807 AP Physics Schmidt

Name: _____ Block:_____

U6H8 (Read 12.11) Angular Momentum and its Conservation

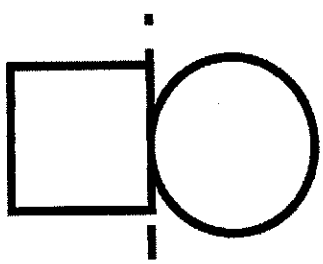
1. The angular momentum of a flywheel having a rotational inertia of 0.140 kg m^2 about its axis decreases from 3.00 to 0.80 kgm^2/s in 1.50 s. (a) What is the average torque acting on the flywheel about its central axis during this period? (-1.47 Nm)

   (b) Assuming a uniform angular acceleration, through what angle will the flywheel have turned? (20.3 rads)

   (c) How much work is done on the wheel? (30 J)

   (d) What is the average power of the flywheel? (20 W)

2. The figure below shows a rigid structure consisting of a circular hoop of radius R and mass m, and a square made of four thin bars, each of length R and mass m. The rigid structure rotates at a constant speed about a vertical axis with a period of rotation of 2.5s. Assuming R = 0.50m and m = 2.0kg, calculate (a) the structure's rotational inertia about the axis of rotation and (b) its angular momentum about that axis. (1.58 kgm^2, 3.97 kgm^2/s) **FYI - the moment of hoop through vertical com is $1/2mr^2$*



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3. A horizontal platform in the shape of a circular disk rotates on a frictionless bearing about its vertical axle through the center of the disk. The platform has a mass of 150 kg, a radius of 2.0 m, and a rotational inertia of 300 kgm^2 about the axis of rotation. A 60 kg student walks slowly from the rim of the platform towards the center. If the angular speed of the system is 1.5 rad/s when the student starts at the rim, what is the angular speed when she is 0.50m from the center? (2.57 rad/s)

4. A phonograph record of mass 0.10 kg and radius 0.10m rotates about a vertical axis through its center with an angular speed of 4.7 rad/s. The rotational inertia of the record about its axis of rotation is $5.0 \times 10^{-4} kgm^2$. a wad of putty of mass 0.020 kg drops vertically onto the record from and sticks to the edge of the record. What is the angular speed of the record immediately after the putty sticks to it? (3.36 rad/s)

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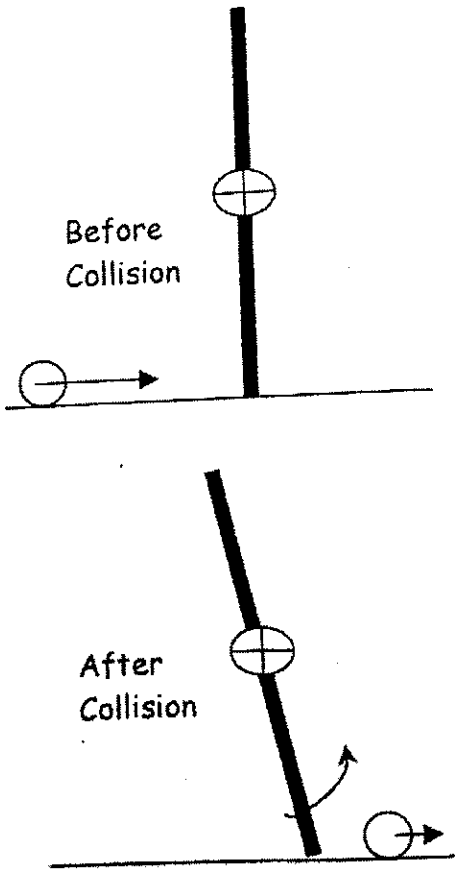
5. A ball of mass 0.5kg slides across a frictionless table at speed V_o = 5.0 m/s. It collides with a uniform rod of length l = 1.0m and mass of 1kg. The rod is pivoted about a frictionless axle through its center, and it is initially hanging straight up and down at rest. After the collision, the ball moves straight ahead with half the speed. (a) What is the rod's angular velocity after the collision? (7.5 rad/s) (b) Is the mechanical energy conserved during the collision? (No, there is a loss of K)



6. A thin rod of mass 20kg and length 1m rests on a smooth frictionless surface. A small (point) ball of mass 2kg moving at 5m/s strikes one end of the rod and is reflected back at 1m/s. What is the linear velocity of the center of mass of the rod? (0.6 m/s) What is the angular velocity of the rod about the center of mass? (3.6 rad/s) Is kinetic energy conserved in this collision? (No, over 25% loss)

7. A thin rod of mass 5kg and length 1m rests on a smooth frictionless surface. A small (point) ball of mass 2kg moving at 5m/s strikes one end of the rod and sticks to it. What is the linear velocity of the center of mass of rod-ball combination after collision? (1.43 m/s) What is the angular velocity of the rod-ball combination after the collision? (4.68 rad/s)

LJ6H8.

