UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 117.3
MIDTERM TEST

February 14, 2013 Time: 90 minutes

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

LECTURE SECTION (please check):

❑ 01 B. Zulkoskey
❑ 02 N. Zarifi
❑ C15 F. Dean

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, including this cover page. **It is the responsibility of the student to check that the test paper is complete**.
3. Only Hewlett-Packard hp 10S or 30S or Texas Instruments TI-30X series calculators, or a calculator approved by your instructor, 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...

PART A

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

B

A1. You are trying to remove a lug nut to change a flat tire. You apply a perpendicular force of magnitude F at a distance of r from the centre of the nut but it doesn't rotate. You then obtain a pole that you attach to the end of your wrench and apply the same perpendicular force of magnitude F at a distance of $3r$ from the nut. By what factor is the torque, τ_2, that you are now applying to the lug nut increased compared to the original torque, τ_1?

$\tau = rF\sin\theta$

(A) $\tau_2 = 2\,\tau_1$ (B) $\tau_2 = 3\,\tau_1$ (C) $\tau_2 = 4\,\tau_1$ (D) $\tau_2 = 6\,\tau_1$ (E) $\tau_2 = 9\,\tau_1$

B

A2. Consider a wheel mounted on a frictionless axle. The wheel is initially not rotating. When a net torque is applied to the wheel…

$\sum \tau = I\alpha$ ↑ angular accel'n

(A) the angular momentum of the wheel decreases.
(B) the wheel has an angular acceleration.
(C) the wheel has a constant angular speed.
(D) the moment of inertia of the wheel increases.
(E) the angular momentum of the wheel remains constant.

D

A3. Consider two uniform, solid spheres: a large, massive sphere and a smaller, lighter sphere. They are simultaneously released from rest at the top of a hill and roll down without slipping. Which one reaches the bottom of the hill first?

$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$

$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v^2}{R^2}\right)$

$Mgh = \frac{1}{2}Mv^2 + \frac{1}{5}Mv^2$

$gh = \frac{7}{10}v^2$ (v is independent of M, R)

(A) The large sphere reaches the bottom first.
(B) The small sphere reaches the bottom first.
(C) The sphere with the greater density reaches the bottom first.
(D) The spheres reach the bottom at the same time.
(E) The answer depends on the values of the spheres' masses and radii.

E

A4. A star originates as a large body of slowly rotating gas. Because of gravitational attraction, this large body of gas slowly decreases in size. Which one of the following statements correctly describes what happens as the radius of the body of gas decreases?

$\tau_{ext} = 0 \Rightarrow L$ cons.

$I_i\omega_i = I_f\omega_f$

$I\downarrow,\ \omega\uparrow$

(A) Both the angular momentum and the angular velocity increase.
(B) The angular momentum increases and the angular velocity decreases.
(C) Both the angular momentum and the angular velocity decrease.
(D) Both the rotational inertia and the angular velocity increase.
(E) The angular momentum remains constant and the angular velocity increases.

B

A5. The Young's modulus of steel is twice the value of the Young's modulus of copper. If a copper wire and a steel wire, each of the same length, stretch by the same amount when the same tensile force is applied to each wire, which one of the following statements is correct?

(A) The cross-sectional area of the steel wire is ¼ the cross-sectional area of the copper wire.
(B) The cross-sectional area of the steel wire is ½ the cross-sectional area of the copper wire.
(C) The cross-sectional area of the steel wire is the same as the cross-sectional area of the copper wire.
(D) The cross-sectional area of the steel wire is twice the cross-sectional area of the copper wire.
(E) The cross-sectional area of the steel wire is four times the cross-sectional area of the copper wire.

$\frac{F}{A} = Y\frac{\Delta L}{L} \Rightarrow \frac{FL}{\Delta L} = YA \Rightarrow Y_sA_s = Y_cA_c \Rightarrow A_s = \frac{Y_c}{Y_s}\cdot A_c = \frac{1}{2}A_c$

B

A6. The dimension of the quantity "stress", expressed in terms of the fundamental dimensions (mass, M; length, L; and time, T), is:

Stress $= F/A = N/m^2 = kg\cdot m/s^2/m^2 = kg/s^2\cdot m \Rightarrow ML^{-1}T^{-2}$

(A) MLT^{-1} (B) $ML^{-1}T^{-2}$ (C) $M^2L^{-1}T^{-3}$ (D) $M^{-1}L^{-1}T^{-2}$ (E) *dimensionless*

