UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 111.6
MIDTERM TEST #3

January 25, 2007 Time: 90 minutes

NAME: MASTER
(Last) **Please Print** (Given)

STUDENT NO.: ____________

LECTURE SECTION (please check):

- ❑ 01 Dr. R. Pywell
- ❑ 02 B. Zulkoskey
- ❑ 03 Dr. A. Robinson
- ❑ C15 F. Dean

INSTRUCTIONS:

1. You should have a test paper, a formula sheet, and an OMR sheet. The test paper consists of 9 pages. **It is the responsibility of the student to check that the test paper is complete.**
2. Enter your name and STUDENT NUMBER on the OMR sheet.
3. The test paper, the formula sheet and the OMR sheet must all be submitted.
4. The test paper will be returned. The formula sheet and the OMR sheet will NOT be returned.

PLEASE DO NOT WRITE ANYTHING ON THIS TABLE

QUESTION NO.	MAXIMUM MARKS	MARKS OBTAINED
Part A	10	
Part B	10	
C1	5	
C2	5	
C3	5	
TOTAL	35	

continued on page 2...

PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

A1. Which one of the following statements regarding an object performing simple harmonic motion is **FALSE**?

B

(A) The acceleration has maximum magnitude when the displacement from the equilibrium position has maximum magnitude.
(B) The speed of the object is constant. $v = -A\omega \sin(\omega t)$
(C) The object has maximum kinetic energy at the equilibrium position.
(D) The graph of displacement versus time has a sinusoidal form.
(E) The acceleration is zero when the displacement from the equilibrium position is zero.

A2. Your physics professor is sitting on a rotating stool with arms crossed and has a total moment of inertia I_0 and angular velocity ω_0. The professor now extends his/her arms out, increasing the moment of inertia by 30%. Which one of the following is the correct expression for the new angular velocity? Assume no external torques are acting. $\Rightarrow L_f = L_o \Rightarrow I_f\omega_f = I_o\omega_o$

C

(A) $1.3I\omega_0$ (B) $1.3\omega_0$ (C) $\frac{\omega_0}{1.3}$ (D) $\frac{I}{1.3\omega_0}$ (E) $(I+1.3)\omega_0$

$\omega_f = \frac{I_o\omega_o}{I_f} = \frac{\omega_o}{1.3}$

A3. Which one of the following units is **NOT** a unit of pressure?

E

(A) Pascal (Pa)
(B) Pounds per square inch (psi)
(C) Newtons per square metre (N/m^2)
(D) Millimeters of mercury (mm Hg)
(E) Joules per square metre (J/m^2)

$P = F/A \Rightarrow [P] = \frac{[F]}{[A]} = N/m^2$

A4. "Any fluid applies an upward force to an object that is partially or completely immersed in it; the magnitude of this force equals the weight of the fluid displaced by the object." This statement is known as:

B

(A) Pascal's Principle
(B) Archimedes' Principle
(C) Poiseuille's Law
(D) Bernoulli's Principle
(E) The Equation of Continuity

p. 332 of text

A5. Which one of the following changes will increase the propagation speed of a periodic wave on a stretched string?

E

(A) decreasing the frequency
(B) decreasing the amplitude
(C) increasing the period
(D) increasing the amplitude
(E) increasing the tension in the string

$v = \sqrt{\frac{F}{m/L}}$

A6. A pipe open at both ends resonates with a fundamental frequency f_{open}. When one end is closed and the pipe is again made to resonate, the fundamental frequency is f_{closed}. How do these frequencies compare?

B

(A) $f_{closed} = f_{open}$
(B) $f_{closed} = ½ f_{open}$
(C) $f_{closed} = 2f_{open}$
(D) $f_{closed} = 3/2 f_{open}$
(E) $f_{closed} = 2/3 f_{open}$

$L = \frac{1}{2}\lambda_o \Rightarrow f_o = \frac{v}{2L}$

$L = \frac{1}{4}\lambda_c \Rightarrow f_c = \frac{v}{4L}$

so $f_c = \frac{1}{2}f_o$

continued on page 3...

