Circle instructor: Poduska or Morrow Name:____________________
Lab period: ____________ Student Number:____________________

MEMORIAL UNIVERSITY OF NEWFOUNDLAND
DEPARTMENT OF PHYSICS AND PHYSICAL OCEANOGRAPHY

Physics 1051 Winter 2009

Term Test 1 February 13, 2009

INSTRUCTIONS:
1. Do all questions. Marks are indicated in the left margin. Budget time accordingly.
2. Write your name and student number on each page.
3. You may use a calculator. All other aids are prohibited.
4. Write answers neatly in space provided. If necessary, continue onto the back of the page.
5. Do not erase or use "whiteout" to correct answers. Draw a line neatly through material to be replaced and continue with correction.
6. Assume all information given is accurate to 3 significant figures.
7. Don't panic. If something isn't clear, ASK!

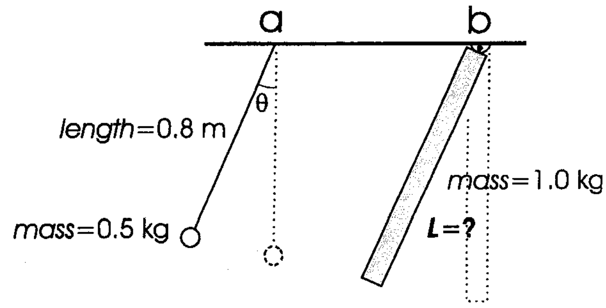
ANSWERS

SEE LAST PAGE FOR SOME POTENTIALLY USEFUL FORMULAE AND CONSTANTS

For office use only:

1	2	3	4	total

[10] 1. (a) Pendulum a is a simple pendulum consisting of a 0.5-kg mass suspended from a massless string of length 0.80 m. Pendulum b is a uniform 1.0-kg rod of length L hanging from a pivot at one end. Its moment of inertia about that pivot is $I = \frac{1}{3}mL^2$. Its period is the same as that of pendulum a. What is L?



IF $T_a = T_b$, then $\omega_a = \omega_b$

[3] $\omega_a = \sqrt{\frac{g}{L_a}}$ AND $\omega_b = \sqrt{\frac{m_b g d}{I}} = \sqrt{\frac{m_b g (L_b/2)}{\frac{1}{3} m_b L_b^2}} = \sqrt{\frac{3g}{2L_b}}$

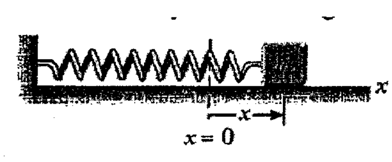
(note $d = L_b/2$, distance from pivot to c of mass)

So: $\sqrt{\frac{g}{L_a}} = \sqrt{\frac{3g}{2L_b}}$

$\therefore L_b = \frac{3}{2} L_a = \frac{3}{2}(0.8\text{cm})$

$\boxed{\therefore L_b = 1.20\,m}$

(b) A 0.2-kg mass attached to a spring is oscillating on a horizontal frictionless surface with a period of 0.7 s and an amplitude of 2.3 cm.



(i) What is the force constant of the spring?
(ii) What is the total mechanical energy of the system?
(iii) If the position of the mass is $x = 2.3$ cm at $t = 0$ s, what is the earliest positive time for which the velocity of the mass is $v_x = +20.6$ cm/s?

[2] (i) $\omega^2 = \frac{k}{m}$ AND $\omega = \frac{2\pi}{T} = 8.98\,s^{-1}$ $\therefore k = m\omega^2 = 0.2\,kg \times (8.98\,s^{-1})^2 = 16.1\,N/m$

[2] (ii) $E_{TOT} = \frac{1}{2}kA^2 = \frac{1}{2}(16.1\,N/m)(0.023\,m)^2 = 4.26 \times 10^{-3}\,J$

(iii) Assume $x = A\cos(\omega t + \phi)$

$x(t{=}0) = 0.023\,m$ $\therefore 0.023m = 0.023m\cos(0+\phi)$ $\therefore \phi = \cos^{-1}(1) = 0$