B

A7. Let h be the depth below the surface of the ocean at which the absolute pressure is three times atmospheric pressure (i.e. $3P_{atm}$). The pressure at a depth of ½ h below the surface of the ocean is

(A) 1.5 P_{atm} (B) 2 P_{atm} (C) 3 P_{atm} (D) 3.5 P_{atm} (E) 4 P_{atm}

P_{atm}

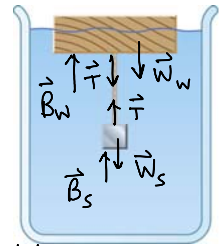
$P_{\frac{1}{2}h} = P_{atm} + \rho g\frac{h}{2} = P_{atm} + \cancel{\rho g}\frac{1}{\cancel{2}}\left(\frac{\cancel{2}P_{atm}}{\cancel{\rho g}}\right) = 2P_{atm}$

h

$P_h = P_{atm} + \rho gh = 3P_{atm} \Rightarrow \rho gh = 2P_{atm} \Rightarrow h = 2P_{atm}/\rho g$

continued on page 3...

A8. A wooden block floats in water, and a solid steel object is attached to the bottom of the block by a string. If the block remains floating, which one of the following statements is **TRUE**?



D

(A) The buoyant force on the steel object is equal to its weight.
(B) The buoyant force on the block is equal to its weight.
(C) The tension in the string is equal to the weight of the steel object.
(D) The tension in the string is less than the weight of the steel object.
(E) The buoyant force on the block is less than the weight of the volume of water it displaces.

Block and steel object are in equilibrium

A9. Which one of the following statements concerning simple harmonic motion (SHM) is **TRUE**?

D

(A) SHM can occur near any point of equilibrium (point of stable or unstable equilibrium).
(B) SHM occurs for any force that tends to restore equilibrium.
(C) SHM occurs for any restoring force whose magnitude is proportional to the square of displacement from a point of stable equilibrium.
(D) SHM occurs for any restoring force whose magnitude is proportional to the magnitude of the displacement from a point of stable equilibrium.
(E) SHM occurs for any restoring force whose magnitude varies inversely with the magnitude of the displacement from a point of stable equilibrium.

$\vec{F} = -k\vec{x}$

A10. 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:

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

A

(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) $\frac{T_1}{T_2} = \frac{m_1 + m_2}{m_1 - m_2}$

$T = 2\pi\sqrt{\frac{m}{k}}$

$\frac{T_1}{T_2} = \sqrt{\frac{m_1}{m_2}}$

A11. A wave is travelling along a guitar string. If the tension in the guitar string is doubled, what is the new wave speed, υ, in terms of the original wave speed, υ_o?

$\upsilon = \sqrt{\frac{F}{\mu}} \Rightarrow \upsilon \propto \sqrt{F}$

B

(A) $\upsilon = \frac{4}{3}\upsilon_o$ (B) $\upsilon = \sqrt{2}\upsilon_o$ (C) $\upsilon = 2\upsilon_o$ (D) $\upsilon = \upsilon_o$ (E) $\upsilon = \frac{1}{4}\upsilon_o$

$\upsilon/\upsilon_o = \sqrt{F/F_o} = \sqrt{2F_o/F_o} = \sqrt{2} \Rightarrow \upsilon = \sqrt{2}\upsilon_o$

A12. If the frequency of a traveling wave train is increased by a factor of three in a medium where the speed is constant, which one of the following is the result?

$\upsilon = f\lambda \qquad f_2 = 3f_1$

C

(A) Amplitude is one-third of the original.
(B) Amplitude is tripled.
(C) Wavelength is one-third of the original.
(D) Wavelength is tripled.
(E) Angular frequency is one-third of the original.

$\upsilon = f_1\lambda_1 = f_2\lambda_2 \Rightarrow \lambda_2 = \frac{f_1\lambda_1}{f_2}$

$\lambda_2 = \frac{f_1\lambda_1}{3f_1} = \frac{1}{3}\lambda_1$

A13. Suppose the air temperature increases from 10°C to 20°C. The speed of sound in the air will

B

(A) decrease.
(B) increase a small amount. The new speed will be less than double the original speed.
(C) not change.
(D) sometimes increase and sometimes decrease.
(E) be double the speed at 10°C.

