PHYS 101 Midterm Examination #2 (version C)

July 8, 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. A solid sphere, solid cylinder, and a hollow pipe all have equal masses and radii. If the three are released simultaneously at the top of an inclined plane and roll without slipping which will reach the bottom first?

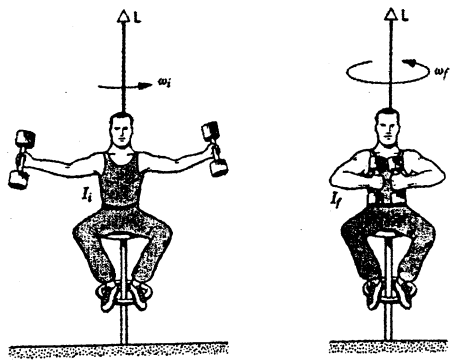
A) pipe $I = mR^2$
B) sphere $I = \frac{2}{5}mR^2$
C) cylinder $I = \frac{1}{2}mR^2$
D) they all reach bottom in the same time
E) It depends on the angle of inclination.

C

2. A student is sitting on a rotating platform with his arms outstretched, holding a heavy weight in each hand. When the student pulls the weights inward toward his body, the moment of inertia of the student, the extended weights, and the platform about the rotation axis is halved. By what factor does the angular velocity change?

A) 8
B) 4
C) 2
D) $\sqrt{2}$
E) 1

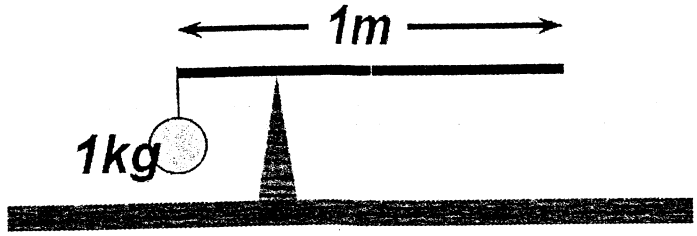
$I_i \omega_i = I_f \omega_f$



C

3. 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



C

4. Ten identical steel wires have equal lengths L and equal Young's modulus Y. The wires are slightly twisted together, so that the resultant wire has length L and is 10 times as thick as each individual wire. What is the Young's modulus of the resulting wire?

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

B

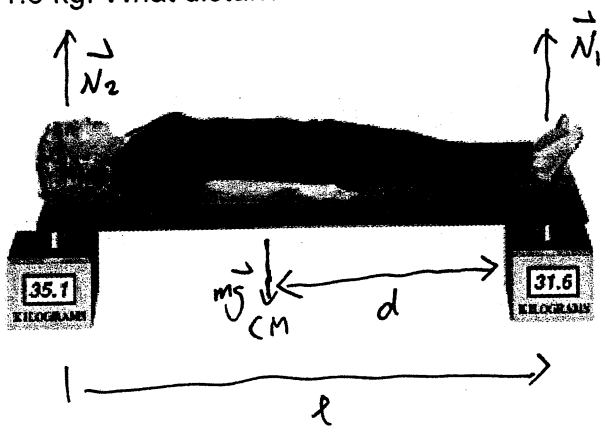
5. A 171cm tall person lies on a light (massless) board which is supported by two scales, one under the top of her head and one beneath the bottom of her feet . The two scales read, respectively, 35.1 and 31.6 kg. What distance is the center of mass of this person from the bottom of her feet?

A) 80cm
(B) 90cm
C) 70cm
D) 60cm
E) 100cm

$N_1 + N_2 = mg$.

$Mgd - N_2 l = 0$

$d = \frac{N_2 l}{mg} = \frac{N_2 l}{N_1 + N_2}$



E

6. Two spherical balls are made of the same material. Ball A has a radius R, while ball B has 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

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

$\therefore \; I \propto R^5$. $\quad 2^5 = 32$.

E

7 A solid cylinder of mass *M* and radius *R* rolls without slipping along a table at speed *v*. What is its kinetic energy?

