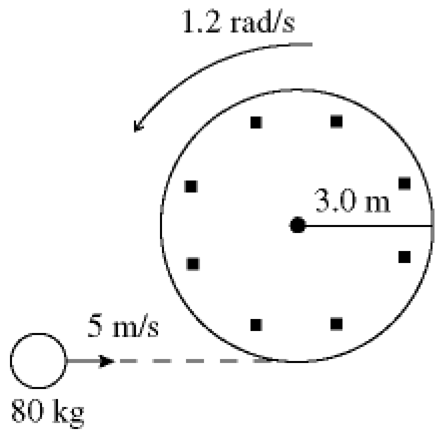
Exam PHYSICS 4A WINTER 2015 QUIZ 7

Name_Professor S. K. Sinha_______________VERSION A_________________

g = 9.8 m/s2 Moments of Inertia: Hoop MR^2 ; Disk 1/2 MR^2; Hollow Cylinder MR^2 ; Solid Cylinder 1/2 MR^2; solid sphere 2/5 MR^2 ; Thin Spherical Shell 2/3 MR^2; rod of length L 1/12 ML^2 (All calculated about the most symmetric axis through the center of the object).

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

Figure 10.8



1) In Fig. 10.8, a carousel has a radius of 3.0 m and a moment of inertia of 8000 kg • m^2. The carousel is rotating unpowered and without friction with an angular velocity of 1.2 rad/s. An 80-kg man runs with a velocity of 5.0 m/s, on a line tangent to the rim of the carousel, overtaking it. The man runs onto the carousel and grabs hold of a pole on the rim. The change in the angular velocity of the carousel is closest to:

A) +0.04 rad/s B) -0.07 rad/s C) +0.06 rad/s D) -0.05 rad/s E) +0.08 rad/s

2) A uniform disk has a mass of 4.4 kg and a radius of 0.65 m. The disk is mounted on frictionless bearings and is used as a turntable. The turntable is initially rotating at 30 rpm. A thin-walled hollow cylinder has the same mass and radius as the disk. It is released from rest, just above the turntable, and on the same vertical axis. The hollow cylinder slips on the turntable for 0.20 s until it acquires the same final angular velocity as the turntable. The average torque exerted on the hollow cylinder during the 0.20 s time interval in which slipping occurs is closest to:

A) 18 N • m B) 7.3 N • m C) 9.7 N • m D) 15 N • m E) 20 N • m

3) A hoop is released from rest at the top of a plane inclined at 16° above horizontal. How long does it take the hoop to roll 16.4 m down the plane?

A) 4.74 s B) 9.39 s C) 2.59 s D) 4.93 s E) 2.64 s

4) A bicycle wheel of radius 0.36 m and mass 3.20 kg is set spinning at 4.00 rev/s. A bolt is attached to extend the axle in length, and a string is attached to the axle at a distance of 0.10 m from the wheel. Initially the axle of the spinning wheel is horizontal, and the wheel is suspended only from the string. At what rate will the wheel process about the vertical?

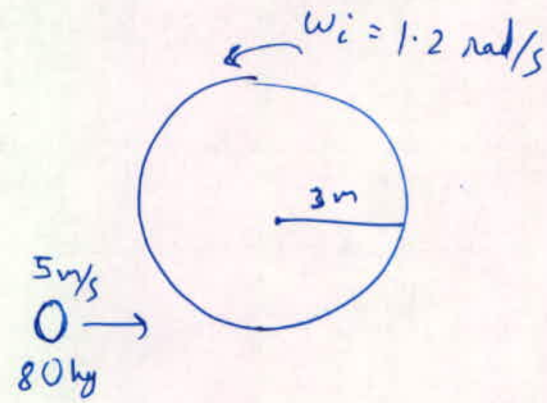
A) 0.77 rpm B) 2.9 rpm C) 1.9 rpm D) 0.30 rpm E) 18 rpm

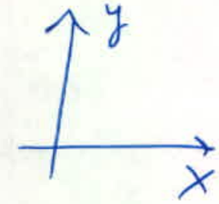
QUIZ 7

PHYS 4A

WINTER '15

1.)





Conserving Angular momentum,

$$\vec{L}_f = \vec{L}_i$$

$$\Rightarrow I_f \,\vec{\omega}_f = \vec{L}_{man_i} + \vec{L}_{carousel_i}$$

$$\vec{L}_{man_i} = 80 \times (3 \times 5)\ \hat{k}$$

$$\vec{L}_{carousel_i} = 8000 \times 1.2\ \hat{k}$$

$$I_f = \underbrace{8000}_{I_{carousel}} + \underbrace{80 \times 3^2}_{I_{man}}$$

$$\therefore \quad \vec{\omega}_f = \frac{(15 \times 80 + 8000 \times 1.2)\ \hat{k}}{(8000 + 80 \times 3^2)}$$

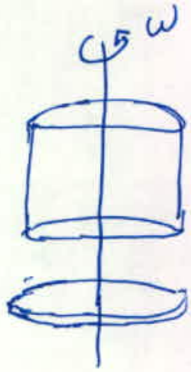
$$\Rightarrow \vec{\omega}_f = \frac{135}{109}\ \hat{k} = 1.238\ \hat{k}\ \text{rad/s}$$

$$\therefore \vec{\omega_f} - \vec{\omega_i} = 1.238\,\hat{k} - 1.2\,\hat{k} \text{ rad/s}$$

$$= 0.038\,\hat{k} \text{ rad/s}$$

$$\approx 0.04 \text{ rad/s}$$

2.)



