UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 117.3
MIDTERM TEST – Alternative Sitting

February 13, 2009 Time: 90 minutes

NAME: SOLUTIONS MASTER STUDENT NO.: ____________
(Last) **Please Print** (Given)

LECTURE SECTION (please check):

❑ 01 B. Zulkoskey
❑ 02 Dr. A. Robinson

INSTRUCTIONS:

1. This is a closed book exam.
2. The test package includes a test paper (this document), a formula sheet, and an OMR sheet. The test paper consists of 8 pages. **It is the responsibility of the student to check that the test paper is complete.**
3. Only Hewlett-Packard hp 30S or Texas Instruments TI-30X series calculators may be used.
4. Enter your name and student number on the cover of the test paper and check the appropriate box for your lecture section. Also enter your student number in the top right-hand corner of each page of the test paper.
5. Enter your name and STUDENT NUMBER on the OMR sheet.
6. The test paper, the formula sheet and the OMR sheet must all be submitted.
7. The test paper will be returned. The formula sheet and the OMR sheet will NOT be returned.

ONLY THE THREE PART B QUESTIONS THAT YOU INDICATE WILL BE MARKED

PLEASE INDICATE WHICH THREE PART B QUESTIONS ARE TO BE MARKED

QUESTION NUMBER	TO BE MARKED	MAXIMUM MARKS	MARKS OBTAINED
A1-15	-	15	
B1	❑	10	
B2	❑	10	
B3	❑	10	
B4	❑	10	
TOTAL		45	

continued on page 2...

Stu. No.: ____________________

PART A

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

A1. Solid disk 1 has a mass of M and a radius of R. Solid disk 2 has a mass of $2M$ and a radius of R. The same torque is applied to each of the disks. The angular acceleration of disk 2, compared to that of disk 1, is

B

(A) $\alpha_2 = \frac{1}{4}\,\alpha_1$ (B) $\alpha_2 = \frac{1}{2}\,\alpha_1$ (C) $\alpha_2 = \alpha_1$ (D) $\alpha_2 = 2\alpha_1$ (E) $\alpha_2 = 4\alpha_1$

A2. Consider two objects: a solid wood disk and a metal hoop. The disk and the hoop have the same mass and radius. If the two objects have the same velocity as they roll along a horizontal surface, which one of the following statements is correct?

A

(A) Their translational kinetic energies are the same but the rotational kinetic energy of the disk is less than that of the hoop.
(B) Their translational kinetic energies are the same but the rotational kinetic energy of the disk is greater than that of the hoop.
(C) Both their translational kinetic energies and their rotational kinetic energies are the same.
(D) Their rotational kinetic energies are the same but the translational kinetic energy of the disk is less than that of the hoop.
(E) Their rotational kinetic energies are the same but the translational kinetic energy of the disk is less than that of the hoop.

A3. Consider a large rectangular block of wood that has a weight of 1.8×10^4 N and dimensions of 1 m $\times$ 2 m $\times$ 3 m. Which one of the following statements is correct concerning the pressure(s) that the block of wood can exert on a flat horizontal floor.

A

(A) The pressure exerted by the block can be 9000 Pa, 6000 Pa, or 3000 Pa, depending on its orientation.
(B) The pressure exerted by the block can only be 9000 Pa.
(C) The pressure exerted by the block can only be 6000 Pa.
(D) The pressure exerted by the block can only be 3000 Pa..
(E) The pressure exerted by the block can be 9000 Pa or 6000 Pa, but not 3000 Pa.

A4. When a spinning figure skater pulls her arms in closer to her body her rotation rate increases. Which one of the following statements is correct? (You may ignore any frictional effects.)

A

(A) As the skater pulls her arms in, her rotational inertia decreases and her angular momentum remains constant.
(B) As the skater pulls her arms in, both her rotational inertia and her angular momentum decrease.
(C) As the skater pulls her arms in, her rotational inertia decreases and her angular momentum increases.
(D) As the skater pulls her arms in, her rotational inertia increases and her angular momentum remains constant.
(E) As the skater pulls her arms in, her rotational inertia increases and her angular momentum decreases.

A5. A compact disc (CD) with a rotational inertia of 5.28×10^{-5} kg·m^2 spins at a speed of 41.9 radians/s. How much work must be done to bring it to rest?

D

(A) -1.01×10^{-2} J (B) -1.99×10^{-2} J (C) -2.23×10^{-2} J
(D) -4.63×10^{-2} J (E) -8.34×10^{-2} J

continued on page 3...