(A) $Mv^2/2$

(B) $Mv^2/4$

(C) $7Mv^2/10$

(D) $2Mv^2$

(E) $3Mv^2/4$

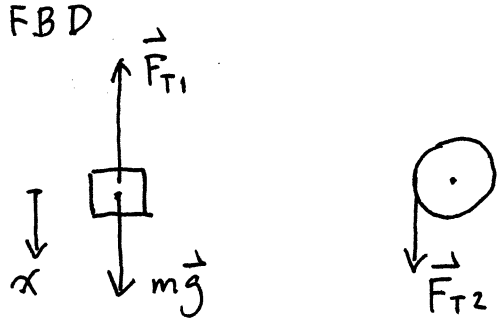
Part II (Full solution questions, 5 marks each. **SHOW ALL WORK FOR FULL MARKS!**)

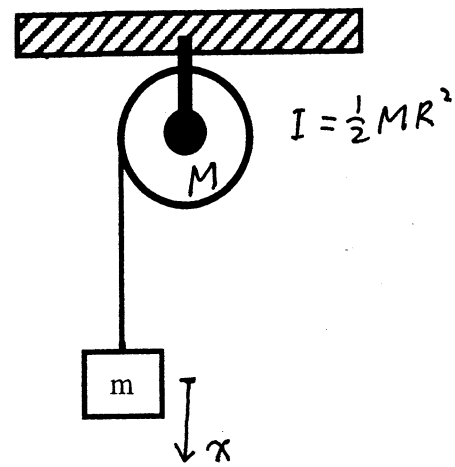
8. A mass of 7.0 kg hangs on a rope wrapped around a freely rotating pulley of mass 2.0 kg as shown in the figure below. The pulley can be considered as a uniform cylinder of radius 0.20 m. The mass is brought to a certain height and dropped, making the pulley turn.

5 mks (a) What is the angular acceleration of the pulley?

1 bonus (b) What is the rotational kinetic energy of the pulley after the mass has fallen through 0.40m?

a) FBD





$F_{T1} = F_{T2} = F_T$.

$\vec{F} = m\vec{a}$: $mg - F_T = ma_x$ ①

$\tau = I\alpha$: $F_T R = \frac{1}{2}MR^2\alpha$. ②

$a_x = R\alpha$. ③

Subs ③ into ①: $mg - F_T = mR\alpha$

②: $F_T = \frac{1}{2}MR\alpha$

(+)

$mg = mR\alpha + \frac{1}{2}MR\alpha$

$$\alpha = \frac{mg}{mR + \frac{1}{2}MR}$$

$$= \frac{7 \times 9.8}{7 \times 0.2 + \frac{1}{2} \times 2 \times 0.2}$$

$= 42.9 \text{ rad/s}^2$

b) Conservation of Mechanical Energy

$0 = -mgh + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$v = R\omega$.

$0 = -mgh + \frac{1}{2}mR^2\omega^2 + \frac{1}{2}(\frac{1}{2}MR^2)\omega^2$

$mgh = (\frac{1}{2}m + \frac{1}{4}M)R^2\omega^2$

$$R^2\omega^2 = \frac{mgh}{\frac{1}{2}m + \frac{1}{4}M}$$

$K_R = \frac{1}{2}I\omega^2 = \frac{1}{2}(\frac{1}{2}MR^2)\omega^2 = \frac{1}{4}MR^2\omega^2$

