

Physics 111 2007-08 Test 3 – Alternative Sitting Answers

A1 A
A2 D
A3 B
A4 C
A5 E
A6 D
A7 A
A8 B
A9 C
A10 C

B1 $1.17 \times 10^8 \text{ Pa}$

B2 0.794 W/m^2

B3 $1.29 \times 10^3 \text{ Hz}$

B4 $-2.95 \times 10^{-5} \text{ C}$

B5 $0.215 \text{ N, } -x$

PART A

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

- A1. A block attached to an ideal spring of spring constant k is undergoing simple harmonic motion on a horizontal frictionless surface. The simple harmonic motion has amplitude A . Let x represent the displacement of the block from its equilibrium position. At $x = A$, which one of the following statements is **FALSE**? *max. displacement*
- (B)
 (A) The speed of the block is zero. τ
 (B) The acceleration of the block is zero. F $a = -\frac{kx}{m} = -\omega^2 x$
 (C) The restoring force on the block has a magnitude of kA . τ ($F = -kx$)
 (D) The displacement of the block is a maximum. τ
 (E) The restoring force on the block and the acceleration of the block are in the same direction. τ
- A2. A block is attached to the free end of an ideal spring which is hanging from the ceiling. The block and the spring are undergoing simple harmonic motion. When the block is moving downwards after passing through its equilibrium position, which one of the following statements is **TRUE**? *Moving downward \Rightarrow PE_{grav} decreasing; already passed equilibrium \Rightarrow spring is stretching \Rightarrow PE_{elas} increasing, and KE decreasing*
- (C)
 (A) Kinetic energy is increasing, gravitational PE is decreasing, and elastic PE is decreasing.
 (B) Kinetic energy is decreasing, gravitational PE is increasing, and elastic PE is increasing.
 (C) Kinetic energy is decreasing, gravitational PE is decreasing, and elastic PE is increasing.
 (D) Kinetic energy is increasing, gravitational PE is decreasing, and elastic PE is increasing.
 (E) Kinetic energy is decreasing, gravitational PE is decreasing, and elastic PE is decreasing.
- A3. Consider two spheres. Both the radius and the mass of sphere 2 are double the radius and mass of sphere 1. The relationship of the density of sphere 2, ρ_2 , to the density of sphere 1, ρ_1 , is $\rho = \frac{M}{V}$
- (C)
 (A) $\rho_2 = 2\rho_1$ (B) $\rho_2 = \frac{1}{2}\rho_1$ (C) $\rho_2 = \frac{1}{4}\rho_1$ (D) $\rho_2 = \frac{1}{8}\rho_1$ (E) $\rho_2 = 8\rho_1$
 $\rho = \frac{M}{\frac{4}{3}\pi r^3}$
 $\rho_2 = \frac{2M_1}{\frac{4}{3}\pi(2r_1)^3} = \frac{2}{8} \left(\frac{M_1}{\frac{4}{3}\pi r_1^3} \right) = \frac{1}{4}\rho_1$
- A4. Water flows through a constriction in a horizontal pipe. As the water enters the constriction, which one of the following statements is **TRUE**? $v \uparrow$ (continuity) $p \downarrow$ (Bernoulli's)
- (A)
 (A) The flow speed increases and the pressure decreases.
 (B) The flow speed increases and the pressure remains constant.
 (C) The flow speed increases and the pressure increases.
 (D) The flow speed decreases and the pressure increases.
 (E) The flow speed decreases and the pressure decreases.
- A5. Which one of the following statements concerning an incompressible fluid is **TRUE**?
- (B)
 (A) The flow velocity is independent of the radius of the pipe through which the fluid is flowing. F
 (B) The mass density is constant. τ
 (C) The viscosity is always zero. F
 (D) The pressure in the fluid is independent of the depth within the fluid. F
 (E) The viscosity must be non-zero. F

A6. A speaker with constant power output, oscillating in simple harmonic motion at a constant frequency, produces a sound wave in air. Which one of the following statements is **FALSE**?

- (C)
 (A) The wave transfers energy from place to place. τ
 (B) The air molecules vibrate with simple harmonic motion. τ
 (C) The speed of the air molecules, as they move (vibrate) due to the sound wave, must be the same as the speed of the sound wave. F
 (D) There is no net movement of air from source to receiver. τ
 (E) The intensity of the sound wave decreases as distance from the speaker increases. τ

A7. Blood with viscosity η is flowing through a cylindrical vein of radius R_1 and length L , with a volume flow rate of Q_1 . The vein expands, so that the new radius R_2 is 105% of the original radius. If the pressure difference between the two ends of the vein remains the same, what is the new volume flow rate Q_2 in terms of Q_1 ?