A

A6. A liquid with a viscosity of η is flowing through a pipe of radius R and length L. A pressure difference of ΔP is required to maintain a volume flow rate Q. If the radius of the pipe is reduced to ½ R then the pressure difference required to maintain the same volume flow rate is:

(A) 16 ΔP (B) 8 ΔP (C) 4 ΔP (D) 2 ΔP (E) ½ ΔP

C

A7. Which one of the following statements best describes the situation in a hydraulic lift.

(A) A small pressure change in a small cylinder produces a large pressure change in a large cylinder.
(B) A small pressure change in a large cylinder produces a large pressure change in a small cylinder.
(C) A small force applied to a small piston produces a large force on a large piston.
(D) A small force applied to a large piston produces a large force on a small piston.
(E) A small displacement of a small piston produces a large displacement of a large piston.

C

A8. A spherical object of radius r falls with a terminal speed v through a fluid with viscosity η. Which one of the following statements is **true**?

(A) The net force on the object has magnitude mg.
(B) The object has an acceleration of g.
(C) The viscous drag force causes the net force on the object to be zero.
(D) The viscous drag force is in the same direction as the force of gravity on the object.
(E) The viscous drag force is the only force acting on the object.

B

A9. A periodic wave passes by an observer who notices that the time between two consecutive wave crests is 2 seconds. Which one of the following statements about the wave is **true**?

(A) The frequency is 2 Hz. (B) The period is 2 seconds.
(C) The wavelength is 2 metres. (D) The amplitude is 2 metres.
(E) The wave speed is 2 m/s.

E

A10. A tensile force F stretches a wire of original length L by an amount ΔL. Consider another wire of the same composition and thickness as the first wire, but of length $2L$. If a force of $2F$ is applied to this wire of length $2L$, then the amount that it stretches is

(A) ¼ ΔL (B) ½ ΔL (C) ΔL (D) 2 ΔL (E) 4 ΔL

D

A11. Which one of the following statements concerning an object in simple harmonic motion is **false**?

(A) The maximum speed of the object is at the point of zero displacement from the equilibrium position.
(B) The maximum magnitude of acceleration of the object occurs at positions of maximum magnitude of displacement from equilibrium.
(C) The speed of the object is zero at positions of maximum magnitude of displacement.
(D) The angular frequency of oscillation depends on the amplitude of vibration.
(E) The acceleration is zero at the point of zero displacement from the equilibrium position.

A

A12. Two masses, m_1 and m_2, are hung on identical springs with spring constant k and set in simple harmonic motion. The ratio of the periods of oscillation, T_1/T_2, is given by:

(A) $\frac{T_1}{T_2}=\sqrt{\frac{m_1}{m_2}}$ (B) $\frac{T_1}{T_2}=2\pi$ (C) $\frac{T_1}{T_2}=\frac{m_2}{m_1}$ (D) $\frac{T_1}{T_2}=2\pi k$ (E) $\frac{T_1}{T_2}=\frac{m_1+m_2}{m_1-m_2}$

continued on page 4...

A13. The diagram shows the third harmonic of a standing wave on a string of length L that is fixed at both ends. Which one of the equations correctly describes the wavelength λ_3 of this harmonic?

C

(A) $\lambda_3 = \frac{L}{2}$ (B) $\lambda_3 = \frac{L}{3}$ (C) $\lambda_3 = \frac{2L}{3}$ (D) $\lambda_3 = \frac{3L}{2}$ (E) $\lambda_3 = \frac{L}{6}$

A14. The intensity of the sound of an aircraft taking off is measured as 3.50×10^2 W/m^2 at a distance of 10.0 metres. Calculate the intensity at a distance of 125 metres. You may assume that the aircraft acts as an isotropic source of sound and you may ignore any absorption of sound energy by the air.

A

(A) 2.24 W/m^2 (B) 3.04 W/m^2 (C) 4.11 W/m^2 (D) 4.87 W/m^2 (E) 5.05 W/m^2

A15. Two speakers are separated by a distance of d. They are vibrating in phase and they both produce sound with identical frequency f and wavelength λ. A listener is a distance L from one of the speakers. Which one of the following distances from the other speaker will ensure the listener is at a position of constructive interference?

C

(A) $L + d$ (B) $L - ½\,\lambda$ (C) $L + \lambda$ (D) $L + ½\,\lambda$ (E) $d + \lambda$

PART B

ANSWER <u>THREE</u> OF THE PART B QUESTIONS ON THE FOLLOWING PAGES AND INDICATE YOUR CHOICES ON THE COVER PAGE.

FOR EACH OF YOUR CHOSEN PART B QUESTIONS ON THE FOLLOWING PAGES, 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.

<u>SHOW AND EXPLAIN YOUR WORK</u> – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.

USE THE BACK OF THE PREVIOUS PAGE FOR YOUR ROUGH WORK.

