White

PHYS 101 Midterm Examination #2 (version A)

November 4, 2011

Time: 50 minutes

Last Name : Key

First Name : ____________________

Student No. : ____________________

Computing ID : ____________________

Tutorial Section : ____________________

	score	*Maximum*
Multiple Choice		7
Written # 8		5
Written # 9		5
Written # 10		5
Total		22

Part I (Multiple choice questions. 1 mark each.)

B

1. Two equal forces are applied to a door. The first force is applied at the midpoint of the door; the second force is applied at the doorknob. Both forces are applied perpendicular to the door. Which force exerts the greater torque?

   A) the first at the midpoint
   B) the second at the doorknob
   C) both exert equal non-zero torques
   D) both exert zero torques
   E) additional information is needed

E

2. A disk, a hoop, and a solid sphere are released at the same time at the top of an inclined plane. They all roll without slipping. In what order do they reach the bottom?

   A) disk, hoop, sphere
   B) hoop, sphere, disk
   C) sphere, hoop, disk
   D) hoop, disk, sphere
   E) sphere, disk, hoop

D

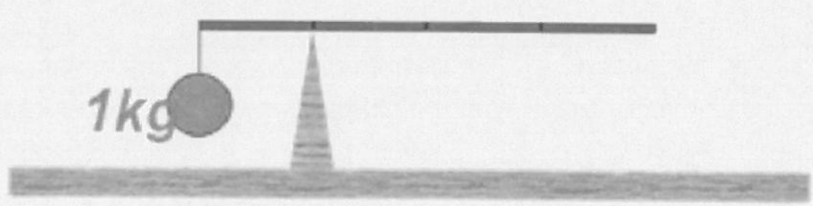
3. A figure skater is spinning slowly with arms outstretched. She brings her arms in close to her body and her angular speed increases dramatically. The speed increase is a demonstration of

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

C

4. A 1-kg ball is hung at the end of a rod 1-m long. If the system balances at a point on the rod 0.25 m from the end holding the mass, what is the mass of the rod?

   A) 0.25 kg
   B) 0.50 kg
   C) 1 kg
   D) 2 kg
   E) 4 kg



B
E E
D E
C A

E

5. Two solid spherical balls are made of the same material. The radius of Ball A is R, while that of ball B is 2R. If ball A has a moment of inertia I, what is the moment of inertia of ball B?

A) 2I
B) 4I
C) 8I
D) 16I
(E) 32I

$I = \frac{2}{5} m R^2$. $m = \frac{4}{3}\pi R^3$

$I \propto R^5$. $2^5 = 32$

C

6. A uniform steel wire was cut into two pieces. The first piece is 2.0 meters long and the second piece is 20meters long. The Young's modulus of the first piece is Y. The Young's modulus of the second piece is

A) 0.01Y
B) 0.1Y
(C) Y
D) 10Y
E) 100Y

A

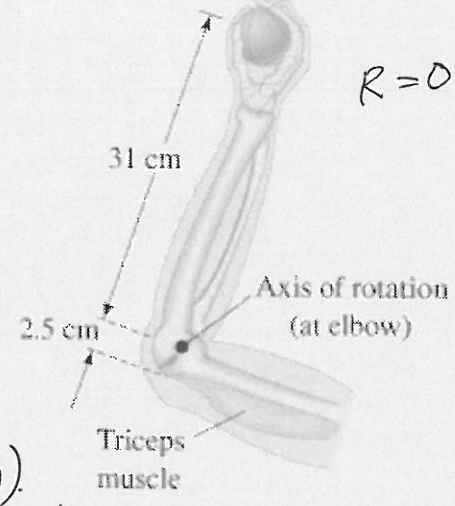
7. A boat carrying a large chunk of steel is floating on a small lake. The chunk is then thrown overboard and sinks. What happens to the water level in the lake (with respect to the shore)?

(A) drops
B) rises
C) remains the same
D) depends on the size of the steel
E) There is not enough information to answer this question.

B	E
E	C
D	A
C	

Part II (Full solution questions, 5 marks each. **SHOW ALL WORK FOR FULL MARKS!**)

8. The forearm in the figure accelerates a 3.0-kg ball at $8.0 m/s^2$ by means of the triceps muscle, as shown .
(*a*) Calculate the torque needed. Ignore the mass of the arm.
(b) Calculate the force that must be exerted by the triceps muscle. Ignore the mass of the arm.



$R = 0.31\ m$

(a). $\tau = I\alpha$, $\alpha = \frac{a}{R}$.