$\therefore v(t) = -\omega A \sin\omega t$ $\omega = \left(\frac{2\pi}{0.7s}\right) = 8.98\,s^{-1}$

$\therefore 0.206\,m/s = -8.98\,s^{-1} \times 0.023m \times \sin(8.98\,s^{-1} \times t)$

$\therefore 0.206\,m/s = -0.206\,m/s\ \sin(8.98\,s^{-1} \times t)$

$\therefore t = \frac{1}{8.98\,s^{-1}} \times \sin^{-1}(-1)$ $\sin^{-1}(-1) = -\frac{\pi}{2}, \frac{3\pi}{2}$, etc (radians)

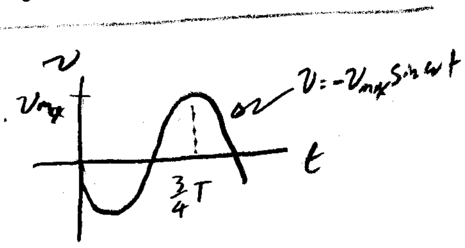
for smallest positive t, choose $\sin^{-1}(-1) = +\frac{3\pi}{2}$.

$\therefore t = \frac{1}{8.98\,s^{-1}} \times \frac{3\pi}{2}$

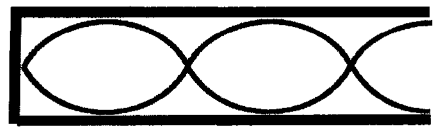
$\boxed{\therefore t = 0.525\,s}$

Alternate: if $\sin^{-1}(-1) = -\frac{\pi}{2}$ chosen $\Rightarrow$ $t = \frac{1}{8.98\,s^{-1}} \times \left(-\frac{\pi}{2}\right) + T = 0.525\,s$.

Alternate: could note that $0.206\,m/s = V_{max}$ and that $V = -V_{max}\sin\omega t$ so that $V = +V_{max}$ for $t = \frac{3}{4}T = 0.525\,s$.



[10] 2. (a) The diagram represents displacement amplitude versus position along the tube for a mode in a tube that is open at one end and closed at the other. The frequency of this mode is found to be 440 Hz.



(i) If the speed of sound in air is 343.2 m/s, what is the length of the tube?
(ii) Assuming the same speed of sound, what is the lowest frequency at which this tube will resonate?

[3] (i) FOR A TUBE WITH ONE END OPEN,

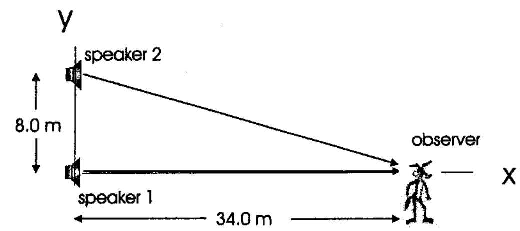
$f = \frac{nv}{4L}$, WHERE HERE $n = 5$, $v = 343.2\,m/s$, $f = 440\,Hz$ $\Rightarrow L = \frac{nv}{4f} = \frac{5(343.2\,m/s)}{4(440\,Hz)}$

$\boxed{L = 0.975\,m}$

[2] (ii) $f_1 = \frac{1 \cdot v}{4L} = \frac{343.2\,m/s}{4(0.975\,m)} = 88.0\,Hz$

(b) Two speakers, located as shown, emit sound waves in phase. Speaker 1 is at the origin and speaker 2 is 8.0 m along the *y*-axis as shown. An observer starts from speaker 1 and walks away from it along the x axis. The observer first notices a minimum in the sound intensity when 34.0 m from speaker 1. Take the speed of sound in air to be 343.2 m/s.

(i) What is the wavelength of the sound?
(ii) The observer now stays in place as the frequency emitted from the speakers is increased. What is the frequency when the sound at the location of the observer is a maximum?