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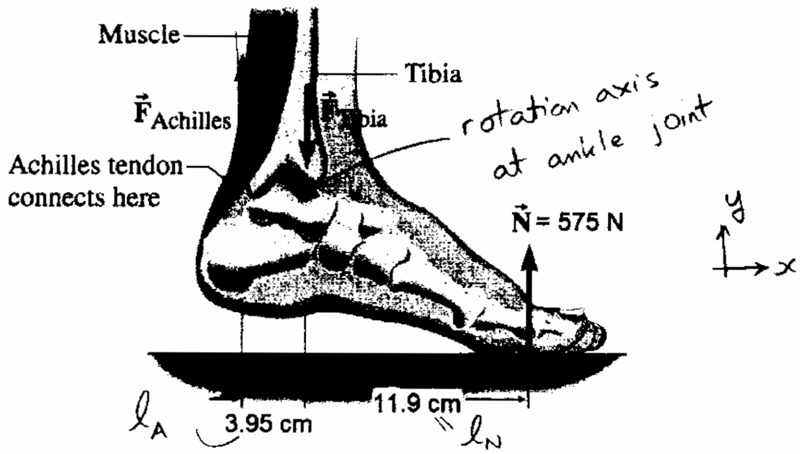
B1. The diagram shows the ankle joint when a person weighing 575 N balances herself on the ball of one foot. You may assume that the foot and ankle are in equilibrium and that the force of the tibia bone acts directly through the ankle joint.



(a) Calculate the magnitude of the tension force in the Achilles tendon, $\vec{F}_{Achilles}$.

Foot is in equilibrium, so $\Sigma \vec{F} = 0$ and $\Sigma \tau = 0$.

$\boxed{1.73 \times 10^3 \text{N}}$

$\Sigma \tau = 0$ and $\tau = F r_\perp$

$\tau_N + \tau_{Achilles} = 0$

$N \ell_N - F_{Achilles} \ell_A = 0$

$F_{Achilles} = \dfrac{N \ell_N}{\ell_A} = \dfrac{(575\text{N})(11.9\text{ cm})}{3.95\text{ cm}} = 1.73 \times 10^3 \text{N}$

(b) Calculate the magnitude of the force of the tibia bone on the ankle joint, $\vec{F}_{Tibia}$.

$\Sigma F_y = 0$

$\boxed{2.31 \times 10^3 \text{N}}$

$F_{Achilles} + N - F_{Tibia} = 0$

$F_{Achilles} + N = F_{Tibia}$

$F_{Tibia} = 1.73 \times 10^3 \text{N} + 575\text{N} = 2.31 \times 10^3 \text{N}$

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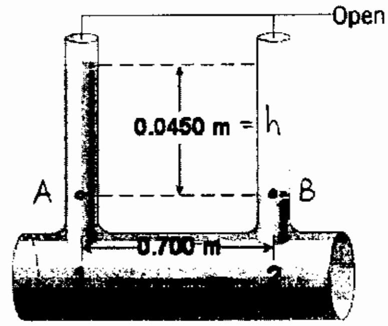
B2. Water is flowing through a horizontal pipe with a volume flow rate of 0.0140 m^3/s. As the drawing shows, there are two vertical tubes that project from the pipe. The density of water is 1.00×10^3 kg/m^3 and its viscosity is 1.00×10^{-3} Pa·s.



(a) Calculate the pressure difference, $P_1 - P_2$, between locations 1 and 2.

Refer to the diagram and note that

$$P_1 - P_2 = P_A - P_B$$

$$\boxed{441\ Pa}$$

$$P_1 - P_2 = (P_{atm} + \rho g h) - P_{atm}$$

$$P_1 - P_2 = \rho g h = (1.00 \times 10^3\ kg/m^3)(9.80\ m/s^2)(0.0450\ m)$$

$$P_1 - P_2 = 441\ N/m^2 = 441\ Pa$$

(b) Calculate the radius of the horizontal pipe.