$I = mR^2$

$\tau = mR^2 \cdot \frac{a}{R} = mRa$.

$\tau = 3.0 \times 0.31 \times 8.0 = 7.44\ (N \cdot m)$.

(b). $\tau = F \cdot R_\perp$ $R_\perp = 0.025\ m$.

$F = \frac{\tau}{R_\perp} = \frac{7.44}{0.025} = 298\ N$

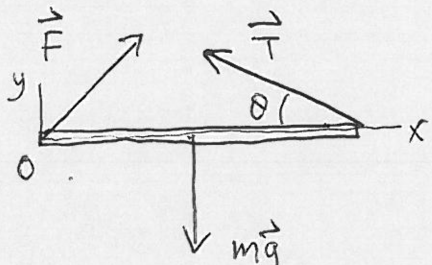
9. A uniform beam, 1.50 m long with mass $m = 4.00$ kg, is mounted by a frictionless hinge on a wall. The beam is held in a horizontal position by a cable that makes an angle $\theta = 25.0°$.

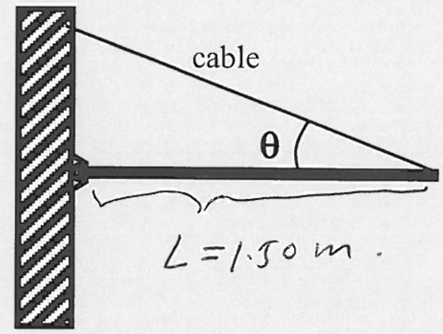
(a) Find the tension in the cable.

(b) If the cable snaps, what is the angular acceleration of the beam?

(c) What is the angular speed of the beam when it hits the wall?

a) . FBD .





$\Sigma \tau = 0$. (about O) .

$$T \cdot \sin\theta \cdot L - mg\frac{L}{2} = 0 \;.\; \Rightarrow \quad T = \frac{mg}{2\sin\theta} = \frac{4\times 9.8}{2\times \sin 25^0} = 46.4\,N.$$

b) . $\alpha = \frac{\tau}{I}$. $\quad \tau = -mg\frac{L}{2}$. $\quad I = \frac{1}{3}mL^2$.

$$\alpha = -\frac{mg\frac{L}{2}}{\frac{1}{3}mL^2} = -\frac{3g}{2L} = -\frac{3\times 9.8}{2\times 1.5} = -9.8\ \text{rad}/s^2$$

c) . Conservation of mechanical energy .

$E_i = E_f$:

$$0 = -mg\frac{L}{2} + \frac{1}{2}I\omega^2 .$$

$$0 = -mg\frac{L}{2} + \frac{1}{2}\cdot\left(\frac{1}{3}mL^2\right)\omega^2 .$$

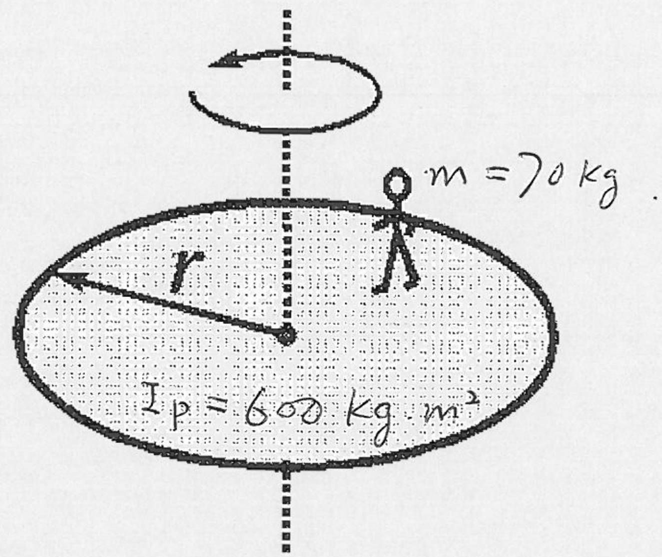
$$0 = -g + \frac{1}{3}L\omega^2$$

$$\omega = \sqrt{\frac{3g}{L}} = \sqrt{\frac{3\times 9.8}{1.50}} = 4.43\ \text{rad}/s$$

10. A horizontal platform with a radius of 5.00 m rotates about a frictionless vertical axle. The moment of inertia of the platform about the axle is 600 kg·m^2. A student (m=70.0 kg) walks slowly from the rim of the platform toward the center and stops when he is at the centre. The initial angular velocity ω of the system is 2.00 rad/s when the student is at the rim. (You may treat the person as a point mass)
(a) Find the angular speed when the student is at the center.
(b) Find the work done by the student.

a). Net external torque = 0.
Angular momentum is conserved.

