

UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 117.3
MIDTERM TEST

February 16, 2012

Time: 90 minutes

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

STUDENT NO.: _____

LECTURE SECTION (please check):

- 01 B. Zulkoskey
- 02 Dr. J-P St. Maurice
- 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. **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

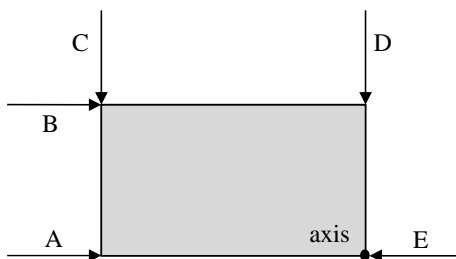


QUESTION NUMBER	TO BE MARKED	MAXIMUM MARKS	MARKS OBTAINED
A1-15	-	15	
B1	<input type="checkbox"/>	10	
B2	<input type="checkbox"/>	10	
B3	<input type="checkbox"/>	10	
B4	<input type="checkbox"/>	10	
TOTAL		45	

PART A

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

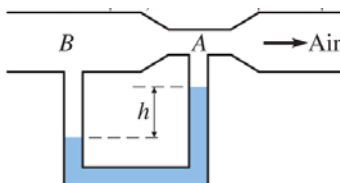
- A1. A uniform bar of length L and weight W is attached to a vertical wall by a frictionless hinge. Which one of the following scenarios can result in the bar being horizontal and stationary?
- (A) A force of magnitude W is applied vertically upward to the bar at a distance of L from the hinge.
 - (B) A force of magnitude W is applied horizontally to the bar at a distance of L from the hinge.
 - (C) A force of magnitude $\frac{1}{2}W$ is applied vertically upward to the bar at a distance of L from the hinge.
 - (D) A force of magnitude $\frac{1}{2}W$ is applied vertically upward to the bar at a distance of $\frac{1}{2}L$ from the hinge.
 - (E) A force of magnitude W is applied horizontally to the bar at a distance of $\frac{1}{2}L$ from the hinge.
- A2. A student holding a pair of dumbbells in his outstretched arms is rotating on a stool that has frictionless bearings. When the student pulls his arms closer to his body...
- (A) both his angular momentum and his angular velocity increase.
 - (B) his angular momentum increases and his angular velocity decreases.
 - (C) both his angular momentum and his angular velocity decrease.
 - (D) both his rotational inertia and his angular velocity increase.
 - (E) his angular momentum remains constant and his angular velocity increases.
- A3. Which one of the following statements is **TRUE**?
- (A) If the net force on an object is zero then the net torque on the object must also be zero.
 - (B) If the net torque on an object is zero then the net force on the object must also be zero.
 - (C) If the net force on an object is zero then the object cannot be rotating.
 - (D) If the net torque on an object is zero then the centre of mass of the object must be stationary.
 - (E) If the net force on an object is zero and the net torque on the object is zero then the object is in rotational equilibrium (no translational acceleration and no angular acceleration)
- A4. Five forces, A, B, C, D, and E, all of equal magnitude, act on a rectangular object as shown below. Which force produces the largest magnitude of torque if the axis of rotation is through the lower right corner of the object and perpendicular to the object?

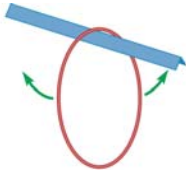


- (A) A (B) B (C) C (D) D (E) E

- A5. Air is flowing into a Venturi meter (see figure). The narrow section of the pipe at point A has a diameter that is $\frac{1}{2}$ of the diameter of the larger section of the pipe at point B. You may assume that the density of the air is constant. The U-shaped tube is filled with water. If the air speed at B is v , how fast is the air moving at point A?