- (D)
 (A) $Q_2 = 0.98Q_1$ (B) $Q_2 = 1.05Q_1$ $Q = \frac{\pi R^4 (P_2 - P_1)}{8\eta L}$ (C) $Q_2 = \frac{Q_1}{1.10}$
 (D) $Q_2 = 1.22Q_1$ (E) $Q_2 = 1.41Q_1$ $Q_2 = \frac{\pi (1.05R_1)^4 (P_2 - P_1)}{8\eta L} = 1.22Q_1$

A8. Which one of the following statements is **FALSE**?

- (D)
 (A) Two waves which are exactly out of phase when they meet will exhibit destructive interference. τ
 (B) If two wave sources vibrate in phase, then a difference in path length which is zero or an integer number of wavelengths results in constructive interference. τ
 (C) Two waves which are exactly in phase when they meet exhibit constructive interference. τ
 (D) If two wave sources vibrate exactly out of phase, then a difference in path length which is an odd multiple of half the wavelength results in destructive interference. F
 (E) If two waves have equal amplitudes A , then the resultant amplitude, if constructive interference occurs, is $2A$. τ

A9. Two similar frequencies, f_1 Hz and f_2 Hz, are sounded together. The speed of sound is v m/s. What is the wavelength, λ_{beat} , of the resultant beat?

- (D)
 (A) $\lambda_{beat} = v \times |f_1 - f_2|$ (B) $\lambda_{beat} = \frac{|f_1 - f_2|}{v}$ (C) $\lambda_{beat} = \frac{v}{f_1} - \frac{v}{f_2}$
 (D) $\lambda_{beat} = \frac{v}{|f_1 - f_2|}$ (E) $\lambda_{beat} = \frac{|f_2 - f_1|}{v}$ $f_{beat} = |f_1 - f_2|$
 $\lambda_{beat} = \frac{v}{f_{beat}} = \frac{v}{|f_1 - f_2|}$

A10. Consider the following procedure: a negatively-charged rod is brought near, but doesn't touch, an isolated, uncharged conducting sphere; the sphere is then connected to ground; the sphere is then disconnected from ground; the rod is then moved away from the sphere. At the end of this procedure

- (D)
 (A) the sphere is still uncharged but the rod is now positively-charged.
 (B) the sphere is now positively-charged and the negative charge on the rod is reduced.
 (C) the sphere is now negatively-charged and the negative charge on the rod is reduced.
 (D) the sphere is now positively-charged and the negative charge on the rod is unchanged.
 (E) the sphere is now positively-charged and so is the rod.

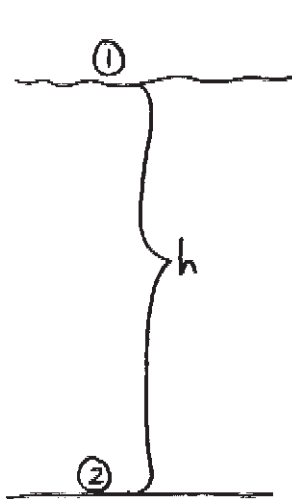


PART B

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. The Mariana Trench is located in the floor of the Pacific Ocean at a depth of 1.11×10^4 m below the surface of the water. Calculate the absolute pressure in the water at this depth. The density of seawater is 1025 kg/m^3 .



$$P_2 = P_1 + \rho gh$$

$$P_2 = 1.013 \times 10^5 \text{ Pa} + \left(\frac{1025 \text{ kg}}{\text{m}^3} \right) \left(9.80 \text{ m/s}^2 \right) \left(1.11 \times 10^4 \text{ m} \right)$$

$$P_2 = 1.12 \times 10^8 \text{ Pa}$$

- B2. The sound intensity level at a rock concert is measured to be 122 dB. Calculate the corresponding sound intensity in W/m^2 .

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

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

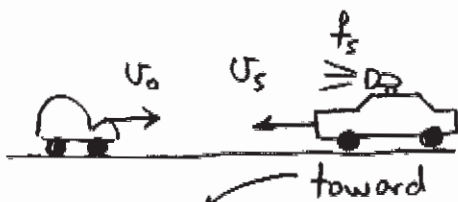
$$I = I_0 \cdot 10^{\beta/10 \text{ dB}}$$

$$I = \left(1.00 \times 10^{-12} \text{ W/m}^2 \right) \cdot 10^{122 \text{ dB}/10 \text{ dB}}$$

$$I = 1.58 \text{ W/m}^2$$

continued on page 5...

- B3. A source emits sound with a frequency of 1.00×10^3 Hz. Both the source and an observer are moving toward each other, each with a speed of ~~1.00×10^2~~ 50.0 m/s. Calculate the frequency of the sound heard by the observer.