$L_i = L_f$.



$(I_p + mr^2)\, w_i = I_p\, w_f$.

$w_f = \frac{(I_p + mr^2)}{I_p} w_i$

$= \frac{(600 + 70 \times 5^2)}{600} \times 2.00 = 7.83$ rad/s.

b). $W = \Delta KE = KE_f - KE_i$.

$= \frac{1}{2} I_p w_f^2 - \frac{1}{2}(I_p + mr^2) w_i^2$

$= \frac{1}{2} \times 600 \times 7.83^2 - \frac{1}{2}(600 + 70 \times 5^2)\, 2^2$

$= 13500$ J

$= 13.5$ KJ.

Green

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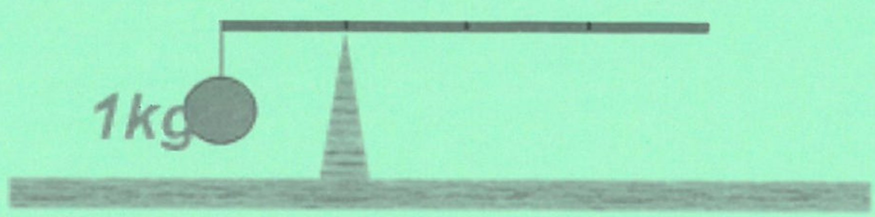


E

5. Two solid spherical balls are made of the same material. The radius of Ball A is R, while that of ball B is 2R. If ball A has a moment of inertia I, what is the moment of inertia of ball B?

A) 2I
B) 4I
C) 8I
D) 16I
E) 32I

$I = \frac{2}{5} m R^2$ $m = \frac{4}{3} \pi R^3$.

$I \propto R^5$. $2^5 = 32$.

C

6. A uniform steel wire was cut into two pieces. The first piece is 2.0 meters long and the second piece is 20meters long. The Young's modulus of the first piece is Y. The Young's modulus of the second piece is

A) 0.01Y
B) 0.1Y
C) Y
D) 10Y
E) 100Y

A.

7. A boat carrying a large chunk of steel is floating on a small lake. The chunk is then thrown overboard and sinks. What happens to the water level in the lake (with respect to the shore)?

A) drops
B) rises
C) remains the same
D) depends on the size of the steel
E) There is not enough information to answer this question.

B
E E
D C
C A

Part II (Full solution questions, 5 marks each. **SHOW ALL WORK FOR FULL MARKS!**)

8. The forearm in the figure accelerates a 5.0-kg ball at 4.0m/s^2 by means of the triceps muscle, as shown .

(*a*) Calculate the torque needed. Ignore the mass of the arm.

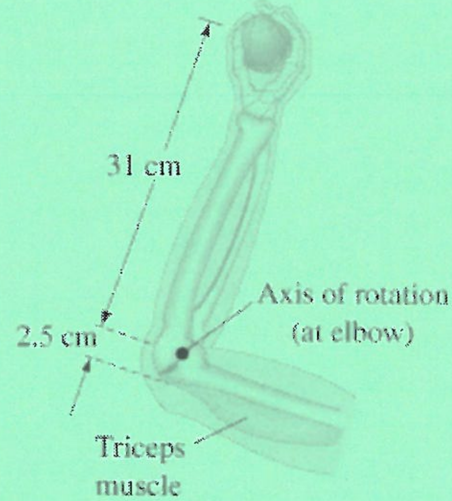
(b) Calculate the force that must be exerted by the triceps muscle. Ignore the mass of the arm.

(a). $\tau = I\alpha$. $\alpha = \frac{a}{R}$,

$I = mR^2$

$\tau = mR^2 \cdot \frac{a}{R} = mRa$

$\tau = 5.0 \times 0.31 \times 4.0 = 6.2 \ N\cdot m$.



(b). $\tau = F \cdot R_\perp$

$F = \frac{\tau}{R_\perp} = \frac{6.2}{0.025} = 248 \ N$

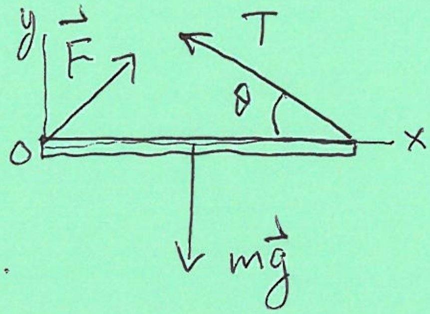
9. A uniform beam, 2.00 m long with mass m = 5.00 kg, is mounted by a frictionless hinge on a wall. The beam is held in a horizontal position by a cable that makes an angle θ = 25.0°.