- (A) $\frac{1}{4}v$ (B) $\frac{1}{2}v$ (C) v (D) $2v$ (E) $4v$



- A6. Which has a greater buoyant force on it, a 25 cm^3 piece of wood floating with part of its volume above water or a 25 cm^3 piece of submerged iron?
- (A) The floating wood.
(B) The submerged iron.
(C) They each experience the same buoyant force.
(D) It is impossible to say without knowing their weights.
(E) It is impossible to say without knowing the depth of the piece of submerged iron.
- A7. A viscous fluid is flowing steadily through a pipe of radius r . Suppose you replace it by two parallel pipes, each of radius $\frac{1}{2} r$, but the same length as the original pipe. If the pressure difference between the ends of these two pipes is the same as for the original pipe, what is the total rate of flow in the two pipes compared to the original flow rate, Q_1 ?
- (A) $\frac{1}{8} Q_1$ (B) $\frac{1}{4} Q_1$ (C) $\frac{1}{2} Q_1$ (D) Q_1 (E) $2Q_1$
- A8. An object attached to a spring is undergoing simple harmonic motion. Which one of the following statements is **FALSE**?
- (A) The object's acceleration is maximum at the equilibrium position.
(B) The restoring force always acts to return the spring to its equilibrium position.
(C) The object's velocity is instantaneously zero at maximum displacement.
(D) The object's velocity is maximum at the equilibrium position.
(E) The restoring force is always directed opposite to the displacement from equilibrium.
- A9. Which one of the following statements is **FALSE**?
- (A) An object in equilibrium can still be deformed by forces.
(B) An elastic object can return to its original shape, provided the applied force is not too large.
(C) A tensile (stretching) force applied to the ends of a wire exerts a shear stress on the wire.
(D) Tensile strain is the fractional change in length.
(E) Strain is a dimensionless measure of the deformation of an object.
- A10. A force F applied to each end of a steel wire (length L , diameter d) stretches it by ΔL . How much does the same force F stretch another steel wire of length $2L$ and diameter $2d$?
- (A) $\frac{1}{4} \Delta L$ (B) $\frac{1}{2} \Delta L$ (C) ΔL (D) $2 \Delta L$ (E) $4 \Delta L$
- A11. A thin circular hoop is suspended from a knife edge as shown in the figure. Its rotational inertia about the rotation axis (along the knife edge) is $I = 2MR^2$. You want to compare its frequency of oscillation to that of a simple pendulum that has its mass suspended at a distance equal to the radius of the hoop. Let f be the frequency of oscillation of the simple pendulum. The frequency of oscillation of the hoop is
- 
- (A) $\frac{f}{2}$ (B) $\frac{f}{\sqrt{2}}$ (C) f (D) $\sqrt{2}f$ (E) $2f$
- A12. 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) $\frac{1}{4} I$ (B) $\frac{1}{2} I$ (C) I (D) $2 I$ (E) $4 I$
- A13. Two speakers, separated by a distance d , are producing coherent sound waves that are in phase at a point P that is the same distance from each speaker. The wavelength of the sound being produced is λ . Point Q is a distance r_1 from speaker 1 and a distance r_2 from speaker 2. Which one of the following conditions will ensure that the sound waves from the speakers interfere destructively at Q ?
- (A) $|r_2 - r_1| = 2d$ (B) $|r_2 - r_1| = d$ (C) $|r_2 - r_1| = \frac{1}{2} d$ (D) $|r_2 - r_1| = \lambda$ (E) $|r_2 - r_1| = \frac{1}{2} \lambda$

- A14. A sign is hanging from a single metal wire, as shown in the left part of the accompanying figure. The shop owner notices that the wire vibrates at a fundamental resonance frequency of f , which irritates his customers. In an attempt to fix the problem, the shop owner cuts the wire in half and hangs the sign from the two halves, as shown in the right part of the figure. Assuming the tension in each of the two wires is now half the original tension, what is the new fundamental frequency of each wire?



- (A) $\frac{f}{2}$ (B) $\frac{f}{\sqrt{2}}$ (C) f (D) $\sqrt{2}f$ (E) $2f$
- A15. The accompanying figure shows a snapshot of a transverse wave moving to the left on a string. The wave speed is 10.0 m/s and to the left, as shown. At the instant the snapshot is taken, in what directions are points A and B moving?



