Physics 111 Test 3 – Alternative Sitting Answers

A1	B	B1	41.8 m/s
A2	A		
A3	B	B2	0.637 m
A4	D		
A5	E	B3	0.396 m
A6	B		
A7	D	B4	253 kg/m^3
A8	E		
A9	B	B5	0.388 m
A10	E		

UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 111.6
MIDTERM TEST #3

MASTER

January 26, 2006 [illegible]: 90 minutes

NAME: ____________________ [illegible] ____________
(Last) **Please Print**

LECTURE SECTION (please [illegible]):

[illegible] Dr. A. [illegible]bins
[illegible] [illegible]skey
[illegible] Singh
[illegible]15 F. Dean

INSTRUCTIONS:

1. You should h[illegible] 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 <u>STUDENT NUMBER</u> 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 <u>NOT</u> 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 concerning an object in simple harmonic motion is true?

A

(A) The object reaches its maximum speed as it passes through the equilibrium position.
(B) The object's acceleration has maximum magnitude at the equilibrium position.
(C) The object has a constant velocity.
(D) The object's velocity is never zero.
(E) When the object's velocity has its most-negative value, the acceleration has maximum magnitude.

A2. A simple pendulum has a frequency f_1 when it is in simple harmonic motion on the earth. The same pendulum is now taken to the moon, where the acceleration due to gravity is one-sixth of the value on earth. The frequency of the pendulum's oscillation on the moon, in terms of f_1 is

D

(A) $6f_1$ (B) $\sqrt{6}\, f_1$ (C) f_1 (D) $\frac{f_1}{\sqrt{6}}$ (E) $\frac{f_1}{6}$

$\omega = \sqrt{\frac{g}{L}}$

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

E

(A) Pascal (Pa) (B) mm Hg (C) bar
(D) pounds per square inch (psi) (E) kg/m^2

$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$

$f \propto \sqrt{g}$

A4. Which one of the following statements regarding a spring which obeys Hooke's law is ***FALSE***?

B

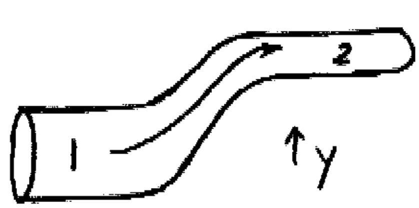
(A) The elastic potential energy of the spring depends on the spring constant k.
(B) The elastic potential energy is greater if the spring is compressed by a distance x than if it is stretched by the same distance.
(C) The elastic potential energy is zero if the spring is at its natural length.
(D) The elastic potential energy of a compressed spring depends upon the square of the distance which the spring is compressed from the unstrained length.
(E) The elastic potential energy of a stretched spring depends upon the square of the distance which the spring is stretched from the unstrained length.

$E_{elas} = \frac{1}{2}kx^2$

A5. Consider an incompressible, non-viscous fluid undergoing steady flow in a pipeline. In region 1, the pipeline is horizontal. The pipeline then rises and narrows, becoming horizontal again in region 2. Consider the change in pressure and the change in flow speed as the fluid flows from region 1 to region 2.

B

(A) The pressure decreases and the flow speed decreases.
(B) The pressure decreases and the flow speed increases.
(C) The pressure increases and the flow speed increases.
(D) The pressure increases and the flow speed decreases.
(E) The pressure remains constant and the flow speed increases.



$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$Q = A_1 v_1 = A_2 v_2 \Rightarrow v_2 > v_1$$

since $v_2 > v_1$ and $y_2 > y_1$, $P_2 < P_1$

continued on page 3...

Stu. No.: ____________________

A6. A pipeline of length L and radius R is to be replaced with one of radius 1.33 R. The volume flow rate in the original pipeline is Q when a fluid of viscosity η is pushed through the pipeline by a difference of pressure of $P_2 - P_1$ between the ends of the pipe. The volume flow rate in the new pipeline for the same fluid and the same pressure difference is

D

(A) 1.33 Q (B) 1.77 Q (C) 0.752 Q (D) 3.13 Q (E) 2.35 Q

$$Q = \frac{\pi R^4 (P_2 - P_1)}{8 \eta L}$$

$$Q \propto R^4$$

$$(1.33)^4 = 3.13$$

A7. Which one of the following is ***NOT*** an application of sound?

