# Chapter 15 In-Class Solutions

**Ex. 1** The speed of sound in air at 20°C is 344 m/s.

a.) $\lambda = ?$ when $f = 784$ Hz

$$v = f\lambda \qquad \lambda = \frac{v}{f} = \frac{344 \text{ m/s}}{784\text{ /s}} = \boxed{0.439 \text{ m}}$$

b.)

$$T = \frac{1}{f} = \frac{1}{784\text{ /s}} = 1.28 \times 10^{-3}\text{ s} = \boxed{1.28 \text{ ms}}$$

c.) $\lambda = ?$ if one octave higher $f \rightarrow 2 \times 784$ Hz

$$\lambda = \frac{v}{f} = \frac{344 \text{ m/s}}{2 \times 784\text{ /s}} = \boxed{0.219 \text{ m}}$$

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**Ex. 8** A certain transverse wave is described by:

$$y(x,t) = (6.50 \text{ mm}) \cos\left[2\pi\left(\frac{x}{28.0\text{cm}} - \frac{t}{0.0360\text{s}}\right)\right]$$

a.) $A = ?$ $\quad A = 6.50$ mm, the amplitude

b.) $\lambda = ?$ $\quad \lambda = 28.0$ cm, the wavelength

c.) $f = ?$ $\quad f = \frac{1}{T} = \frac{1}{0.0360\text{ s}} = 27.8$ Hz, the frequency

d.) $v = ?$ $\quad v = f\lambda = (27.8 \text{ s}^{-1})(0.280 \text{ m}) = 7.78$ m/s propagation speed

e.) direction = ? $\quad \cos\left[2\pi\left(\frac{x}{\lambda} \ominus \frac{t}{T}\right)\right]$ ↗ Propagates L → R +x

↑ minus sign

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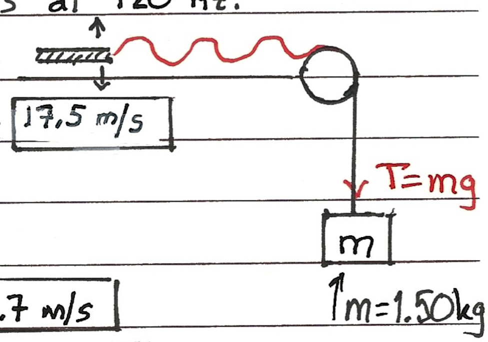
**Ex. 15** One end of a horizontal rope is attached to a prong of an electrically driven tuning fork that vibrates at 120 Hz.




a.)

$$v = \sqrt{F/\mu} = \sqrt{\frac{mg}{\mu}} = \sqrt{\frac{1.50 \text{ kg}(9.8) \text{ m/s}^2}{0.048 \text{ kg/m}}} = \boxed{17.5 \text{ m/s}}$$

b.)

$$\lambda = v/f = \frac{17.5 \text{ m/s}}{120 \text{ s}^{-1}} = \boxed{0.146 \text{ m}}$$

c.) $m \rightarrow 2 \times m$, then $v = \sqrt{2}\,(17.5 \text{ m/s}) = \boxed{24.7 \text{ m/s}}$

then $\lambda = \frac{24.7 \text{ m/s}}{120 \text{ Hz}} = \boxed{0.206 \text{ m}}$

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**Ex. 22**

A piano wire with mass 3.00 g and length 80.0 cm is stretched with a tension of 25.0 N.

$f = 120$ Hz $\qquad A = 1.6$ mm

a.) $P_{AV} = \frac{1}{2}\sqrt{\mu F}\,\omega^2 A^2 = \frac{1}{2}\sqrt{\frac{3.0\times10^{-3}\text{kg}}{0.80\text{m}}(25.0\text{N})}\,(2\pi\ 120\,s^{-1})^2(1.6\times10^{-3}\text{m})^2$

$P_{AV} = 0.223$ watts

b.) $P_{AV} \rightarrow ?$ if $A \rightarrow \frac{1}{2}A$ $\qquad P_{AV} \rightarrow \frac{1}{4}(0.223\text{ W}) = 0.0557\text{ W}$

**Ex. 30**

Interference of Triangular Pulses. Two triangular pulses are traveling toward each other on a stretched spring...

At $t = 0.000$ s, the leading edges of the pulses are 1.00 cm apart.

Sketch the shape of the string at $t = 0.250$ s, $t = 0.500$ s, $t = 0.75$ s, $t = 1.000$ s, and $t = 1.250$ s.

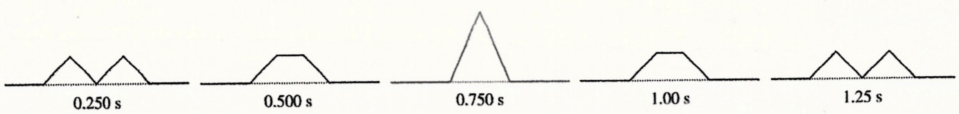


Figure 15.30

**Ex. 35**

Standing waves on a wire are described by

$$y(x,t) = A_{SW}(\sin(kx))\sin(\omega t)$$

with $A_{SW} = 2.50$ mm, $\omega = 942$ rad/s, and $K = 0.750\pi\ \frac{\text{rad}}{\text{m}}$

a.) Nodes occur at $kx = n\pi$ $(n = 0, 1, 2, 3, \ldots)$ $\qquad x = n\pi/k$

$$x = \frac{n\pi}{\frac{3}{4}\pi\ \frac{\text{rad}}{\text{m}}} = \frac{4}{3}n\ (\text{meters}) = (1.33\text{ m})\,n \quad (n = 0, 1, 2, \ldots)$$

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**Ex. 35 cont'd**

b.) Antinodes occur at where $kx = (n + \frac{1}{2})\pi \quad (n = 0, 1, 2, \ldots)$

$$x = \left(n + \tfrac{1}{2}\right)\frac{\pi}{k} = \left(n + \tfrac{1}{2}\right)\frac{\pi}{\frac{3}{4}\pi} = 1.33\,m\left(n + \tfrac{1}{2}\right) \quad (n = 0, 1, 2, \ldots)$$

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**Ex. 38** A piano tuner stretches a steel piano wire with a tension of 800 N.

$$\mu = \frac{3.00 \times 10^{-3}\ kg}{0.400\ m} = 7.50 \times 10^{-3}\ kg/m$$

a.) $f_1 = ?$ $\quad f_n = \frac{nv}{2L} \quad (n=1) \quad f_1 = \frac{v}{2L}$

Calculate v. $\quad v = \sqrt{\frac{\text{Tension}}{\mu}} = \sqrt{\frac{800\ N}{7.50 \times 10^{-3}\ kg/m}} = 327\ m/s$

$$f_1 = \frac{v}{2L} = \frac{327\ m/s}{2(0.400\,m)}$$

$$\boxed{f_1 = 409\ Hz}$$

b.) What is n, the highest harmonic that can be heard < 10,000 Hz ?

$f_n = f_1 n \qquad n = \frac{f_n}{f_1} = \frac{10{,}000\ Hz}{409\ Hz} = 24.5$

The 24th harmonic is the highest harmonic that can be heard.

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