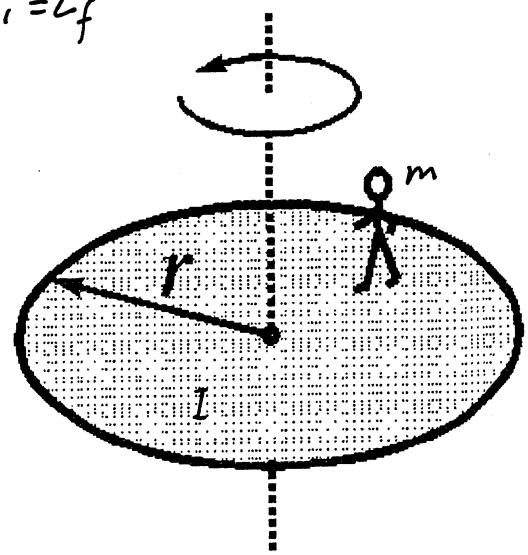
$$= \frac{Mmgh}{4(\frac{1}{2}m + \frac{1}{4}M)}$$

$$= \frac{Mmgh}{2m + M} = \frac{7 \times 2 \times 9.8 \times 0.4}{7 \times 2 + 2}$$

$= 3.43 \text{ J}$.

9. 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 800 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 3.00 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). Conservation of angular momentum $L_i = L_f$



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

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

$$= \frac{(800 + 70 \times 5^2)3}{800}$$

$$= 9.56 \text{ rad/s} .$$

b). $W = \Delta K$

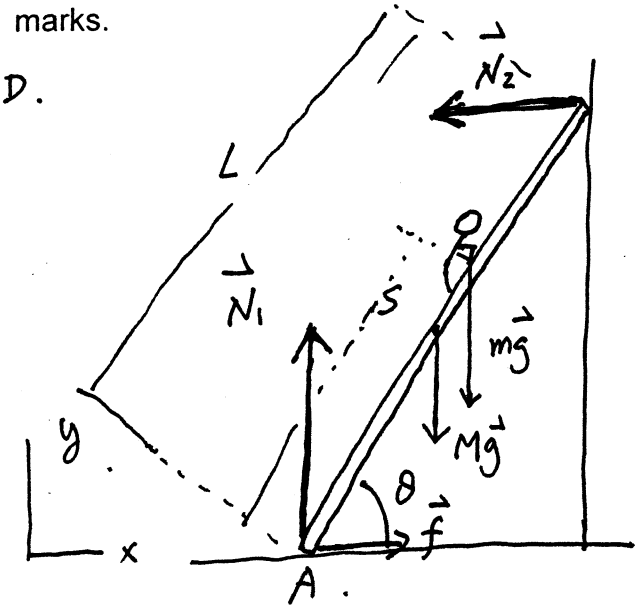
$$= \frac{1}{2} I\omega_f^2 - \frac{1}{2}(I + mr^2)\omega_i^2$$

$$= \frac{1}{2} \times 800 \times 9.56^2 - \frac{1}{2}(800 + 70 \times 5^2)3^2$$

$$= 25000 \text{ J} .$$

10. A uniform ladder of mass $M=5.0kg$ and length $L=8.0m$ leans against a frictionless wall. The angle between the ladder and the ground is $\theta=60°$. The coefficient of static friction between the ladder and the ground is $\mu_s=0.40$. How far up the ladder can a man of mass m=70kg climb before the ladder slips? Include a free-body diagram for full marks.

FBD.



About to slip : $f = \mu_s N_1$.

$\Sigma \vec{F} = 0$: $\mu_s N_1 - N_2 = 0$ ①

$N_1 - Mg - mg = 0$ ②

$\Sigma \tau = 0$ about A : $N_2 L \sin\theta - Mg\frac{L}{2}\cos\theta - mgs\cos\theta = 0$. ③

② : $N_1 = (m+M)g$.

① : $N_2 = \mu_s N_1 = \mu_s (m+M)g$.

③ : $s = \dfrac{\mu_s (m+M)gL\sin\theta - Mg\frac{L}{2}\cos\theta}{mg\cos\theta} = \dfrac{L\left[\mu_s (m+M)\sin\theta - M\cos\theta/2\right]}{m\cos\theta}$

$= \dfrac{0.4(5+70)9.8\times 8\cdot\sin 60° - 5\times 9.8\times 4\cdot\cos 60°}{70\times 9.8\times\cos 60°}$

$= 5.65\ m$.