E

(A) ultrasonic imaging
(B) cavitron ultrasonic surgical aspiration
(C) high-intensity focussed ultrasonic surgery
(D) Doppler blood flow measurement
(E) x-ray imaging

A8. A 440 Hz tuning fork is sounded together with an out-of-tune guitar string, and a beat frequency of 3 Hz is heard. As the string is slowly tightened, the beat frequency is heard to decrease. The original frequency of the guitar string was $f_1 = \frac{v}{2L}$

B

(A) 434 Hz (B) 437 Hz (C) 443 Hz (D) 446 Hz (E) 449 Hz

$f_{beat} = |f_1 - f_2|$ and tightening the string increases the speed and frequency

A9. Which one of the following materials is a poor electrical conductor?

E

(A) copper (B) aluminum (C) silver (D) gold (E) rubber

A10. Consider three identical, initially uncharged, conducting spheres: A, B, and C. Sphere A is now given a charge of $-2\ \mu C$ and sphere B is given a charge of $+6\ \mu C$. Sphere A is brought into contact with sphere B and the spheres are then separated. Sphere B is then brought into contact with sphere C and the spheres are then separated. The charge on sphere C is now:

B

(A) 0 (B) $+1\ \mu C$ (C) $-1\ \mu C$ (D) $+2\ \mu C$ (E) $-2\ \mu C$

identical $\Rightarrow$ equal size $\therefore$ when touching, charge is distributed equally.

$q_A + q_B = -2\mu C + 6\mu C = +4\mu C$

$\therefore$ each has charge of $+2\mu C$

$q_B + q_C = +2\mu C + 0 = +2\mu C$

$\therefore$ each has charge of $+1\mu C$

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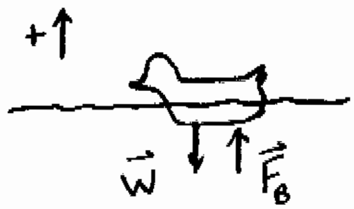
Stu. No.: ____________________

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. A duck is floating in seawater with 21.5% of its volume below the water. Calculate the average density of the duck. You may assume that the density of seawater is 1.02×10^3 kg/m^3.



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

$$F_B - W = 0$$

$$\rho_w g V_{dis} = mg$$

$$\rho_w V_{dis} = \rho_{duck} V_{duck}$$

Given $V_{dis} = 0.215 V_{duck}$

$$\rho_w (0.215 \cancel{V_{duck}}) = \rho_{duck} \cancel{V_{duck}}$$

$$\rho_{duck} = (1.02 \times 10^3 \text{ kg/m}^3)(0.215)$$

$$\rho_{duck} = 2.19 \times 10^2 \text{ kg/m}^3$$

B2. A siren on a police car produces sound of frequency 882 Hz. When you are standing on the side of the road and this police car approaches you with its siren producing sound, you hear a siren frequency of 985 Hz. Calculate the speed of the police car.

Source approaching stationary observer:

$$f_o = f_s \left(\frac{1}{1 - \frac{v_s}{v}} \right)$$

$$f_o \left(1 - \frac{v_s}{v} \right) = f_s$$

$$f_o - \frac{f_o v_s}{v} = f_s$$

$$f_o - f_s = \frac{f_o v_s}{v}$$

$$v_s = v \left(\frac{f_o - f_s}{f_o} \right)$$

$$v_s = v \left(1 - \frac{f_s}{f_o} \right)$$

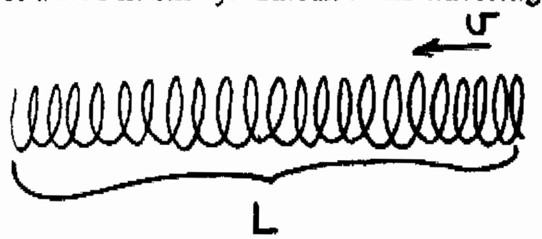
$$v_s = 343 \text{ m/s} \left(1 - \frac{882 \text{ Hz}}{985 \text{ Hz}} \right)$$

$$v_s = 35.9 \text{ m/s}$$

continued on page 5...

Stu. No.: ____________________

B3. In a time of 1.65 s, a longitudinal wave with a frequency of 2.97 Hz travels from one end to the other of a 2.51 m Slinky. Calculate the wavelength of the wave.



