ldots$

$$x = \left(n + \tfrac{1}{2}\right)\pi / k = \left(n + \tfrac{1}{2}\right)\frac{\pi}{0.750\pi \text{ rad/m}} = (1.33 \text{ m})\left(n + \tfrac{1}{2}\right),\ n = 0, 1, 2, \ldots$$

EVALUATE: $\lambda = 2\pi / k = 2.66$ m. Adjacent nodes are separated by $\lambda/2$, adjacent antinodes are separated by $\lambda/2$, and the node to antinode distance is $\lambda/4$.

15.39. **IDENTIFY:** Use Eq.(15.1) for v and Eq.(15.13) for the tension F. $v_y = \partial y / \partial t$ and $a_y = \partial v_y / \partial t$.

(a) SET UP: The fundamental standing wave is sketched in Figure 15.39.

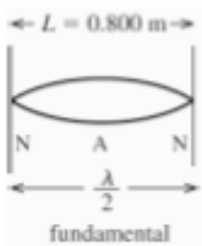

Figure 15.39

$f = 60.0$ Hz

From the sketch,

$\lambda / 2 = L$ so

$\lambda = 2L = 1.60$ m

EXECUTE: $v = f\lambda = (60.0 \text{ Hz})(1.60 \text{ m}) = 96.0$ m/s

(b) The tension is related to the wave speed by Eq.(15.13):

$v = \sqrt{F/\mu}$ so $F = \mu v^2$.

$\mu = m/L = 0.0400 \text{ kg}/0.800 \text{ m} = 0.0500$ kg/m

$F = \mu v^2 = (0.0500 \text{ kg/m})(96.0 \text{ m/s})^2 = 461$ N.

(c) $\omega = 2\pi f = 377$ rad/s and $y(x, t) = A_{SW} \sin kx \sin \omega t$

$v_y = \omega A_{SW} \sin kx \cos \omega t$; $a_y = -\omega^2 A_{SW} \sin kx \sin \omega t$

$(v_y)_{max} = \omega A_{SW} = (377 \text{ rad/s})(0.300 \text{ cm}) = 1.13$ m/s.

$(a_y)_{max} = \omega^2 A_{SW} = (377 \text{ rad/s})^2 (0.300 \text{ cm}) = 426 \text{ m/s}^2$.

EVALUATE: The transverse velocity is different from the wave velocity. The wave velocity and tension are similar in magnitude to the values in the Examples in the text. Note that the transverse acceleration is quite large.

15.75. **IDENTIFY:** The standing wave frequencies are given by $f_n = n\left(\frac{v}{2L}\right)$. $v = \sqrt{F/\mu}$. Use the density of steel to calculate μ for the wire.

SET UP: For steel, $\rho = 7.8 \times 10^3 \text{ kg/m}^3$. For the first overtone standing wave, $n = 2$.

EXECUTE: $v = \frac{2Lf_2}{2} = (0.550 \text{ m})(311 \text{ Hz}) = 171$ m/s. The volume of the wire is $V = (\pi r^2)L$. $m = \rho V$ so

$\mu = \frac{m}{L} = \frac{\rho V}{L} = \rho \pi r^2 = (7.8 \times 10^3 \text{ kg/m}^3)\pi (0.57 \times 10^{-3} \text{ m})^2 = 7.96 \times 10^{-3}$ kg/m. The tension is

$F = \mu v^2 = (7.96 \times 10^{-3} \text{ kg/m})(171 \text{ m/s})^2 = 233$ N.

EVALUATE: The tension is not large enough to cause much change in length of the wire.