$$\left.\begin{aligned} r &= 0.65\text{m} \\ m &= 4.4\text{kg} \end{aligned}\right\} \text{ For Both of them}$$

Conserving Angular momentum of the system,

$$L_i = L_f$$

$$\Rightarrow I_{cylinder} \cancelto{0}{\omega_{i_{cylinder}}} + I_{TT}\,\omega_{i_{TT}}$$

$$= \left(I_{cylinder} + I_{TT}\right)\omega_f$$

$$\Rightarrow \omega_f = \frac{\frac{mr^2}{2}(30 \text{ rpm})}{\left(\frac{mr^2}{2} + mr^2\right)}$$

$$\Rightarrow \omega_f = 10 \text{ rpm}$$

Now; considering only hollow cylinder,

$$\frac{d\vec{L}}{dt} = \vec{\tau}_{\text{Net on hollow cylinder}}$$

$$\Rightarrow \quad (\Delta L)_{\text{cylinder}} = \underset{\substack{\uparrow \\ \text{on cylinder}}}{\tau} (\Delta t)$$

$$\Rightarrow \quad L_f - L_i = \tau (0.2)$$

where $L_i = 0$ as $\omega_{i\,\text{cylinder}} = 0$

$$\Delta L_f = I_f \, \omega_f$$

$$= mr^2 (10 \text{ rpm})$$

$$= 4.4 \times (0.65)^2 \times 10 \times \frac{2\pi}{60}$$

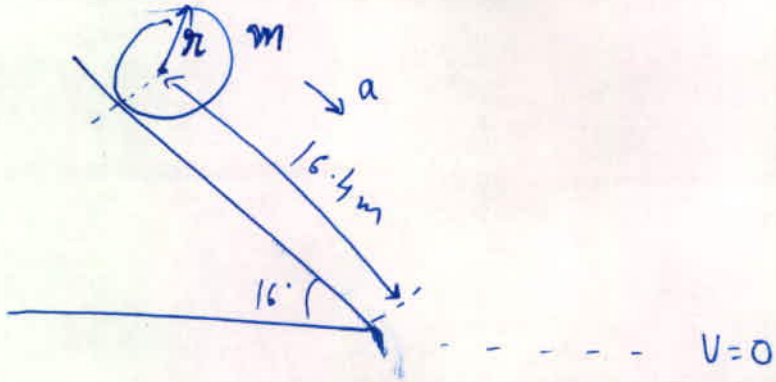
$$= 1.947 \ \text{kg m}^2/\text{s}.$$

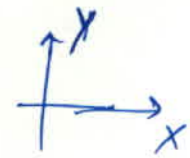
$$\therefore \quad \tau = \frac{L_f - L_i}{0.2}$$

$$= \frac{1.947 - 0}{0.2}$$

$$\simeq 9.7 \text{ Nm}.$$

3.)





Since the hoop rolls down without slipping,

$$v = \omega r$$

and $\Delta U + \Delta K = W_{nc} = 0$

$$\Rightarrow U_f - U_i + K_f - K_i = 0$$

$$\Rightarrow 0 - mg(16.4 \sin 16^\circ) + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 - 0 = 0$$

$$\Rightarrow \frac{1}{2}\cancel{m}v^2 + \frac{1}{2}\cancel{m}r^2\omega^2 = \cancel{m}g(16.4)\sin 16^\circ$$

$$\Rightarrow v^2 = g(16.4)\sin 16^\circ \quad \{\text{as } v = \omega r\}$$

Using,

$$v_f^2 = v_i^2 + 2as$$

$$\Rightarrow g(16.4)\sin 16^\circ = 2a(16.4)$$

$$\Rightarrow a = \frac{g \sin 16^\circ}{2}.$$

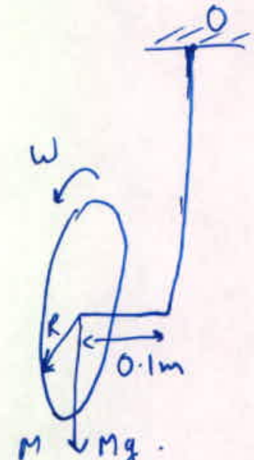
Now, using $v_f = u_f + at$

$$\Rightarrow \sqrt{g(16.4)\sin 16} = \frac{g\sin 16}{2}\, t$$

$$\Rightarrow t = 2\sqrt{\frac{16.4}{g\sin 16}}$$

$$\Rightarrow t = 4.93\ s$$

4.)



$R = 0.36\ m$
$M = 3.2\ kg$
$\omega = 4\ rev/s$

$$\Omega = \tau/L$$

where, $\tau = mgl = 3.2\,g(0.1)\ Nm.$

$$L = I\omega = MR^2(4\ rev/s) = 3.2(0.36)^2\, 4 \times 2\pi\ rad/s$$

$$\therefore \Omega = \frac{\cancel{3.2}\,g(0.1)}{(\cancel{3.2})(0.36)^2 \times 4 \times 2\pi}\ rad/s$$

$$\Rightarrow \Omega = 0.0307g \times \frac{60}{2\pi}\ rpm = 2.87\ rad/s$$
or $2.9\ rad/s$