D

A7. A pipeline carrying water has a section where it bends upward and its diameter decreases. Let A represent a location in the lower section of the pipeline (before the upward bend) and let B represent a location in the upper section of the pipeline (after the upward bend). Which one of the following statements is **TRUE** concerning the flow speed and pressure at these locations?

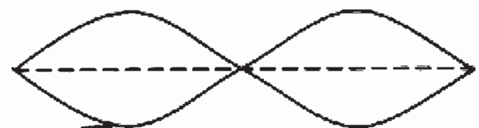
(A) Both the flow speed and pressure are greater at A than at B.
(B) Both the flow speed and pressure are less at A than at B.
(C) The flow speed is greater at A than at B, while the pressure is less at A than at B.
(D) The flow speed is less at A than at B, while the pressure is greater at A than at B.
(E) The flow speed is less at A than at B, and it is not possible to determine the relationship between the pressures at A and B.

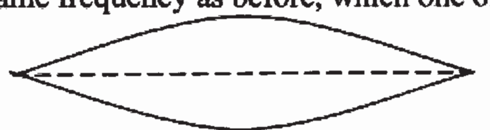
From continuity eq'n, $v\uparrow$, so $v_A < v_B$

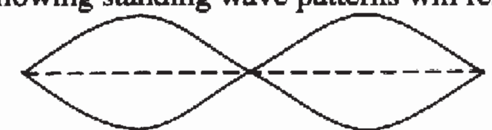
From Bernoulli, $P_A > P_B$.

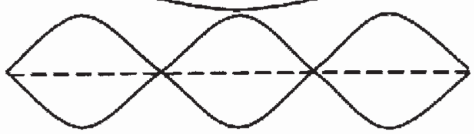
D

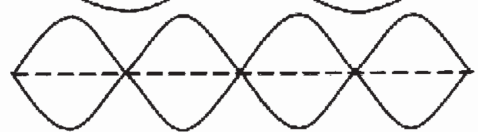
A8. A guitar string is made to vibrate with a frequency such that the string has the standing wave pattern as shown at right. While keeping the length and mass per unit length of the string the same, the tension in the string is decreased by a factor of 4. If the string is now made to vibrate with the same frequency as before, which one of the following standing wave patterns will result?



(A)


(B)


(C)


(D)


(E) No standing wave will result.

$v \propto \sqrt{F}$, so v decreases to $\frac{1}{2}$ the original value. f remains the same. $\therefore \lambda = \frac{v}{f}$ is $\frac{1}{2}$ the original value.

A

A9. Two identical speakers are producing identical, in-phase, single-frequency sound waves. The speakers are separated by a distance λ, where λ is the wavelength of the sound being produced by the speakers. Imagine a line connecting the speakers and consider the region to the right of the rightmost speaker and lying on this line. Which one of the following statements is **TRUE**?

(A) All points in the region will be locations of constructive interference.
(B) All points in the region will be locations of destructive interference.
(C) There will be alternating locations of constructive and destructive interference in this region.
(D) It is impossible to determine the nature of the interference pattern without knowing the frequency of the sound waves.
(E) It is impossible to determine the nature of the interference pattern without knowing the speed of the sound waves.

b/c $|\ell_1 - \ell_2| = \lambda$ for all points in this region.

C

A10. Three metal objects are brought near to each other two at a time. When object A is brought near object B, they repel. When object B is brought near object C, they also repel. Which one of the following statements is true?

(A) Objects A and C possess charges of the same sign which is opposite to the charge on B.
(B) Objects A and C possess charges of opposite sign.
(C) All three objects possess charges of the same sign.
(D) One of the objects has no charge.
(E) More experiments are necessary to determine which of the above statements is correct.

A, B repel ⇒ same sign
B, C repel ⇒ same sign
$\therefore$ A, C same sign.

continued on page 4...