$\upsilon = 331\,m/s\sqrt{\frac{T}{273K}}$

T : 10°C to 20°C
⇓
283K to 293K
∴ small increase

A14. Which one of the following statements best explains why the tissue to be examined is coated with mineral oil prior to performing ultrasonic imaging?

A

(A) The mineral oil ensures that most of the ultrasonic energy is transmitted into the tissue.
(B) The mineral oil minimizes friction as the ultrasonic probe slides across the skin.
(C) The mineral oil decreases the sensitivity of the skin to contact with the ultrasonic probe.
(D) The mineral oil increases the temperature of the probe so that it is more comfortable on the skin.
(E) The mineral oil dissolves the outer layer of skin, which would otherwise completely block the ultrasonic waves from entering the tissue.

A15. A sound source radiates sound uniformly in all directions. The power of the source is constant. The sound intensity is I at a distance of r from the source. The intensity at a distance of $2r$ is

A

(A) ¼ I (B) ½ I (C) I (D) 2 I (E) 4 I

$P = IA = \text{constant} \Rightarrow I_1A_1 = I_2A_2$

$I_2 = \frac{I_1A_1}{A_2} = \frac{I4\pi r^2}{4\pi(2r)^2} = \frac{I \cdot r^2}{4r^2} = \frac{1}{4}I$

continued on page 4...

PART B

ANSWER THREE 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.

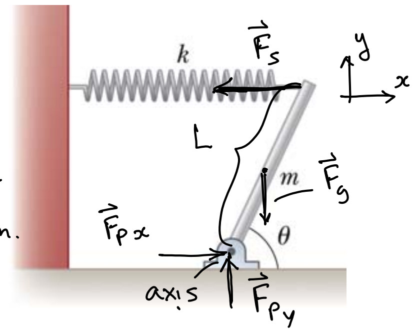
SHOW AND EXPLAIN YOUR WORK – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.

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

continued on page 5...

B1. A uniform beam of mass m, pivoted at its lower end, has a horizontal spring, with spring constant, k, attached between its top end and a vertical wall. The beam makes an angle θ with the horizontal.



Let L = length of beam
uniform ⇒ centre of gravity is at centre
Choose the pivot as the axis of rotation.

(a) Derive an expression for the distance d that the spring is stretched from its equilibrium length. Your answer may be expressed in terms of the quantities m, g, k, θ, and no others. (6 marks)

$d = \dfrac{mg}{2k\tan\theta}$

The beam is in equilibrium.

$$\therefore \sum\tau = 0, \quad \sum F_x = 0, \quad \sum F_y = 0$$

$$\Downarrow$$

$$\tau_{F_s} + \tau_{F_g} + \tau_{F_{px}} + \tau_{F_{py}} = 0$$

$$+ r_s F_s \sin\theta - r_g F_g \sin(90° - \theta) + 0 + 0 = 0$$

$$\cancel{L}(kd)\sin\theta - \tfrac{1}{2}\cancel{L}mg\cos\theta = 0$$

$$kd\sin\theta = \frac{mg\cos\theta}{2} \Rightarrow d = \frac{mg\cos\theta}{2k\sin\theta} = \frac{mg}{2k\tan\theta}$$

(b) Derive an expression for the magnitude of the horizontal component of the force exerted by the pivot on the beam. If you did not obtain an answer for (a), you may include d as one of the symbols in your expression. (2 marks)

$F_x = kd = \dfrac{mg}{2\tan\theta}$

$$\sum F_x = 0$$

$$+ F_{px} - F_s = 0$$

$$F_{px} = F_s$$

$$F_{px} = kd = k\left(\frac{mg}{2k\tan\theta}\right) = \frac{mg}{2\tan\theta}$$

(c) Derive an expression for the magnitude of the vertical component of the force exerted by the pivot on the beam. (2 marks)

$F_y = mg$

$$\sum F_y = 0$$

$$+ F_{py} - F_g = 0$$

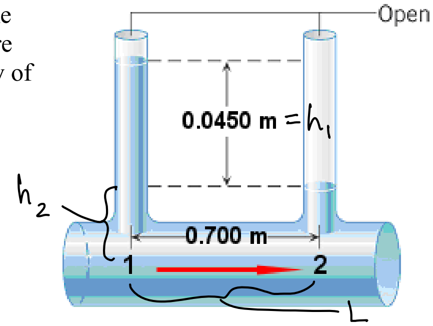
$$F_{py} = F_g$$

$$F_{py} = mg$$

continued on page 6...

