Student No. SOLUTIONS Last Name _____ First Name _____

The University of British Columbia
Physics 101, Section 102 Nov 09, 2005 Midterm 2

No books or notes are permitted. Do all 4 questions.

1: The plots below show the displacement of a transverse wave as a function of time and position. The time plot was acquired at x = 0 but the **position plot was not acquired at *t* = 0.**

(a) Find the **Time period (T)** and **angular frequency** for this wave. (2)

$T = 0.32\ s$ $\omega = \frac{2\pi}{T} = 19.6\ rad/s$

(b) Find the **wavelength (λ)** for this wave. (2)

$\lambda = 1.25\ m$

(c) What is the **propagation velocity of this wave**? (2)

$$V = \lambda f = \frac{\lambda}{T} = \frac{1.25\ m}{0.32\ s} \cong 4.0\ m/s$$

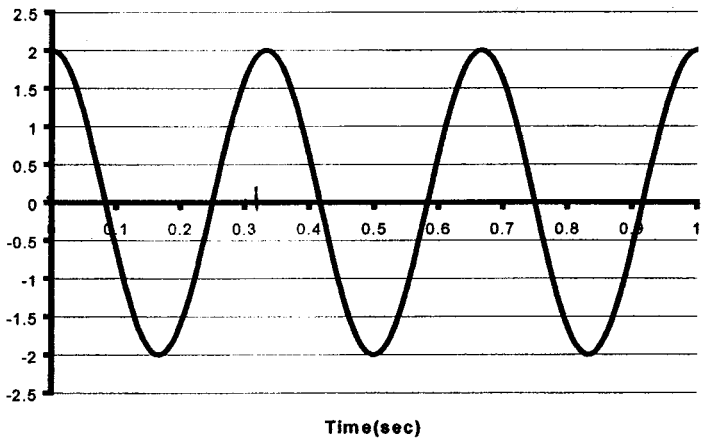
(d) Write down the complete equation, D(*x*,t) for this wave. (4)

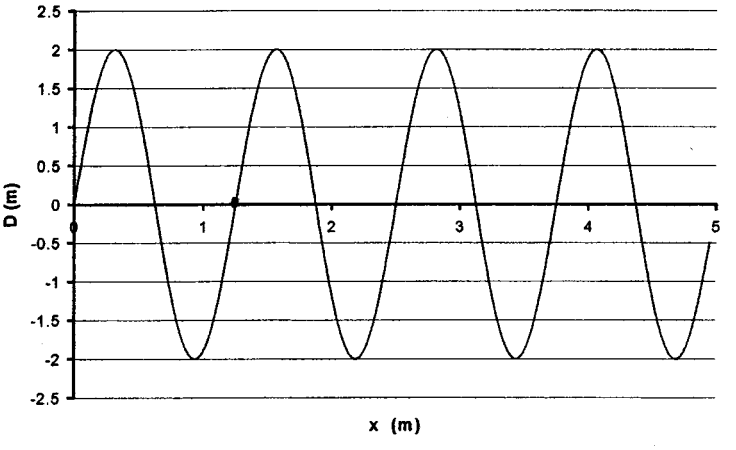
$$D(x,t) = 2.0 \sin\left(\frac{2\pi}{\lambda}x - \omega t + \phi\right)$$

$$= 2.0 \sin(5.03x - 19.6t + \phi).$$

$$D(0,0) = 2.0 \sin(\phi) = 2.0 \Rightarrow \phi = \frac{\pi}{2}\ \text{radians}$$

$$D(x,t) = 2.0 \sin\left(5.03x - 19.6t + \frac{\pi}{2}\right) \qquad \frac{\pi}{2} = 1.57$$





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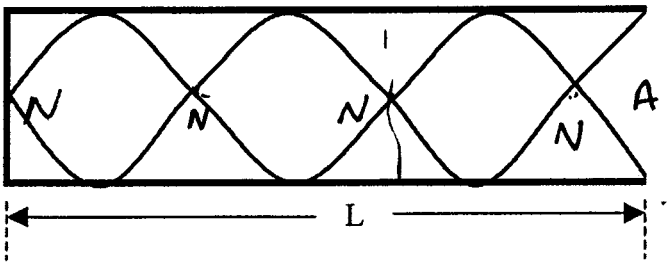
2: (a) A 100 Hz sound wave travels with a speed of 340 m/s. What is the phase difference between two points that are 0.6 m apart along the direction the wave is travelling?

