

Physics 117A – Exam #3 – Fall 2007

Only calculators and pens/pencils are allowed on your desk. No cell phones or additional scrap paper. You have 2.0 hours to complete the exam.

Name \_\_\_\_\_

Section (Circle):      Ernst      MWF 10:10-11:00

                                 Sheldon      TR 11:00-12:15

*I pledge my honor that I have neither given nor received aid on this work.*

Signed \_\_\_\_\_



MC (50) = \_\_\_\_\_ Prob 11 (16) = \_\_\_\_\_ Prob 12 (17) = \_\_\_\_\_ Prob 13 (17) \_\_\_\_\_ Total = \_\_\_\_\_

**Multiple choice, circle the correct answer (5 points each).**

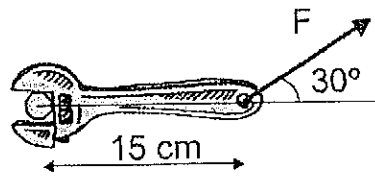
1. Consider a solid sphere of R and mass M rolling without slipping. Which form of kinetic energy is larger, translational or rotational?

- A) Translational kinetic energy is larger.
- B) Rotational kinetic energy is larger.
- C) Both are equal.
- D) You need to know the speed of the sphere to tell.
- E) You need to know the acceleration of the sphere to tell.

$$K(\text{Rot}) = \frac{1}{2} I \omega^2 = \frac{1}{5} M R^2 \left( \frac{v}{R} \right)^2$$

$$K(\text{trans}) = \frac{1}{2} M v^2$$

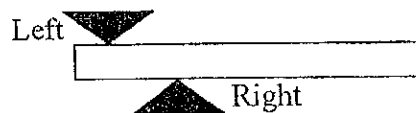
$$K(\text{trans}) > K(\text{rot})$$



$$\begin{aligned} |\vec{\tau}| &= r F \sin \theta \\ &= .15 \cdot 150 \cdot \sin 30^\circ \\ &= 11.3 \text{ N}\cdot\text{m} \end{aligned}$$

2. A wrench is acting on a nut. The length of the wrench lies directly to the east of the nut. A force 150 N acts on the wrench at a position 15.0 cm from the center of the nut in a direction 30.0° north of east. What is the magnitude of the torque about the center of the nut?

- A) 22.5 N·m
- B) 11.3 N·m
- C) 19.5 N·m
- D) 2250 N·m
- E) 1949 N·m



3. A massive uniform beam is supported in equilibrium by two fulcrums as shown. Which fulcrum applies the greater magnitude force to the beam?

- A) the right fulcrum
- B) the left fulcrum
- C) The answer depends on the length of the beam.
- D) The answer depends on the mass of the beam.
- E) Both fulcrums apply the same force.

$$\sum F_y = -F_L + F_R - mg = 0$$

$$F_R > F_L$$

4. A mass  $M$  is attached to a spring with spring constant  $k$ . When this system is set in motion with amplitude  $A$ , it has a period  $T$ . What is the period if the amplitude of the motion is increased to  $2A$ ?

- A)  $2T$       B)  $T/2$       C)  $\sqrt{2}T$       D)  $4T$       E)  $T$

Period ~~is~~ does not depend on amplitude

5. A rock, initially totally submerged, sinks deeper and deeper into water of constant density. What happens to the buoyant force on it as it sinks?

- A) It increases.  
 B) It remains constant.  
 C) It decreases.  
 D) It may increase or decrease, depending on the shape of the rock.  
 E) It may increase or decrease, depending on the weight of the rock.

Buoyancy force = weight of water displaced which is constant...