Stu. No.: ____________________

B2. Water is flowing through a horizontal pipe with a volume flow rate of 0.0240 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 0.500×10^{-3} Pa·s.



(a) Calculate the pressure difference, $P_1 - P_2$, between locations 1 and 2. (3 marks)

$$P_1 = P_{atm} + \rho g h_1 + \rho g h_2$$

$$P_2 = P_{atm} + \rho g h_2$$

$$P_1 - P_2 = P_{atm} + \rho g h_1 + \rho g h_2 - P_{atm} - \rho g h_2 = \rho g h_1$$

$$P_1 - P_2 = (1.00 \times 10^3 \, kg/m^3)(9.80 \, m/s^2)(0.0450 \, m) = 441 \, Pa$$

$\boxed{441 \text{ Pa}}$

(b) Calculate the radius of the horizontal pipe. (5 marks)

Viscous flow ⇒ Poiseuille's Law

$$\frac{\Delta V}{\Delta t} = \frac{\pi R^4 (P_1 - P_2)}{8 \eta L} = \text{volume flow rate}$$

$$R = \sqrt[4]{\frac{8 \eta L}{\pi (P_1 - P_2)} \left(\frac{\Delta V}{\Delta t}\right)} = \left(\frac{8 (0.500 \times 10^{-3} \, Pa \cdot s)(0.700 \, m)(0.0240 \, m^3/s)}{\pi (441 \, Pa)}\right)^{1/4}$$

$$R = 1.48 \times 10^{-2} \, m = 1.48 \, cm$$

$\boxed{1.48 \text{ cm}}$

(c) Calculate the flow speed in the horizontal pipe. If you did not obtain an answer for (b), use 1.50 cm. (2 marks)

$$\frac{\Delta V}{\Delta t} = A v \; ; \quad A = \pi R^2$$

$$v = \frac{\Delta V / \Delta t}{\pi R^2} = \frac{0.0240 \, m^3/s}{\pi (1.48 \times 10^{-2} \, m)^2} = 34.9 \, m/s$$

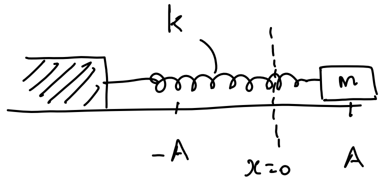
$\boxed{34.9 \text{ m/s}}$

ALT. VALUE: 34.0 m/s

continued on page 7...

B3. A cart of mass 250 g is placed on a frictionless horizontal air track. A spring with a spring constant of 9.50 N/m is attached between the cart and the left end of the track. The cart is displaced 4.50 cm from its equilibrium position and released.

(a) Calculate the period of the oscillations of the cart. (3 marks)



$m = 0.250\,\text{kg}$
$k = 9.50\,\text{N/m}$
$A = 0.0450\,\text{m}$

$\boxed{1.02\,\text{s}}$

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

$$T = 2\pi\sqrt{\frac{0.250\,\text{kg}}{9.50\,\text{N/m}}} = 1.02\,\text{s}$$

(b) Calculate the maximum speed of the cart. (3 marks)

$\boxed{0.277\,\text{m/s}}$

From $v = -A\omega \sin(2\pi f t)$, $v_{max} = \omega A$

$$v_{max} = \sqrt{\frac{k}{m}}\cdot A = \sqrt{\frac{9.50\,\text{N/m}}{0.250\,\text{kg}}}\cdot 0.0450\,\text{m} = 0.277\,\text{m/s}$$

or from Conservation of Mechanical Energy:

$$\cancel{\tfrac{1}{2}}kA^2 = \cancel{\tfrac{1}{2}}mv_{max}^2 \Rightarrow v_{max} = \sqrt{\frac{k}{m}}\cdot A$$

(c) Calculate the speed of the cart when it is a distance of 2.00 cm from its equilibrium position. (4 marks)

$\boxed{0.248\,\text{m/s}}$

From Conservation of Mechanical Energy:

$$\tfrac{1}{2}mv^2 + \tfrac{1}{2}kx^2 = \tfrac{1}{2}mv_{max}^2 = \tfrac{1}{2}kA^2$$

$$\cancel{\tfrac{1}{2}}mv^2 + \cancel{\tfrac{1}{2}}kx^2 = \cancel{\tfrac{1}{2}}kA^2 \Rightarrow mv^2 = k(A^2 - x^2)$$

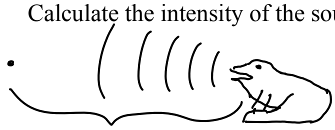
$$v = \pm\sqrt{\frac{k}{m}(A^2 - x^2)} = \pm\sqrt{\frac{9.50\,\text{N/m}}{0.250\,\text{kg}}\left((0.0450\,\text{m})^2 - (0.0200\,\text{m})^2\right)}$$

$$v = \pm 0.248\,\text{m/s}$$

continued on page 8...