(2)

$$\lambda = \frac{V}{f} = \frac{340\ m/s}{100} = 3.4\ m.$$

$$\Delta\Phi = \frac{2\pi}{\lambda}(\Delta x) = \frac{2\pi}{3.4}(0.6) = 0.35\pi = \boxed{1.108\ rad}$$

(b) The air pipe (20°C) illustrated below has a standing wave pattern with **4** nodes and **4** antinodes. The frequency of the sound emitted is 324 Hz.



i) What is the length L of this tube?

(4)

$$\frac{7}{4}\lambda = L \qquad \lambda = \frac{4L}{7}$$

$V = 340\ m/s, \quad f = 324\ Hz. \quad \lambda = \frac{V}{f} = 1.049\ m.$

$$\therefore \boxed{L = 1.836 m}$$

ii) What is the fundamental frequency for this tube?

(2)

$$f_7 = \frac{7}{4L} \times V = 324\ Hz.$$

$$f_1 = \frac{V}{4L} = \boxed{46.28\ Hz.}$$

iii) If the highest frequency detectable by human ears is 20,000 Hz, what is the highest harmonic that can be heard from this tube?

(2)

$$20000 = \frac{n}{4L} \times V = n * f_1$$

$$n = \frac{20000 \times 4L}{V} = 432$$

$$\therefore \boxed{n_H = 431} \quad n \text{ must be odd.}$$

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3: Sound pulses produced by a bat have a duration of 60×10^{-3} seconds. The velocity of the sound in air is 340 m/s.

How long is each pulse? (2)

$\lambda = V \times t = 340 \times 60 \times 10^{-3}$ m = **20.4 m**

If the energy carried by each pulse is 2.5×10^{-9} J, what is the power emitted by the bat? (2)

$P = \frac{E}{t} = \frac{2.5 \times 10^{-9}}{60 \times 10^{-3}} =$ **4.17×10^{-8} W**

What is the corresponding intensity intercepted by a person who is 10.0 m away from the bat? (2)

$I = \frac{P}{4\pi R^2} = \frac{4.17 \times 10^{-8}\ W}{4 \times \pi \times 100\ m^2} =$ **$3.32 \times 10^{-11} \frac{W}{m^2}$**

If the cross-sectional area of the person's ear is 1.0 cm^2, what is the power intercepted by the ear? (2)

$P_{ear} = A \cdot I = 10^{-4} \times 3.32 \times 10^{-11}$

$= 3.32 \times 10^{-15}$ W

4: A damped mass-spring oscillator starts with energy of 2.0 J. After one complete oscillation its energy is reduced by 10%. If the mass of the oscillator is 0.10 kg and the time period of the oscillations is 2.0 s what is the damping constant b? (2.5)

$E(t) = E(0)\, e^{-\frac{bt}{m}}$ $\qquad E(0) = 2.0$ J.

$T = 2.0$ s.

$E(2.0) = 2.0 \times e^{-\frac{2b}{m}} = 1.8$ J.

$e^{-\frac{2b}{m}} = \frac{1.8}{2} \Rightarrow -\frac{2b}{m} = \ln\left(\frac{1.8}{2}\right)$

$b = -\frac{m}{2} \ln\left(\frac{1.8}{2}\right) = -\frac{0.1}{2} \ln\left(\frac{1.8}{2}\right)$

$b = 0.0053 \frac{kg}{s}$