Stu. No.: ____________________

PART B

FOR EACH OF THE FOLLOWING PROBLEMS, WORK OUT THE SOLUTION IN THE SPACE PROVIDED AND ENTER YOUR ANSWERS ON PAGE 6.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

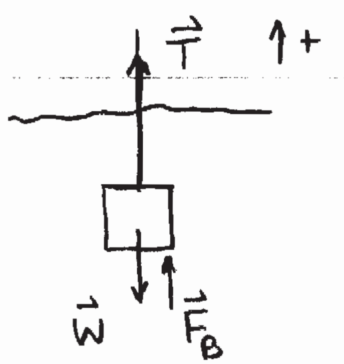
B1. Calculate the rotational kinetic energy of the Earth due to its rotation about its axis.

$$KE_{rot} = \frac{1}{2} I\omega^2$$

$$KE_{rot} = \frac{1}{2}\left(\frac{2}{5}(5.98\times10^{24}\,\text{kg})(6.38\times10^{6}\,\text{m})^2\right)\cdot\left(\frac{2\pi\,\text{rad}}{24\,\text{h}}\cdot\frac{1\,\text{h}}{3600\,\text{s}}\right)^2$$

$$KE_{rot} = 2.58\times10^{29}\,\text{J}$$

B2. A rock has a weight of 17.5 N. When it is suspended from a cord of negligible mass and completely submerged in water, the tension in the cord is 11.2 N. Calculate the volume of the rock.



$$\sum \vec{F} = 0$$

$$T + F_B - W = 0$$

$$T + \rho_{H_2O}\, g\, V_{dis} - W = 0$$

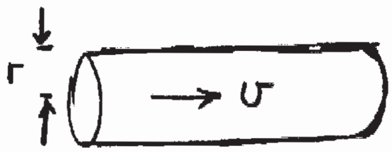
and $V_{dis} = V_{rock}$ since the rock is completely submerged.

$$\therefore \rho_{H_2O}\, g\, V_{rock} = W - T$$

$$V_{rock} = \frac{W-T}{\rho_{H_2O}\, g} = \frac{17.5\,\text{N} - 11.2\,\text{N}}{(1000\,\text{kg/m}^3)(9.80\,\text{m/s}^2)} = 6.43\times10^{-4}\,\text{m}^3$$

continued on page 5...

B3. Oil flows with an average speed of 1.25 m/s through a pipeline of radius 0.325 m. Calculate the volume of oil (in cubic metres, m^3) that flows through the pipeline in one hour.



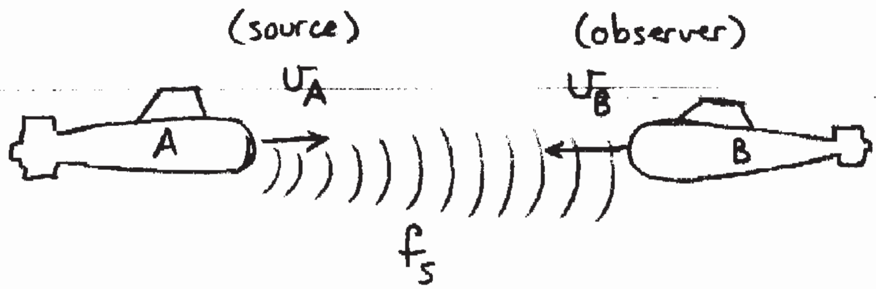
$$Q = Av = \pi r^2 v = \frac{V}{t}$$

$$V = Qt = \pi r^2 v t$$

$$V = \pi (0.325\text{m})^2 (1.25\text{ m/s})(3600\text{ s})$$

$$\boxed{V = 1.49 \times 10^3\ \text{m}^3}$$

B4. Two submarines are underwater and approaching each other head-on. Submarine A has a speed of 13.6 m/s and submarine B also has a speed of 13.6 m/s. Submarine A sends out a 1.49×10^3-Hz sonar wave that travels at a speed of 1.52×10^3 m/s. Calculate the frequency of the sonar wave detected by an operator on submarine B.



$$f_o = f_s \left[\frac{1 + \frac{v_B}{v}}{1 - \frac{v_A}{v}} \right] = 1.49 \times 10^3\ \text{Hz} \left(\frac{1 + \frac{13.6\text{ m/s}}{1520\text{ m/s}}}{1 - \frac{13.6\text{ m/s}}{1520\text{ m/s}}} \right)$$

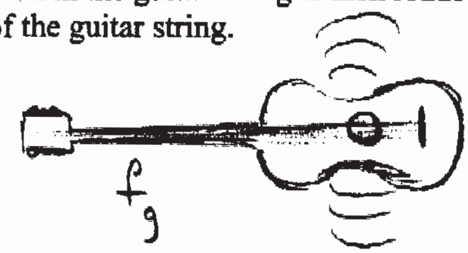
$$\boxed{f_o = 1.52 \times 10^3\ \text{Hz}}$$

continued on page 6...