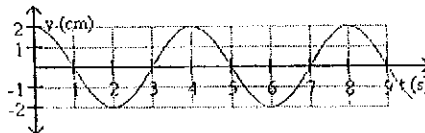
6. At a given point above the surface of the earth, gravitational acceleration is equal to  $5.4 \text{ m/s}^2$ . The distance to this point, measured from the surface of the earth, is closest to:

- A) 2200 km  
 B) 6300 km  
 C) 5700 km  
 D) 4200 km  
 E) 6990 km

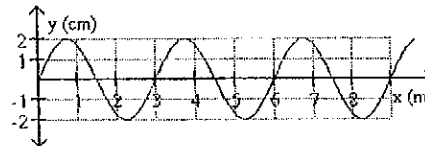
$$F_G = ma = \frac{GMm}{r^2} \Rightarrow a = \frac{GM}{r^2}$$

$$r = \sqrt{\frac{GM}{a}} = \sqrt{\frac{(6.67 \times 10^{-11})(5.97 \times 10^{24})}{(5.4)}}$$

$$\Delta r = r - r_e = 8.587 \times 10^6 - 6.38 \times 10^6 = 2,200 \text{ km}$$



$\rightarrow T = 4 \text{ s}$



$\rightarrow \lambda = 3 \text{ m}$

7. The figure above shows the displacement of a wave at a given position as a function of time and the displacement of the same wave at a given time as a function of position. Determine the speed of the wave.

- A) 3.0 m/s      B) 0.75 m/s      C) 0.66 cm/s      D) 1.5 m/s      E) 2.00 cm/s

$$v = \lambda f = \frac{\lambda}{T} = 0.75 \text{ m/s}$$

8. An air conditioning unit is vibrating in simple harmonic motion with period of 0.270 s and an amplitude of 1.50 cm. At  $t = 0$  it is at its central position and moving in the +x direction. What is its position when  $t = 0.19$  s?

- A)  $x = -0.430$  cm
- B)  $x = -0.511$  cm
- C)  $x = +0.430$  cm
- D)  $x = -1.41$  cm
- E)  $x = -1.44$  cm

$$x = A \cos(\omega t + \phi)$$

$$v = -\omega A \sin(\omega t + \phi)$$

@  $t = \phi$

$$x = A \cos \phi = \phi \Rightarrow \phi = \frac{3\pi}{2}$$

$$v = -\omega A \sin \phi = +$$

$$x = A \cos(\omega t + \frac{3\pi}{2}) = -1.44 \text{ cm}$$

$$\Rightarrow \phi = \frac{3\pi}{2}$$

9. A figure skater is spinning slowly with arms outstretched. She brings her arms in close to her body and her angular speed increases dramatically. The speed increase is a demonstration of

- A) Conservation of kinetic energy: her moment of inertia is decreased, and so her angular speed must increase to conserve energy.
- B) Conservation of total energy: her moment of inertia is decreased, and so her angular speed must increase to conserve energy.
- C) Conservation of angular momentum: her moment of inertia is decreased, and so her angular speed must increase to conserve angular momentum.
- D) Newton's second law for rotational motion: she exerts a torque and so her angular speed increases.
- E) This has nothing to do with mechanics; it is simply a result of her natural ability to perform.

No Net external torque  $\Rightarrow L$  cons.  
 $E$  not conserved if non-cons forces doing work and she is doing work...

10. A 520 kg object is released from rest at an altitude of 800,000 m above the surface of the earth (over the north pole). Ignore atmospheric friction. The speed of the object as it strikes the surface of the earth is closest to:

- A) 1,900 m/s
- B) 2,300 m/s
- C) 2,700 m/s
- D) 3,700 m/s
- E) 4,000 m/s

$$\Delta E = \phi$$

$$E_i = u_i + k_i = -\frac{GMm}{(r_e + 800,000)} + \phi$$

$$E_f = \frac{1}{2}mv^2 - \frac{GMm}{r_e}$$

$$v^2 = 2GM \left[ \frac{1}{r_e} - \frac{1}{(r_e + 800,000)} \right] \Rightarrow v = 3700 \text{ m/s}$$

Show all your work on the problems. Place boxes around your final answers. Partial credit will be given, but we need to see your work.