B4. The toadfish makes use of resonance in a closed tube to produce very loud sounds. The tube is its swim bladder, used as an amplifier. The sound level of this creature has been measured as high as 95.0 dB at a distance of 1.00 m.

(a) Calculate the intensity of the sound wave at a distance of 1.00 m from the toadfish. (4 marks)



$\boxed{3.16\times10^{-3}\,W/m^2}$

$r = 1.00\,m$

β at $1.00\,m = 95.0\,dB$; $\beta = 10\log\left(\frac{I}{I_o}\right)$

$$\frac{\beta}{10} = \log\left(\frac{I}{I_o}\right) \Rightarrow \frac{I}{I_o} = 10^{\beta/10} \Rightarrow I = I_o \cdot 10^{\beta/10}$$

$$I = \left(1.00\times10^{-12}\,\frac{W}{m^2}\right)10^{95.0/10} = 3.16\times10^{-3}\,\frac{W}{m^2}$$

(b) Calculate the intensity level at a distance of 2.00 m from two of these toadfish when they are producing sound simultaneously. If you did not obtain an answer for (a), use a value of 3.20×10^{-3} W/m^2. (6 marks)

$\boxed{92.0\,dB}$

P_1 = power of one toadfish

P_2 = power of two toadfish $= 2P_1$

r_2 = distance from two toadfish $= 2.00\,m = 2r_1$ where r_1 is initial distance from one toadfish.

I_2 = intensity at distance r_2 from two toadfish $= \frac{P_2}{A_2} = \frac{P_2}{4\pi r_2^2}$

$$I_2 = \frac{P_2}{4\pi r_2^2} = \frac{2P_1}{4\pi(2r_1)^2} = \frac{2}{4}\left(\frac{P_1}{4\pi r_1^2}\right) = \frac{1}{2}I_1 = \frac{1}{2}\left(3.16\times10^{-3}\,W/m^2\right)$$

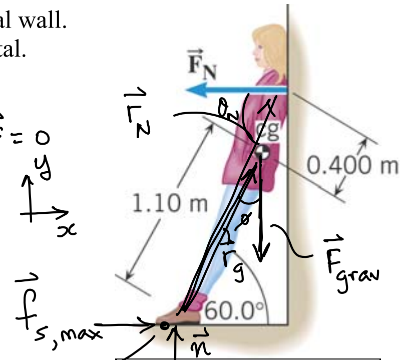
$$I_2 = 1.58\times10^{-3}\,\frac{W}{m^2}$$

$$\beta_2 = 10\log\left(\frac{I_2}{I_o}\right) = 10\log\left(\frac{1.58\times10^{-3}\,W/m^2}{1.00\times10^{-12}\,W/m^2}\right) = 92.0\,dB$$

END OF EXAMINATION

B1. A woman with a mass of 50.0 kg is leaning against a vertical wall. The force exerted on the woman by the wall, $\mathbf{F}_N$, is horizontal.

(a) Calculate the magnitude of $\mathbf{F}_N$. (5 marks)



axis

$\boxed{207\,N}$

Woman is in equilibrium $\Rightarrow \sum \tau = 0$, $\sum \vec{F} = 0$

Choose the contact pt. with the ground as the axis of rotation.

$$\sum \tau = 0$$

$$+ r_N F_N \sin\theta_N - r_g F_{grav} \sin\phi = 0$$

(τ_{f_s} and $\tau_n = 0$ since $\vec{f}_s$ and $\vec{n}$ pass through the axis of rotation.)

$$r_N F_N \sin\theta_N = r_g F_{grav} \sin\phi \Rightarrow F_N = \frac{r_g F_{grav} \sin\phi}{r_N \sin\theta_N} \; ; \; F_{grav} = mg$$

$$F_N = \frac{(1.10\,m)(50.0\,kg)(9.80\,m/s^2)\sin(90° - 60.0°)}{(1.10\,m + 0.400\,m)(\sin 60.0°)} = 207\,N$$