- (A) They are both moving to the left.
(B) They are both moving up.
(C) Point A is moving up while point B is moving down.
(D) Point A is moving down while point B is moving up.
(E) They are both moving down.

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.

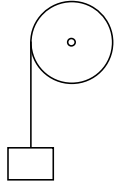
SHOW AND EXPLAIN YOUR WORK – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.

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

B1. A light rope is wrapped several times around a large uniform wheel with a radius of 0.400 m. The wheel rotates in frictionless bearings about a stationary horizontal axis. The free end of the rope is tied to a suitcase with a mass of 15.0 kg. The suitcase is released from rest at a height of 4.00 m above the ground, and has a speed of 3.50 m/s when it reaches the ground.

(a) Calculate the angular velocity of the wheel when the suitcase reaches the ground. (2 marks)



(b) Calculate the rotational inertia of the wheel. If you did not obtain an answer for (a), use a value of 9.00 rad/s (5 marks)

(c) Calculate the mass of the wheel. If you did not obtain an answer for (b) use a value of 12.5 kg·m². (3 marks)

B2. A block of wood, with density 700 kg/m^3 , has a cubic shape with sides 0.330 m long. A rope of negligible mass is used to tie a piece of lead (density 11300 kg/m^3) to the bottom of the wood. The lead pulls the wood into the water (density of 1000 kg/m^3) until the block of wood is just completely covered with water.

(a) Calculate the volume of the wood block in m^3 . (1 mark)

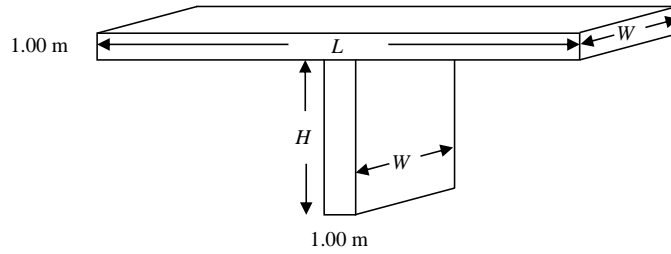
(b) Calculate the mass of the wood block in kg. (1 mark)

(c) Since lead is so dense, assume for a quick first order answer that the volume of lead is negligible compare to the volume of the block of wood. With this approximation, use Archimedes' principle to obtain an approximate value for the mass of the piece of lead. (3 marks)

(d) If you were now to take account of the additional volume occupied by the piece of lead, would you expect to obtain a larger value or a smaller value for the mass of the piece of lead? Explain briefly. (2 marks)

(e) Do the exact calculation for the mass of lead by properly taking its volume into account. (3 marks)

- B3. An engineer wants to construct a “table” made of concrete (a piece of super highway over the mountains, really). The “table” is to be 1.00 m thick, W m wide and L m long. It is to be supported by a rectangular column of concrete H m high, with an area W m by 1.00 m large:



- (a) Show that the pressure on the bottom of the concrete support column is independent of the width W . For $L = H = 100$ m, calculate the compression stress, in Pa, at the bottom of the column. Use 2400 kg/m^3 for the density of concrete. (3 marks)

- (b) The maximum mass load from cars that might pile up on the highway during a traffic jam is estimated to be $(9000 L) \text{ kg}$. If the width W is 20.0 m, calculate the additional pressure, in Pa, exerted on the base of the support column in terms of L . (Obtain a number times L which will give you Pa if L is in m). (3 marks)

- (c) In order to make more money, the contractor decides to have each column support a chunk of road 300 m long ($L = 300$ m), while H is still 100 m high. She also uses cheap concrete with a compressive strength of $2.00 \times 10^7 \text{ Pa}$. Under traffic jam conditions, calculate the ratio of the actual compressive stress at the bottom of the column to the compressive strength. If you did not obtain an answer to question (b) use $(4100 L) \text{ Pa}$ for the compressive stress from the traffic jam. (4 marks)

B4. One of the 63.5-cm-long strings of a guitar vibrates at a frequency of 490 Hz in its second resonance mode (the second harmonic).