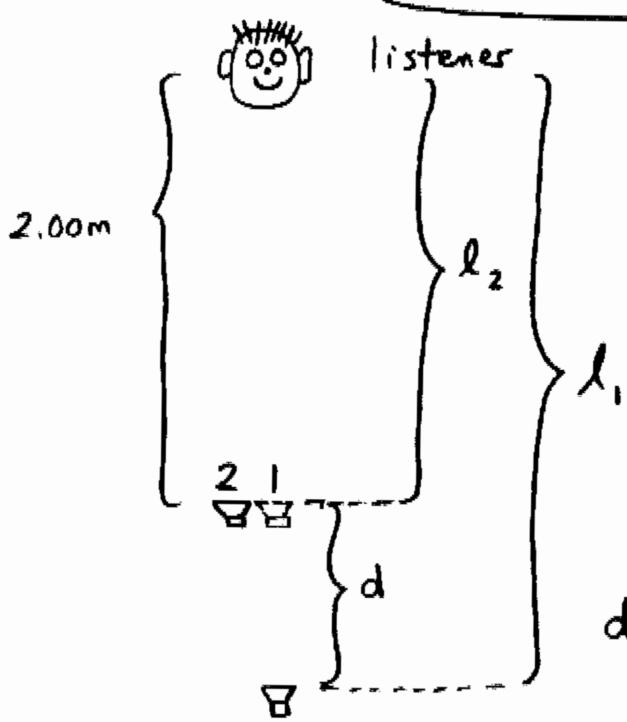
$$v = f\lambda = \frac{L}{t}$$

$$\lambda = \frac{L}{t \cdot f}$$

$$\lambda = \frac{2.51\,m}{(1.65\,s)(2.97\,Hz)} = 0.512\,m$$

B4. Two small speakers are connected to a single 865 Hz source. Initially the speakers are side-by-side, a few cm apart, equal distances from a listener 2.00 m in front of the speakers. One of the speakers is now slowly moved straight back away from the listener until at some point the listener hears almost no sound. Calculate how far the speaker has been moved.

first location of destructive interference



$$\therefore\ d = |\ell_1 - \ell_2| = \frac{1}{2}\lambda$$

and since $v = f\lambda$,

$$\lambda = \frac{v}{f}$$

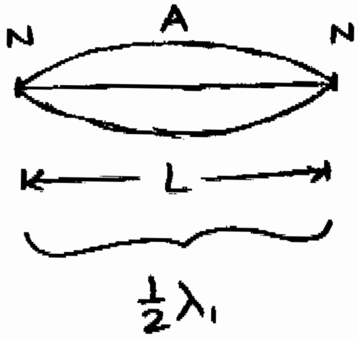
$$\therefore\ d = \frac{1}{2}\left(\frac{v}{f}\right)$$

$$d = \frac{1}{2}\left(\frac{343\,m/s}{865\,Hz}\right) = 0.198\,m$$

continued on page 6...

Stu. No.: ______________

B5. The E string on a guitar has a length of 0.660 m. The string's fundamental frequency is 165 Hz. Pressing the string against one of the frets along the neck of the guitar effectively shortens the length of the string. Calculate the length that will give the E string a fundamental frequency of 262 Hz. Assume that the tension in the string is constant.



(fundamental)

$$L = \frac{1}{2}\lambda_1 \Rightarrow \lambda_1 = 2L$$

$$v = f\lambda \Rightarrow v = f_1(2L)$$

Let new length be L':

$$L' = \frac{v}{2f_1'} = \frac{f_1 2L}{2f_1'}$$

$$L' = \frac{(165\,Hz)(0.660\,m)}{262\,Hz} = 0.416\,m$$

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	219 kg/m^3
B2	35.9 m/s
B3	0.512 m
B4	0.198 m
B5	0.416 m

continued on page 7...

 Stu. No.: ____________________

PART C

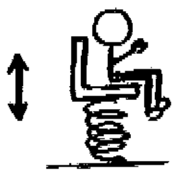
IN EACH OF THE FOLLOWING QUESTIONS, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.

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

NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY. EQUATIONS NOT PROVIDED ON THE FORMULA SHEET MUST BE DERIVED.

C1. An astronaut in a spacecraft in deep space sits in a spring-mounted chair in order to measure her mass. The astronaut and chair oscillate in simple harmonic motion with a period of 2.25 s and an amplitude of 6.00 cm. The spring constant is 575 N/m.

(a) Calculate the combined mass of the astronaut and chair.



$T = 2.25\,s$

$A = 6.00\,cm = 0.0600\,m$

$\boxed{73.7\,kg}$

SHM $\Rightarrow$ $\omega = \sqrt{\frac{k}{m}}$ and $\omega = \frac{2\pi}{T}$ $\Rightarrow$ $\frac{2\pi}{T} = \sqrt{\frac{k}{m}}$

$$\frac{4\pi^2}{T^2} = \frac{k}{m} \Rightarrow m = \frac{kT^2}{4\pi^2}$$

$$m = \frac{(575\,N/m)(2.25\,s)^2}{4\pi^2} = 73.7\,kg$$

(b) Calculate the magnitude of the maximum force exerted by the spring on the astronaut and chair.