Stu. No.: ____________________

B5. A tuning fork of frequency 4.40×10^2 Hz is struck at the same time as a guitar string is plucked, and beats of frequency 6.00 Hz are heard. The tension in the guitar string is then reduced until no beats are heard. Calculate the initial frequency of the guitar string.

$f_f = 4.40 \times 10^2 \text{ Hz}$



f_g

$$f_{beat} = |f_f - f_g|$$

reducing the tension reduces the guitar string's freq'y, because $f \propto v$ and $v \propto \sqrt{F}$.

$\therefore f_g$ is initially $> f_f$. so f_g is 446 Hz initially.

ANSWERS FOR PART B

ENTER THE ANSWERS FOR THE PART B PROBLEMS IN THE BOXES BELOW.

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

B1	2.58×10^{29} J
B2	6.43×10^{-4} m^3
B3	1.49×10^{3} m^3
B4	1.52×10^{3} Hz
B5	446 Hz

continued on page 7...

PART C

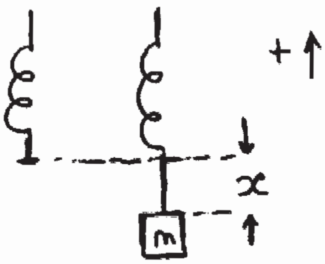
IN EACH OF THE FOLLOWING QUESTIONS, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.

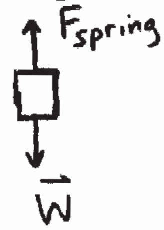
THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY, SHOW AND EXPLAIN YOUR WORK. EQUATIONS NOT PROVIDED ON THE FORMULA SHEET MUST BE DERIVED.

C1. A 1.25 kg mass is hung on a vertical spring, which stretches 3.75 cm from its original length.

(a) The mass is now displaced from its equilibrium position and released. Calculate the frequency of oscillation of the mass.





Answer: 2.57 Hz

$$\Sigma \vec{F} = 0$$

$$F_{spring} - W = 0$$

$$kx = mg \Rightarrow k = \frac{mg}{x}.$$

$$\omega = 2\pi f = \sqrt{\frac{k}{m}} \Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{mg/x}{m}} = \frac{1}{2\pi}\sqrt{\frac{g}{x}} = \frac{1}{2\pi}\sqrt{\frac{9.80\,m/s^2}{0.0375\,m}}$$

$$f = 2.57\,Hz$$

(b) The oscillating mass is now stopped and replaced with another mass. Calculate the new mass that must be hung on the spring to achieve a stretch of 8.14 cm from its original, unstretched length.

Answer: 2.71 kg

From above, $kx = mg$ so

$$m_2 = \frac{kx_2}{g} \quad \text{where } k = \frac{m_1 g}{x_1}$$

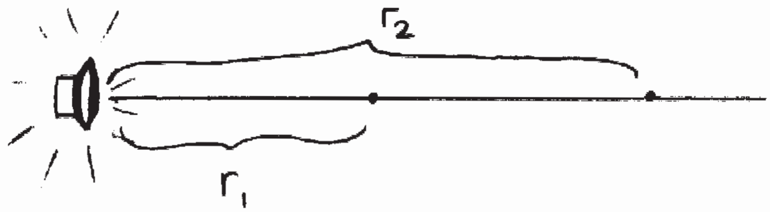
$$\text{so } m_2 = \frac{(m_1 g/x_1)\,x_2}{g} = \frac{m_1 x_2}{x_1}$$

$$m_2 = \frac{(1.25\,kg)(0.0814\,m)}{(0.0375\,m)} = 2.71\,kg$$

continued on page 8...