(b) Assuming that her feet are on the verge of slipping, calculate the coefficient of static friction between her feet and the ground. If you did not obtain an answer for (a), use a value of 225 N. (5 marks)

$\boxed{0.422}$

$$\sum F_x = 0 \Rightarrow +f_{s,max} - F_N = 0$$

$$f_{s,max} = F_N$$

$$\sum F_y = 0 \Rightarrow +n - F_{grav} = 0 \Rightarrow n = F_{grav} \; ; \; n = mg$$

$$f_{s,max} = \mu_s n \Rightarrow \mu_s = \frac{f_{s,max}}{n} = \frac{F_N}{mg} = \frac{207\,N}{(50.0\,kg)(9.80\,m/s^2)}$$

$$\mu_s = 0.422$$

ALT. ANSWER: 0.459

continued on page 6...

B2. A straight horizontal pipe with a diameter of 1.00 cm and a length of 50.0 m carries oil with a coefficient of viscosity of 0.120 Pa·s. At the output of the pipe, the flow rate is 8.60×10^{-5} m^3/s and the pressure is 1.00 atm.

(a) Calculate the speed of the fluid at the output of the pipe. (4 marks)

$\boxed{1.09 \text{ m/s}}$

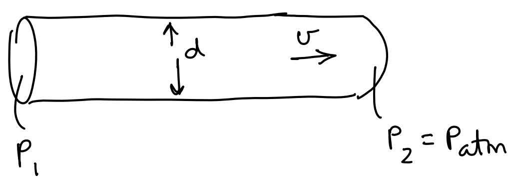
$$\text{flow rate} = \frac{\Delta V}{\Delta t} = Av \; ; \; R = \frac{1}{2}d$$

$$v = \frac{1}{A}\cdot\frac{\Delta V}{\Delta t} = \frac{1}{\pi R^2}\cdot\frac{\Delta V}{\Delta t} = \frac{1}{\pi\left(\frac{0.0100\text{m}}{2}\right)^2}\left(8.60\times10^{-5}\,\text{m}^3/\text{s}\right)$$

$$v = 1.09 \text{ m/s}$$

(b) Calculate the gauge pressure at the pipe input. (6 marks)

$\boxed{2.10\times10^6 \text{ Pa}}$



Viscous fluid $\Rightarrow$ Poiseuille's Law: $\frac{\Delta V}{\Delta t} = \frac{\pi R^4 (P_1 - P_2)}{8\eta L}$

$$P_1 - P_2 = \frac{8\eta L}{\pi R^4}\left(\frac{\Delta V}{\Delta t}\right)$$

Since $P_2 = P_{atm}$, $P_1 - P_2 = P_1 - P_{atm} = P_{1\,gauge}$

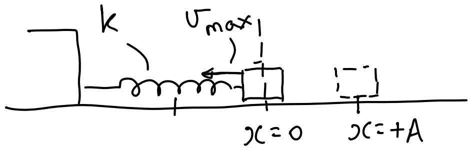
$$P_{1\,gauge} = \frac{8\eta L}{\pi (d/2)^4}\left(\frac{\Delta V}{\Delta t}\right) = \frac{8(0.120\text{ Pa}\cdot\text{s})(50.0\text{m})}{\pi(0.00500\text{m})^4}\left(8.60\times10^{-5}\,\text{m}^3/\text{s}\right)$$

$$P_{1\,gauge} = 2.10\times10^6 \text{ Pa}$$

continued on page 7...

B3. A horizontal block-spring system with the block on a frictionless surface has total mechanical energy of 47.0 J and a maximum displacement from equilibrium of 0.240 m. The maximum speed of the block is 3.45 m/s.