$F = -kx$

$\boxed{34.5\,N}$

$$F_{max} = |-k x_{max}| = kA$$

$$F_{max} = (575\,N/m)(0.0600\,m)$$

$$F_{max} = 34.5\,N$$

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C2. A sound source is emitting sound energy uniformly in all directions at a constant rate. The intensity is 5.64×10^{-5} W/m^2 at location *A*, a distance of 2.34 m from the source.

(a) Calculate the power of the sound being emitted by the source.

$$I = \frac{P}{A}$$

$$\boxed{3.88 \times 10^{-3}\,\text{W}}$$

$$P = IA = I \cdot 4\pi r^2$$

r = distance from source (radius of spherical wavefront)

$$P = \left(5.64\times10^{-5}\,\frac{\text{W}}{\text{m}^2}\right)\left(4\pi\,(2.34\,\text{m})^2\right)$$

$$P = 3.88\times10^{-3}\,\text{W}$$

(b) Calculate the intensity level in dB at location A.

$$\beta = 10\,\text{dB}\,\log\left(\frac{I}{I_0}\right)$$

$$\boxed{77.5\,\text{dB}}$$

$$\beta = 10\,\text{dB}\,\log\left(\frac{5.64\times10^{-5}\,\text{W/m}^2}{1.00\times10^{-12}\,\text{W/m}^2}\right)$$

$$\beta = 77.5\,\text{dB}$$

(c) Calculate the intensity (in W/m^2) at a distance of 4.68 m from the source.

$$I = \frac{P}{A} = \frac{3.88\times10^{-3}\,\text{W}}{4\pi\,(4.68\,\text{m})^2} = 1.41\times10^{-5}\,\frac{\text{W}}{\text{m}^2}$$

$$\boxed{1.41\times10^{-5}\,\text{W/m}^2}$$

or note that $r_1 = 2.34\,\text{m}$ and $r_2 = 4.68\,\text{m} \Rightarrow r_2 \Rightarrow 2r_1$

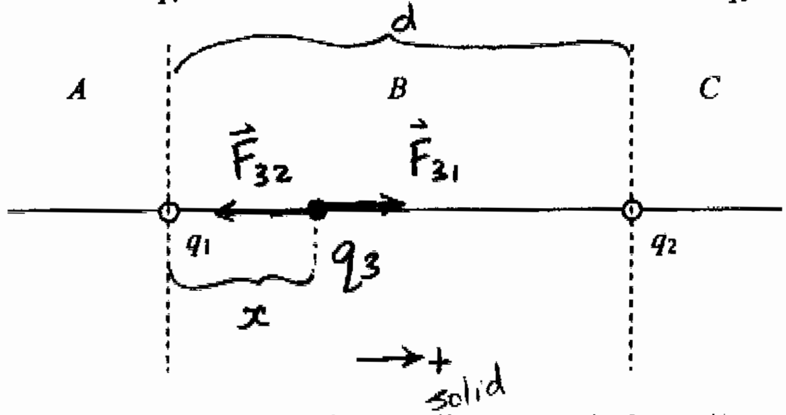
since $I \propto \frac{1}{r^2}$, $\therefore I_2 = \frac{1}{4} I_1 = \frac{5.64\times10^{-5}\,\text{W/m}^2}{4}$

$$I_2 = 1.41\times10^{-5}\,\text{W/m}^2$$

continued on page 9...

Stu. No.: ____________________

C3. Two point charges, q_1 and q_2, are separated by a distance d. $q_2 = 4\,q_1$. A third charge, q_3, is now placed a distance x from q_1 such that the resultant electrostatic force of q_3 is zero.



(a) In which of the regions A, B, or C along the solid line must q_3 be located?

For $\Sigma\vec{F}_3 = 0$, $\vec{F}_{31}$ and $\vec{F}_{32}$ must be in opposite dir'ns. $\therefore$ region B

$\boxed{B}$

(b) Determine the expression for x in terms of d.

Assume all charges are +ve.

want $\Sigma\vec{F}_3 = 0$

$\boxed{x = d/3}$

$$F_{31} - F_{32} = 0 \Rightarrow F_{31} = F_{32}$$

$$\frac{k|q_1q_3|}{r_1^2} = \frac{k|q_2q_3|}{r_2^2}$$

note that $r_1 = x$ and $r_2 = d - x$ and $q_2 = 4q_1$

$$\frac{\cancel{k}|q_1q_3|}{x^2} = \frac{\cancel{k}|4q_1q_3|}{(d-x)^2} \Rightarrow \frac{1}{x^2} = \frac{4}{(d-x)^2}$$

$$\left(\frac{d-x}{x}\right)^2 = 4 \Rightarrow \frac{d-x}{x} = 2 \Rightarrow d - x = 2x$$

$$d = 3x$$

END OF EXAMINATION

$$x = d/3$$