Poiseuille's Law:

$$\boxed{1.54 \times 10^{-2}\ m}$$

$$\frac{\Delta V}{\Delta t} = \frac{\pi}{8} \frac{\Delta P / L}{\eta} r^4$$

$$r^4 = \left(\frac{\Delta V}{\Delta t}\right) \frac{8 \eta L}{\pi \Delta P} \Rightarrow r = \left[\left(\frac{\Delta V}{\Delta t}\right) \frac{8 \eta L}{\pi \Delta P}\right]^{1/4}$$

$$r = \left[\frac{(0.0140\ m^3/s)(8)(1.00 \times 10^{-3}\ Pa\ s)(0.700\ m)}{\pi\ (441\ Pa)}\right]^{1/4}$$

$$r = 1.54 \times 10^{-2}\ m$$

(c) Calculate the flow speed in the horizontal pipe. If you did not obtain an answer for (b), use 1.50 cm.

$$\boxed{18.8\ m/s}$$

$$\frac{\Delta V}{\Delta t} = A v$$

$$v = \frac{\Delta V / \Delta t}{A} = \frac{\Delta V / \Delta t}{\pi r^2}$$

$$v = \frac{0.0140\ m^3/s}{\pi\ (1.54 \times 10^{-2}\ m)^2} = 18.8\ m/s$$

(19.8 m/s for $r = 1.50$ cm)

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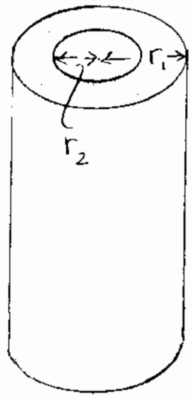
B3. A person is standing on one leg. The tibia, which is the lower leg bone between the knee and the ankle joint, may be approximated as a 0.400-m-long hollow cylinder with an outer radius of 1.25×10^{-2} m and a hollow inside core with a radius of 6.50×10^{-3} m. Ignoring the lower leg, the mass of the person is 63.0 kg. Young's modulus for compression for bone is 9.40×10^9 N/m^2. You may assume that the leg is vertical and that there are no muscle forces acting on it.

(a) Calculate the cross-sectional area of the bone in the tibia.



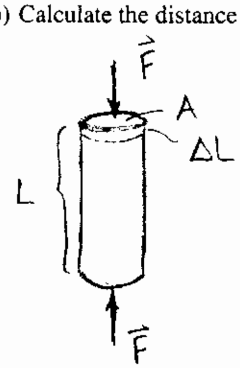
$\boxed{3.58 \times 10^{-4} m^2}$

$$A_{bone} = \pi r_1^2 - \pi r_2^2$$

$$A_{bone} = \pi\left[(1.25 \times 10^{-2} m)^2 - (6.50 \times 10^{-3} m)^2\right]$$

$$A_{bone} = 3.58 \times 10^{-4} m^2$$

(b) Calculate the distance by which the tibia is compressed.



$\boxed{7.34 \times 10^{-5} m}$

$$\frac{F}{A} = Y \frac{\Delta L}{L}$$

F = weight of person.

$$\Delta L = \frac{FL}{AY} = \frac{mgL}{AY}$$

$$\Delta L = \frac{(63.0 kg)(9.80 m/s^2)(0.400 m)}{(3.58 \times 10^{-4} m^2)(9.40 \times 10^9 N/m^2)}$$

$$\Delta L = 7.34 \times 10^{-5} m$$

(c) The ultimate compressive strength of the tibia is 2.01×10^8 N/m^2. Calculate the maximum compressive force that the tibia can withstand before fracturing.

$\boxed{7.20 \times 10^4 N}$

$$S = \frac{F_{max}}{A}$$

$$F_{max} = SA = (2.01 \times 10^8 N/m^2)(3.58 \times 10^{-4} m^2)$$

$$F_{max} = 7.20 \times 10^4 N$$

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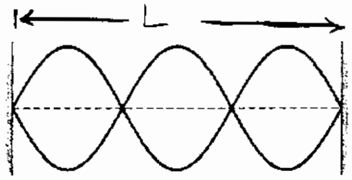
B4. A string has a linear mass density of 8.50×10^{-3} kg/m and is under a tension of 280 N. The string is 1.80 m long, is fixed at both ends, and is vibrating in the standing wave pattern shown in the diagram below.



$$L = 3\left(\tfrac{1}{2}\lambda\right)$$

(a) Calculate the speed of the traveling wave that makes up the standing wave.

$$\boxed{181\ \text{m/s}}$$

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

$$v = \sqrt{\frac{280\text{N}}{8.50\times10^{-3}\,\text{kg/m}}} = 181\ \text{m/s}$$

(b) Calculate the wavelength of the traveling wave that makes up the standing wave.

$$L = 3\left(\tfrac{1}{2}\lambda\right) \quad \text{(refer to diagram)} \qquad \boxed{1.20\text{m}}$$

$$\lambda = \frac{2L}{3} = \frac{2(1.80\text{m})}{3} = 1.20\text{m}$$

(c) Calculate the frequency of the traveling wave that makes up the standing wave.

$$\boxed{151\ \text{Hz}}$$

$$f = \frac{v}{\lambda} = \frac{181\ \text{m/s}}{1.20\text{m}} = 151\ \text{Hz}$$

END OF EXAMINATION