[3] (i) MINIMUM INTENSITY MEANS $\frac{\lambda}{2}$ PATH LENGTH DIFFERENCE, SO

$\Delta r = \sqrt{(34\,m)^2 + (8\,m)^2} - 34\,m = 0.928\,m$

$\Delta r = \frac{\lambda}{2}$, SO $\lambda = 2\Delta r = 2(0.928\,m) = 1.86\,m$

[2] (ii) FOR MAXIMUM INTENSITY, $\Delta r = \lambda$, SINCE $\Delta r = 0.928\,m$, $\lambda = 0.928\,m$.

$f = \frac{v}{\lambda} = \frac{343.2\,m/s}{0.928\,m} = 370\,Hz$

[10] 3. A sinusoidal wave propagates along a very long string in the positive x-direction. The wavelength is observed to be 2.7 m and the period is 0.08 s. The linear density (mass per unit length) of the string is 0.0065 kg/m.

(a) What is the speed of propagation for this wave?
(b) If the maximum transverse speed of a point on the string is 4.0 m/s, what is the amplitude of the wave?
(c) What is the tension in the string?
(d) A second string is made of the same material but with twice the cross-sectional area of the original string. The second string is stretched with half of the tension applied to the original string. What is the wavelength for the second string if the period is kept at 0.08 s? (Show all steps in your calculation.)

[2] (a) $v = f\lambda = \frac{\lambda}{T} = \frac{2.7\,m}{0.08\,s} = 33.8\ m/s$

[2] (b) $v_{MAX} = -\omega A$, so $A = \frac{v_{MAX}}{\omega} = \frac{v_{MAX}\,T}{2\pi} = \frac{(4.0\,m/s)(0.08\,s)}{2\pi} = 0.0509\ m$

[2] (c) $v = \sqrt{\frac{T}{\mu}}$, so $v^2\mu = T = (33.8\,m/s)^2(0.0065\,kg/m) = 7.40\ \frac{kg\cdot m}{s^2}$

[4] (d) $v = f\lambda$, so $\lambda = \frac{v}{f} = \frac{vT}{2\pi}$. SINCE $\frac{T}{2\pi}$ IS CONSTANT, JUST LOOK AT CHANGE IN v.

$$\frac{v_{OLD}}{v_{NEW}} = \frac{\sqrt{\frac{T_{OLD}}{\mu_{OLD}}}}{\sqrt{\frac{\frac{1}{2}T_{OLD}}{2\mu_{OLD}}}} = \sqrt{\frac{1}{1/4}} = \sqrt{4} = 2$$, so $v_{NEW} = \frac{1}{2} v_{OLD}$

$\Downarrow$

$\lambda_{NEW} = \frac{1}{2}\lambda_{OLD}$

$\lambda_{NEW} = \frac{1}{2}(2.7\,m)$

$\lambda_{NEW} = 1.35\,m$

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[10] 4. One charge, $q_A = +2\,\mu\text{C}$, is located at the origin. A second charge, $q_B = +3\,\mu\text{C}$, is located at $x = 1.5\text{ m}$, $y = 0\text{ m}$. Point **P** is located on the y-axis at $y = 1.5\text{ m}$.

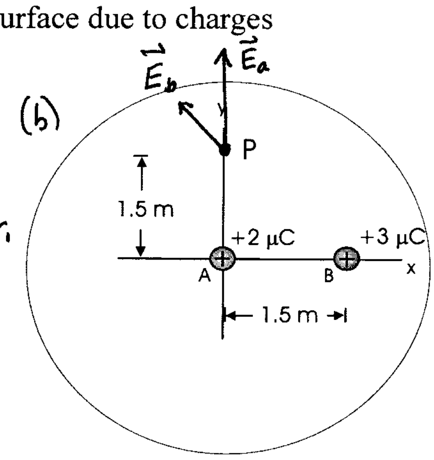
(a) Find the location on the x-axis where the electric field is zero.

(b) On the diagram, draw vectors representing $\vec{E}_A$ and $\vec{E}_B$ at point **P**.