Doppler Effect:

$$f_s = 1.00 \times 10^3 \text{ Hz}$$

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

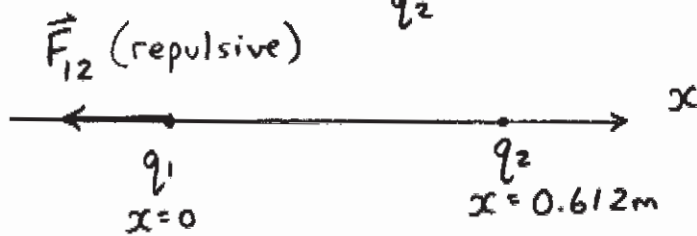
toward toward

$$f_o = 1.00 \times 10^3 \text{ Hz} \left(\frac{1 + \frac{50.0 \text{ m/s}}{343 \text{ m/s}}}{1 - \frac{50.0 \text{ m/s}}{343 \text{ m/s}}} \right) = 1.34 \times 10^3 \text{ Hz}$$

- B4. A metal sphere has an initial charge of $+2.50 \mu\text{C}$. Calculate the net charge on the sphere after 3.00×10^{14} electrons are transferred onto the sphere.

$$Q_{\text{net}} = Q_o + n(-e)$$
$$Q_{\text{net}} = (+2.50 \times 10^{-6} \text{ C}) + (3.00 \times 10^{14})(-1.60 \times 10^{-19} \text{ C})$$
$$Q_{\text{net}} = -4.55 \times 10^{-5} \text{ C} = -45.5 \mu\text{C}$$

B5. Calculate the magnitude and direction of the electric force exerted on a charge of $+2.30 \mu\text{C}$ located at the origin by a charge of $+3.75 \mu\text{C}$ located at $x = +0.612 \text{ m}$.



$$F_{12} = \frac{k |q_1 q_2|}{r^2} = \frac{(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2) (+2.30 \times 10^{-6} \text{ C}) (+3.75 \times 10^{-6} \text{ C})}{(0.612 \text{ m})^2}$$

$$F_{12} = 0.207 \text{ N}, -x$$

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 $1.12 \times 10^8 \text{ Pa}$

B2 1.58 W/m^2

B3 $1.34 \times 10^3 \text{ Hz}$

B4 $-4.55 \times 10^{-5} \text{ C}$

B5 0.207 N

direction: $+x$; $(-x)$ $+y$; $-y$ (circle your choice)

PART C

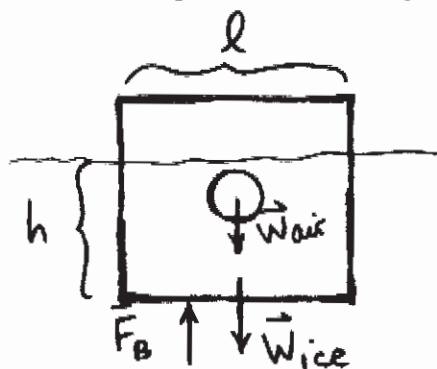
IN EACH OF THE FOLLOWING QUESTIONS, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.

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. An ice cube with an air bubble trapped inside is floating in a container of water. The bottom of the ice cube is a distance h below the surface of the water. The ice cube is a cube with sides of length $\ell = 2.00$ cm, and the air bubble is a sphere of radius $r = 0.500$ cm. The density of the ice is $\rho_{ice} = 917$ kg/m³ and the density of the air in the bubble is $\rho_{air} = 1.29$ kg/m³.

(a) Draw a clearly labelled free body diagram corresponding to the situation described above.



ice cube is floating,

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

$$F_B - W_{ice} - W_{air} = 0 \quad (1)$$

$$F_B = W_{fluid} = \rho_{H_2O} g V_{dis}$$

$$F_B = \rho_{H_2O} g \ell^2 h$$

(b) Calculate h .

Substituting into eq'n (1):

$$\rho_{H_2O} g \ell^2 h - \rho_{ice} g V_{ice} - \rho_{air} g V_{air} = 0$$

where $V_{air} = \frac{4}{3}\pi r^3$ and $V_{ice} = \ell^3 - V_{air}$

$$\rho_{H_2O} g \ell^2 h - \rho_{ice} g (\ell^3 - V_{air}) - \rho_{air} g \frac{4}{3}\pi r^3 = 0$$

$$\rho_{H_2O} \ell^2 h = \rho_{air} \frac{4}{3}\pi r^3 + \rho_{ice} (\ell^3 - V_{air})$$

$$h = \frac{\rho_{air} \frac{4}{3}\pi r^3 + \rho_{ice} (\ell^3 - \frac{4}{3}\pi r^3)}{\rho_{H_2O} \ell^2} = \frac{\rho_{ice} \ell^3 - \frac{4}{3}\pi r^3 (\rho_{ice} - \rho_{air})}{\rho_{H_2O} \ell^2}$$

$$h = \frac{(917 \text{ kg/m}^3)(0.0200 \text{ m})^3 - \frac{4}{3}\pi (0.00500 \text{ m})^3 (917 \text{ kg/m}^3 - 1.29 \text{ kg/m}^3)}{(1.00 \times 10^3 \text{ kg/m}^3)(0.0200 \text{ m})^2}$$

continued on page 8...

$$h = 1.71 \times 10^{-2} \text{ m} = 1.71 \text{ cm}$$

C2. A particular wave on a string is described by the equation:

$$y = (5.10 \times 10^{-3}) \sin(305t - 1.9x) \text{ where all quantities are in SI units.}$$

(a) Calculate the frequency of the wave.