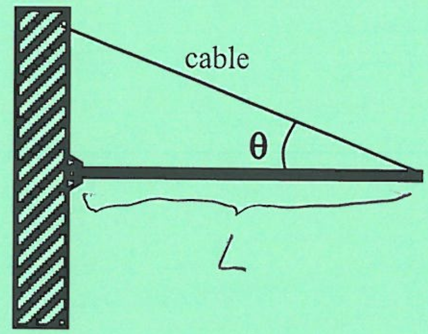
(a) Find the tension in the cable.

(b) If the cable snaps, what is the angular acceleration of the beam?

(c) What is the angular speed of the beam when it hits the wall?

(a) FBD.





$\sum \tau = 0$

(about O).

$$T \cdot L \cdot \sin\theta - mg\frac{L}{2} = 0$$

$$T = \frac{mg}{2\sin\theta} = \frac{5.00 \times 9.8}{2 \cdot \sin 25^\circ} = 58\ N$$

(b). $\alpha = \frac{\tau}{I}$. $\tau = -mg\frac{L}{2}$, $I = \frac{1}{3}mL^2$

$$\alpha = \frac{-mg\frac{L}{2}}{\frac{1}{3}mL^2} = -\frac{3g}{2L} = -\frac{3 \times 9.8}{2 \times 2} = -7.35\ rad/s^2$$

(c). Conservation of mechanical energy:

$E_i = E_f$: $\quad 0 = -mg\frac{L}{2} + \frac{1}{2}I\omega^2$.

$$0 = -mg\frac{L}{2} + \frac{1}{2} \cdot \left(\frac{1}{3}mL^2\right)\omega^2.$$

$$0 = -g + \frac{1}{3}L\omega^2$$

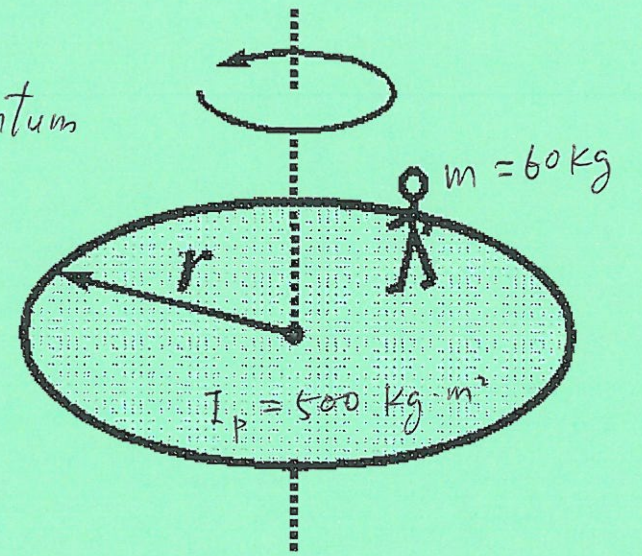
$$\omega = \sqrt{\frac{3g}{L}} = \sqrt{\frac{3 \times 9.8}{2}} = 3.83\ rad/s.$$

10. A horizontal platform with a radius of 4.00 m rotates about a frictionless vertical axle. The moment of inertia of the platform about the axle is 500 kg·m^2. A student (m=60.0 kg) walks slowly from the rim of the platform toward the center and stops when he is at the centre. The initial angular velocity ω of the system is 2.50 rad/s when the student is at the rim. (You may treat the person as a point mass)
(a) Find the angular speed when the student is at the center.
(b) Find the work done by the student.

(a). Net external torque = 0,

∴ Conservation of angular momentum

$L_i = L_f$.



$(I_p + mr^2)\omega_i = I_p \omega_f$.

$\omega_f = \frac{(I_p + mr^2)\omega_i}{I_p}$

$= \frac{(500 + 60 \times 4^2) \times 2.5}{500}$

$= 7.3$ rad/s.

(b). $W = \Delta K = KE_f - KE_i$

$= \frac{1}{2} I_p \omega_f^2 - \frac{1}{2}(I_p + mr^2)\omega_i^2$

$= \frac{1}{2} \times 500 \times 7.3^2 - \frac{1}{2}(500 + 60 \times 4^2) \times 2.5^2$

$= 13323 - 4563$

$= 8760$ J

$= 8.76$ kJ.