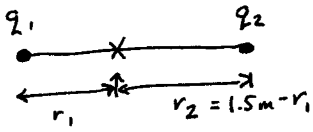
(c) What would be the magnitude of the force on a charge $q_C = -0.15\,\mu\text{C}$, placed at point **P**, due to charge q_B?

(d) Imagine a spherical surface, centred on the origin, with a radius larger than 1.5 m. What is the total electric flux through that surface due to charges q_A and q_B?

(b)



(a) $|\vec{E}| = \dfrac{kq}{r^2}$, so $\dfrac{q_1}{r_1^2} = \dfrac{q_2}{r_2^2}$



$$\frac{q_1}{q_2} = \left(\frac{r_1}{r_2}\right)^2 \Rightarrow \sqrt{\frac{q_1}{q_2}} = \frac{r_1}{r_2} \Rightarrow r_1 = r_2\sqrt{\frac{q_1}{q_2}}$$

$$r_1 = (1.5\text{m} - r_1)\sqrt{\frac{2\mu C}{3\mu C}} \Rightarrow r_1 = \frac{\sqrt{\frac{2}{3}}(1.5\text{m})}{1+\sqrt{\frac{2}{3}}} = 0.674\text{m} \qquad \boxed{x = 0.674\text{m}}$$

(c) $$|\vec{F}| = \left|\frac{k\, q_B q_C}{r_{BC}^2}\right| = \frac{\left(8.99\times10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)(0.15\times10^{-6}\,\text{C})(3\times10^{-6}\,\text{C})}{\left(\sqrt{(1.5\text{m})^2 + (1.5\text{m})^2}\right)^2} = \boxed{8.99\times10^{-4}\,\text{N} = |\vec{F}|}$$

(d) $$\Phi = \frac{q_{INSIDE}}{\varepsilon_0} = \frac{(2\times10^{-6}\,\text{C}) + (3\times10^{-6}\,\text{C})}{8.85\times10^{-12}\,\frac{\text{C}^2}{\text{N}\cdot\text{m}^2}} = \boxed{5.65\times10^{5}\,\frac{\text{N}\cdot\text{m}^2}{\text{C}} = \Phi}$$

Some Potentially Useful Formulae and Constants:

$$\frac{d^2x}{dt^2} = -\omega^2 x$$

$F_x = -k_{\text{spring}} x$ (Hooke's Law)

$\omega = \frac{2\pi}{T}$ (angular frequency)

$$\omega^2 = \frac{k_{spring}}{m}$$

$$\omega^2 = \frac{g}{L}$$

$$\omega^2 = \frac{mgd}{I}$$

$k = \frac{2\pi}{\lambda}$ (angular wave number)

$v = f\lambda$ (wave speed)

$$v = \sqrt{\frac{T}{\mu}}$$

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

$$\vec{F}_{12} = k_e \frac{q_1 q_2}{r^2}\hat{r}_{12}$$

$$\vec{E} = k_e \frac{q}{r^2}\hat{r}$$

$$\vec{E} = k_e \sum_i \frac{q_i}{r_i^2}\hat{r}_i$$

$$v_{\text{sound}} = 331\,\text{m/s} + 0.6\,\frac{\text{m}}{\text{s}\cdot{}^\circ\text{C}} \times T_{{}^\circ\text{C}}$$

$$\Phi_E = \int \vec{E} \cdot d\vec{A}$$

$$\Phi_E = \frac{q_{\text{inside}}}{\varepsilon_0}$$

$$V = k_e \frac{q}{r}$$

$$V = k_e \sum_i \frac{q_i}{r_i}$$

$$V_{\text{sphere}} = \frac{4}{3}\pi r^3$$

$$A_{\text{sphere}} = 4\pi r^2$$

Physical constants:

$$k_e = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$$

$$e = 1.60 \times 10^{-19}\ \text{C}$$

$$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2/\text{N}\cdot\text{m}^2$$

$$g = 9.81\,\text{m/s}^2$$