11. (16 points) A 5.0-m radius playground merry-go-round with a moment of inertia of  $2000 \text{ kg}\cdot\text{m}^2$  is rotating freely with an angular speed of  $1.0 \text{ rad/s}$ . Two people, each having a mass of  $60 \text{ kg}$  are standing right outside the edge of the merry-go-round and step on it with negligible speed. What is the angular speed of the merry-go-round right after the two people have stepped on?

Angular momentum is conserved  
(No  $\tau_{\text{net}}$  external torque)

$$L_{\text{initial}} = I_{\text{mgr}} \omega_{\text{i}} = \left\{ \begin{matrix} 2000 \\ 3000 \end{matrix} \right\} \text{kg}\cdot\text{m}^2 \times \left\{ \begin{matrix} 1.0 \\ 2.0 \end{matrix} \right\} \text{rad/s}$$

$$I_{\text{final}} = I_{\text{mgr}} + 2 I_{\text{person}}$$

$$I_{\text{person}} = m R^2$$

$$I_{\text{final}} = I_{\text{mgr}} + 2mR^2$$

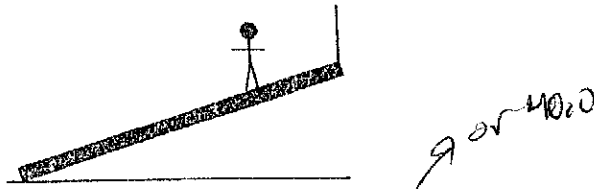
$$L_{\text{final}} = I_{\text{final}} \omega_{\text{final}}$$

$$I_{\text{mgr}} \omega_{\text{i}} = I_{\text{final}} \omega_{\text{final}}$$

$$\omega_{\text{final}} = \frac{I_{\text{mgr}}}{(I_{\text{mgr}} + 2mR^2)} \omega_{\text{i}} = \frac{(2000 \text{ kg}\cdot\text{m}^2)}{(2000 + 2 \cdot 60 \cdot 25) \text{ kg}\cdot\text{m}^2} \cdot 1.0$$

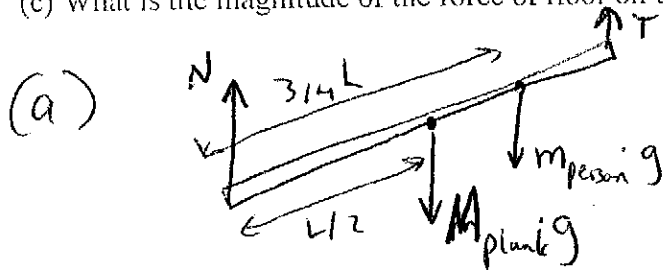
$$\omega_{\text{final}} = 0.40 \frac{\text{rad}}{\text{s}} \quad \text{OR} \quad \boxed{\omega_{\text{i}} = \left[ \frac{3000}{3000 + 3000} \right] \cdot 2 = 1.0 \frac{\text{rad}}{\text{s}}}$$

Show all your work on the problems. Place boxes around your final answers. Partial credit will be given, but we need to see your work.



12. (17 points) A ~~20.0~~ <sup>10.0</sup> kg uniform plank is supported by the floor at one end and by a vertical rope at the other as shown in the figure above. A 50.0-kg mass person stands on the plank a distance three-fourths of the length plank from the end on the floor. (Note: you do not need to know the angle between the plank and the floor to solve this problem. It might help to include it at the beginning, however.)

- (a) Draw a Free-Body Diagram for the plank, showing all forces and where they act.
- (b) What is the tension in the rope?
- (c) What is the magnitude of the force of floor on the plank?