(a) Calculate the mass of the block. (3 marks)



$\boxed{7.90\text{ kg}}$

Mechanical Energy is conserved:

$$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}mv_{max}^2 + 0 = 0 + \frac{1}{2}kA^2$$

$$E = \frac{1}{2}mv_{max}^2 \Rightarrow m = \frac{2E}{v_{max}^2} = \frac{2(47.0\text{J})}{(3.45\text{m/s})^2} = 7.90\text{ kg}$$

(b) Calculate the speed of the block when its displacement is 0.160 m. If you did not obtain an answer for (a), use a value of 8.00 kg. (4 marks)

$\boxed{2.57\text{ m/s}}$

$$E = \frac{1}{2}kA^2 \Rightarrow k = \frac{2E}{A^2} = \frac{2(47.0\text{J})}{(0.240\text{m})^2}$$

$$k = 1.63 \times 10^3\text{ N/m}$$

$$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 \Rightarrow \frac{1}{2}mv^2 = E - \frac{1}{2}kx^2 \Rightarrow v^2 = \frac{2E}{m} - \frac{k}{m}x^2$$

$$v = \sqrt{\frac{2(47.0\text{J})}{(7.90\text{ kg})} - \frac{1.63\times10^3\text{N/m}}{7.90\text{kg}}(0.160\text{m})^2} = 2.57\text{ m/s}$$

(c) Calculate the period of the block's oscillations. If you did not obtain an answer for (a), use a value of 8.00 kg. (3 marks)

$\boxed{0.437\text{ s}}$

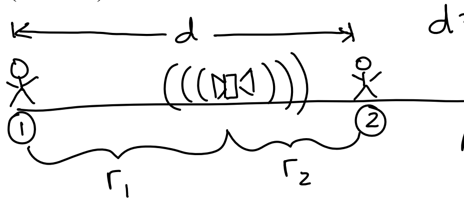
$$\omega = \frac{2\pi}{T} = \sqrt{\frac{k}{m}}$$

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{7.90\text{ kg}}{1.63\times10^3\text{N/m}}} = 0.437\text{s}$$

continued on page 8...

B4. A stereo speaker is placed between two observers who are 36.0 m apart, along the line connecting them. Observer 1 records an intensity level of 62.0 dB and observer 2 records an intensity level of 85.0 dB.

(a) Calculate the intensity at observer 1's position and the intensity at observer 2's position. (4 marks)



$d = 36.0\,m$

$\beta_1 = 62.0\,dB$

$\beta_2 = 85.0\,dB$

1:	$1.58\times10^{-6}\,W/m^2$
2:	$3.16\times10^{-4}\,W/m^2$

$$\beta = 10\log\left(\frac{I}{I_o}\right) \Rightarrow \log\left(\frac{I}{I_o}\right) = \beta/10 \Rightarrow \frac{I}{I_o} = 10^{\beta/10}$$

$$I = I_o \cdot 10^{\beta/10} \Rightarrow I_1 = (1.00\times10^{-12}\,W/m^2)10^{62.0/10} = 1.58\times10^{-6}\,\frac{W}{m^2}$$

$$I_2 = (1.00\times10^{-12}\,W/m^2)\,10^{85.0/10} = 3.16\times10^{-4}\,W/m^2$$

(b) Calculate the distance of observer 1 from the speaker. If you did not obtain answers for (a), use values of $I_1 = 1.60 \times 10^{-6}$ W/m^2 and $I_2 = 3.20 \times 10^{-4}$ W/m^2. (6 marks)

33.6m

The speaker is producing sound energy at a constant rate P.

$$P = I_1 A_1 = I_2 A_2 \Rightarrow I_1(\cancel{4\pi} r_1^2) = I_2(\cancel{4\pi} r_2^2)$$

$$I_1 r_1^2 = I_2 r_2^2 \Rightarrow \sqrt{I_1}\cdot r_1 = \sqrt{I_2}\cdot r_2$$

and $r_1 + r_2 = d \Rightarrow r_2 = d - r_1$

$$\therefore \sqrt{I_1}\cdot r_1 = \sqrt{I_2}(d - r_1) \Rightarrow \sqrt{I_1}\cdot r_1 = \sqrt{I_2}\cdot d_2 - \sqrt{I_2}\cdot r_1$$

$$r_1\left(\sqrt{I_1} + \sqrt{I_2}\right) = \sqrt{I_2}\cdot d$$

$$r_1 = \frac{\sqrt{I_2}}{\sqrt{I_1} + \sqrt{I_2}}\cdot d = \frac{\sqrt{3.16\times10^{-4}\,W/m^2}}{\sqrt{1.58\times10^{-6}\,\frac{W}{m^2}} + \sqrt{3.16\times10^{-4}\,\frac{W}{m^2}}}(36.0\,m)$$

$$r_1 = 33.6\,m$$

END OF EXAMINATION