Compare with general expression for harmonic wave:

$$y = A \sin\left(2\pi ft \mp \frac{2\pi x}{\lambda}\right)$$

$$2\pi f = 305$$

$$f = \frac{305}{2\pi} \text{ Hz (SI unit)}$$

$$f = 48.5 \text{ Hz}$$

$$48.5 \text{ Hz}$$

(b) Calculate the speed of the wave.

$$v = f\lambda$$

$$1.60 \times 10^2 \text{ m/s}$$

$$\frac{2\pi}{\lambda} = 1.9 \text{ from wave eq'n}$$

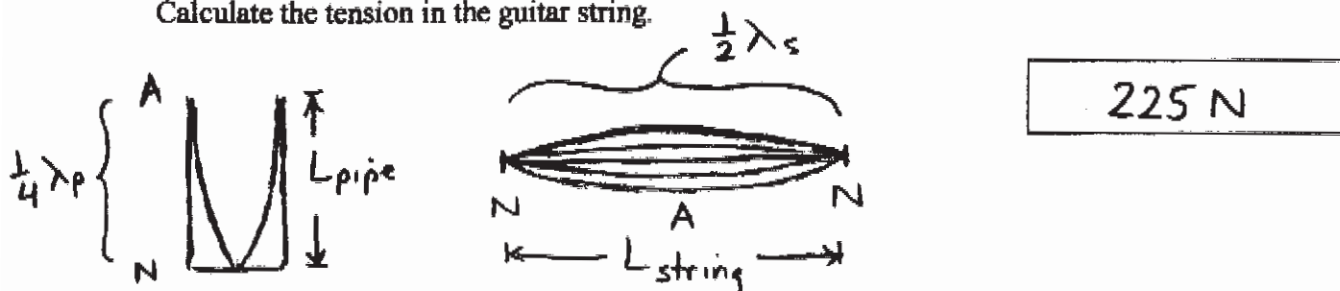
$$\lambda = \frac{2\pi}{1.9} \text{ m (SI unit)}$$

$$\lambda = 3.31 \text{ m}$$

$$v = f\lambda = (48.5 \text{ Hz})(3.31 \text{ m}) = 1.60 \times 10^2 \text{ m/s}$$

- C3. An organ pipe, open at one end and closed at the other, is producing sound at its fundamental frequency. The length of the pipe is 0.200 m. The sound wave produced by the organ pipe causes a string on a nearby guitar to vibrate at the same frequency, which is also the fundamental frequency of the guitar string. The length of the guitar string is 0.625 m and its linear mass density is $7.83 \times 10^{-4} \text{ kg/m}$.

Calculate the tension in the guitar string.



For organ pipe resonating at fundamental freqy:

$$L_{\text{pipe}} = \frac{1}{4} \lambda_p \Rightarrow \lambda_p = 4L_{\text{pipe}} \Rightarrow f_{\text{pipe}} = \frac{v_{\text{sound}}}{\lambda_p} = \frac{v_{\text{sound}}}{4L_{\text{pipe}}}$$

For guitar string:

$$f_{\text{string}} = f_{\text{pipe}} = \frac{v_{\text{sound}}}{4L_{\text{pipe}}}$$

$$L_{\text{string}} = \frac{1}{2} \lambda_s \Rightarrow \lambda_s = 2L_{\text{string}}$$

Know that $v_{\text{string}} = \sqrt{\frac{F}{m/L}}$ and $v = f\lambda$

$$\therefore f_{\text{string}} \lambda_s = \sqrt{\frac{F}{m/L}} \Rightarrow f_{\text{string}}^2 \lambda_s^2 \cdot \frac{m}{L} = F$$

$$F = \frac{v_{\text{sound}}^2}{(4L_{\text{pipe}})^2} \cdot (2L_{\text{string}})^2 \cdot \frac{m}{L} = \frac{1}{4} \cdot v_{\text{sound}}^2 \cdot \frac{L_{\text{string}}^2}{L_{\text{pipe}}^2} \cdot \frac{m}{L}$$

$$F = \frac{1}{4} (343 \text{ m/s})^2 \left(\frac{0.625 \text{ m}}{0.200 \text{ m}} \right)^2 \cdot 7.83 \times 10^{-4} \text{ kg/m} = \boxed{225 \text{ N}}$$

END OF EXAMINATION