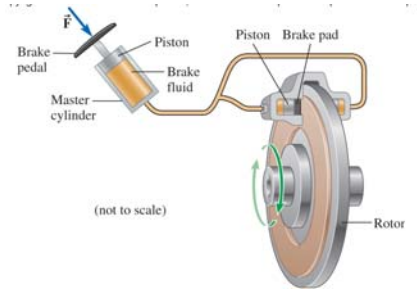
(a) Draw the wave pattern when the string is vibrating in its second mode of vibration. (2 marks)

(b) Calculate the wavelength of the second mode of vibration. (2 marks)

(c) Calculate the wave speed on the string. (2 marks)

(d) If the tension in the string is increased by 1.00 %, calculate the new frequency of vibration of the string in its second mode of vibration. (4 marks)

B1. Depressing the brake pedal in a truck pushes on a piston with a cross-sectional area of 2.00 cm^2 . The piston applies pressure to the brake fluid, which is connected to two pistons, each with area of 12.0 cm^2 . Each of the pistons presses a brake pad against one side of a rotor attached to one of the wheels. See the figure.



(a) When a 7.50 N force is applied to the small piston (that is, the brake pedal), what will be the force, in N , applied to each side of the rotor? (2 marks)

(b) If the coefficient of kinetic friction between a brake pad and the rotor is 0.800 and each pad is 23 cm away from the rotation axis of the rotor, what is the torque on the rotor due to the two pads? If you did not obtain an answer for (a) use a value of 55 N for the force applied on each side of the rotor. (3 marks)

(c) Assume the truck is moving at 100 km/hr when the brake pedal is applied. Assume that the radius of the wheel to which the rotor is attached is 35.0 cm . Calculate the angular frequency of the rotor in this case. (2 marks)

(d) Assume that the rotational inertia of the wheel plus rotor is $2.00 \text{ kg}\cdot\text{m}^2$. At the moment when the brakes are first applied, what is the power in kW that is applied to the wheel through the brakes? If you did not get answer for the torque use a value of $20.0 \text{ N}\cdot\text{m}$. If you did not get an answer for part (c), use 50.0 rad/s for the angular frequency. (3 marks)

B2. A plastic sphere is held below the surface of a swimming pool by a cord anchored to the bottom of the pool. The sphere has a volume of $1.41 \times 10^{-2} \text{ m}^3$ and the tension in the cord is 124 N.

(a) Calculate the buoyant force exerted by the water on the sphere. (3 marks)

(b) Calculate the mass of the sphere. (3 marks)

(c) The cord breaks and the sphere rises to the surface. When the sphere comes to rest, calculate the percentage of its volume that is submerged. (4 marks)

- B3. A 250 g object on a spring oscillates left to right on a frictionless surface with a frequency of 5.00 Hz. Its position as a function of time is given by $x = (10.0 \text{ cm}) \sin(\omega t)$.
- (a) Sketch a graph of the elastic potential energy as a function of time. Use Joules for your energy units. Include numerical labels for the maximum energy and the period. (3 marks)
- (b) The object's velocity is given by $v_x = \omega(10.0 \text{ cm}) \cos(\omega t)$. Graph the system's kinetic energy in Joules as a function of time. Include numerical labels for the maximum energy and the period. (3 marks)
- (c) Graph the sum of the kinetic energy and the potential energy as a function of time. Include a numerical label for the maximum energy. (2 marks)
- (d) Describe in words how your last answer would change if the surface weren't frictionless. (2 marks)

B4. A string of length 1.50 m is fixed at both ends. Its mass per unit length is 1.20 g/m and the tension is 12.0 N.

- (a) Calculate the speed of a transverse wave on this string. (2 marks)

- (b) Calculate the wavelength associated with the fundamental frequency of oscillation for this string. (2 marks)

- (c) Calculate the fundamental frequency of oscillation for the string. (2 marks)

- (d) Calculate the tension required for the $n = 3$ mode to have a frequency of 0.150 kHz. (4 marks)