If you put static friction with floor on it's ok, as long as you show it is zero.

$$(b) \quad \sum F_y = T + N - mg - Mg = 0 \quad \left( \begin{array}{l} M = m_{\text{plank}} \\ m = m_{\text{person}} \end{array} \right)$$

$$\sum F_x = 0$$

$$\sum \tau = -Mg \frac{L}{2} \sin \theta - mg \frac{3L}{4} \sin \theta + TL \sin \theta = 0$$

$$T = \frac{Mg}{2} + \frac{3mg}{4} = 9.8 \left[ 10 + 37.5 \right] =$$

$$T = \left\{ \begin{array}{l} 466 \text{ N} \\ 441 \text{ N} \end{array} \right\} \quad [15 + 30]$$

take around floor end

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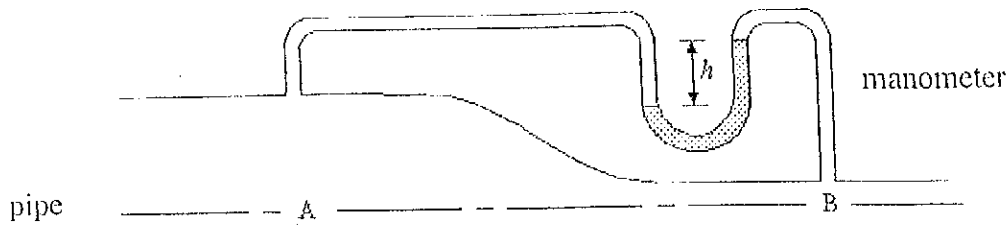
$$(C) \quad N + T - mg - Mg = 0$$

$$N = -T + mg + Mg = -\left(\frac{1}{2}Mg + \frac{3}{4}mg\right) + mg + Mg$$

$$N = \frac{1}{2}Mg + \frac{1}{4}mg = 9.8 \cdot \left[ \begin{array}{l} \{10 + 12.5\} \\ \{15 + 10\} \end{array} \right]$$

$$N = \left\{ \begin{array}{l} 220 \text{ N} \\ 245 \text{ N} \end{array} \right\}$$

Show all your work on the problems. Place boxes around your final answers. Partial credit will be given, but we need to see your work.



13. (17 points) Water flows in the horizontal pipe shown in Fig. 13-6. At A the area is  $25.0 \text{ cm}^2$  and the speed of the water is  $2.00 \text{ m/s}$ . At B the area is  $16.0 \text{ cm}^2$ . The small diameter tube above the pipe contains a manometer, which is used to measure the pressure difference at points A and B. The manometer is mostly filled with air except for in the shaded region, where it is filled with mercury. Mercury has a density of  $13,600 \text{ kg/m}^3$ . The density of water is  $1,000 \text{ kg/m}^3$ .

(a) What is the speed of the water at B?

(b) What is the manometer reading  $h$ ?

$$(a) A_A v_A = A_B v_B \Rightarrow v_B = \frac{A_A}{A_B} v_A = \begin{cases} \frac{25}{16} \cdot 2 = 3.13 \frac{\text{m}}{\text{s}} \\ \frac{25}{15} \cdot 2.4 = 4.00 \frac{\text{m}}{\text{s}} \end{cases}$$

(b) Use Bernoulli to find pressure diff @ A and B.

$$\text{then } \rho_{\text{Hg}} g h = P_A - P_B$$

$$\frac{1}{2} \rho_w v_A^2 + \cancel{\rho_w g h_A} + P_A = \frac{1}{2} \rho_w v_B^2 + \cancel{\rho_w g h_B} + P_B$$

$$P_A - P_B = \frac{1}{2} \rho_w [v_B^2 - v_A^2] = 500 \cdot \begin{cases} 5.8 \\ 10.2 \end{cases} = \begin{cases} 2900 \\ 5120 \end{cases}$$

$$h = \frac{P_A - P_B}{\rho_{\text{Hg}} g} = \frac{2900}{(13,600 \cdot 9.8)} \approx 2.16 \text{ cm} \text{ or } \frac{5120}{(13,600 \cdot 9.8)} = 3.84 \text{ cm}$$