Stu. No.: ______________________

C2. A speaker produces sound energy at a constant rate and the sound waves propagate uniformly in all directions. At a distance of 2.21 m from the speaker the sound intensity level is 83.6 dB. Calculate the sound intensity level at a distance of 4.42 m from the source.



77.6 dB

$r_1 = 2.21\,m$, $\beta_1 = 83.6\,dB$

$r_2 = 4.42\,m$, $\beta_2 = ?$

$$I = \frac{P}{A} = \frac{P}{4\pi r^2} \quad \text{and } P = \text{constant}$$

$$\therefore \quad I_1 r_1^2 = I_2 r_2^2 \quad (1) \Rightarrow \text{determine } I_1 \text{ from } \beta_1, \text{ determine } I_2, \text{ determine } \beta_2.$$

I_1: from $\beta = (10\,dB)\log\left(\frac{I}{I_0}\right)$, $I = I_0 \cdot 10^{\beta/10dB}$

$$I_1 = (1.00\times10^{-12}\,W/m^2)(10^{83.6dB/10dB}) = 2.29\times10^{-4}\,W/m^2$$

From eq'n (1):
$$I_2 = \frac{I_1 r_1^2}{r_2^2} = \frac{(2.29\times10^{-4}\,W/m^2)(2.21\,m)^2}{(4.42\,m)^2}$$

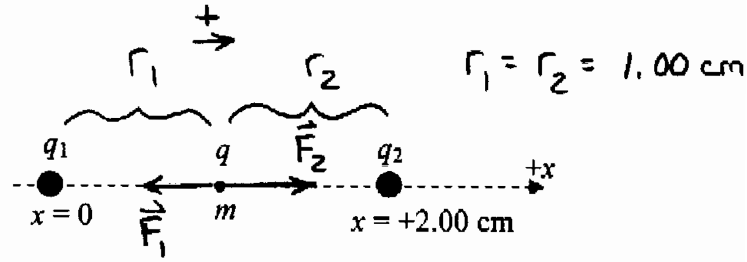
$$I_2 = 5.73\times10^{-5}\,W/m^2$$

$$\beta_2 = 10\,dB \log\left(\frac{I_2}{I_0}\right) = 10\,dB \log\left(\frac{5.73\times10^{-5}\,W/m^2}{1.00\times10^{-12}\,W/m^2}\right)$$

$$\boxed{\beta_2 = 77.6\,dB}$$

continued on page 9...

C3. A charge of $q_1 = +2.00\ \mu C$ is fixed at the origin and a second charge of $q_2 = +1.00\ \mu C$ is fixed at $x = +2.00$ cm as shown. A small object of mass $m = 1.20$ g and charge $q = -3.00\ \mu C$ is placed on the x-axis midway between q_1 and q_2. Calculate the initial acceleration of the mass m. (You may ignore friction. The gravitational force is negligible compared to the electrostatic forces. Indicate the direction of the acceleration as either positive or negative, using the coordinate system provided.)



From Newton II:

$$\boxed{-2.25 \times 10^5\ m/s^2}$$

$$\vec{a} = \frac{\Sigma \vec{F}}{m} \quad \text{where} \quad \Sigma \vec{F} = \vec{F}_1 + \vec{F}_2$$

Choose +ve dir'n to right, then $\Sigma F = -F_1 + F_2$

$$a = \frac{-F_1 + F_2}{m} = \frac{1}{m}\left(-\frac{k|q_1 q|}{r_1^2} + \frac{k|q_2 q|}{r_2^2}\right)$$

Let $r = r_1 = r_2$

$$a = \frac{k|q|}{mr^2}\left(-|q_1| + |q_2|\right)$$

$$a = \frac{(8.99 \times 10^9\ N \cdot m^2/C^2)\,|-3.00 \times 10^{-6}\ C|}{(1.20 \times 10^{-3}\ kg)(1.00 \times 10^{-2}\ m)^2}\left(-|2.00 \times 10^{-6}\ C| + |1.00 \times 10^{-6}\ C|\right)$$

$$a = -2.25 \times 10^5\ m/s^2$$

END OF EXAMINATION