1. $I = 0.140\ kgm^2$

(a) $\Delta L = \tau \cdot \Delta t$

$0.8 - 3.0 = \tau \cdot 1.5$

$\therefore \tau = \dfrac{0.8 - 3.0}{1.5} = -1.47\ N \cdot m$

(b) $\tau = I \cdot \alpha.$

$\alpha = \dfrac{\tau}{I} = \dfrac{-1.47}{0.140} = -10.5\ rad/s^2$

$\theta = \omega_0 t + \frac{1}{2} \alpha \Delta t^2$

$L_0 = I_0 \omega_0$

$3 = 0.14 \cdot \omega_0 \qquad \omega_0 = 21.429\ rad/s$

$\therefore \theta = 21.429 \underset{(1.5)}{\wedge} + \frac{1}{2}(-10.5)(1.5)^2$

$= 20.3\ rads$

U6H8

(c). Work = $F \cdot s$

$= \tau \cdot \theta$

$= 1.47 \times 20.3$

$= 30\ J$

(d) Power = $\frac{\text{Work}}{\text{sec}}$

$= \frac{30}{1.5} = 20$ Watt

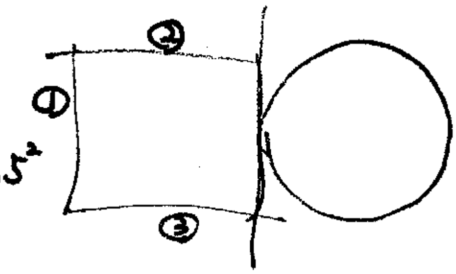
UbH8

2. $T = 2.5 \text{ sec}$

$R = 0.5\ m \qquad m = 2\ kg.$

(a) $I = 2 \times 0.5^2 + \frac{1}{3} \times 2 \times 0.5^2$

$+ \frac{1}{3} \times 2 \times 0.5^2 + \frac{1}{2} \times 2 \times 0.5^2 + 2 \times 0.5^2$



$= 1.58\ kg \cdot m^2$

(b). $L = I \cdot \omega.$

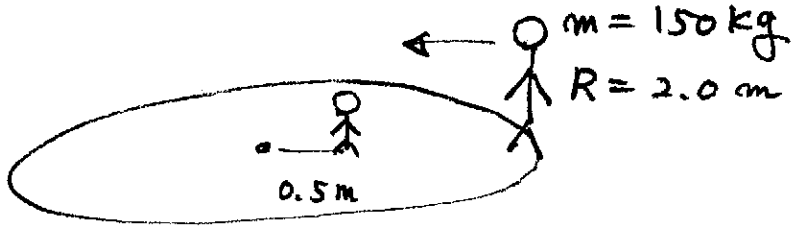
$$\omega = \frac{2\pi}{2.5}$$

$$\therefore L = 1.58 \times \frac{2\pi}{2.5} = 3.97\ kg\,m^2/s.$$

U6H8

60kg.

3.



$I = 300\ kg\ m^2$

$\omega_0 = 1.5\ rad/s$

$I_0 = 300 + 60 \times 2^2 = 540\ kg \cdot m^2$

$I_f = 300 + 60 \times 0.5^2 = 315\ kg \cdot m^2$.

$\therefore \quad I_0 \cdot \omega_0 = I_f\ \omega_f$

$$\omega_f = \frac{I_0}{I_f}\ \omega_0$$

$$= \frac{540}{315} \times 1.5 = 2.57\ rad/s$$

U6H8

4. $m = 0.1\ kg$ $\quad I_o = 5.0 \times 10^{-4}\ kg \cdot m^2$

$r = 0.1\ m$

$\omega_o = 4.7\ rad/s$

$M = 0.02\ kg$ @ edge.

$I = 5 \times 10^{-4} + 0.02 \times 0.1^2 = 0.0007\ kg \cdot m^2$.

$\therefore (5 \times 10^{-4})(4.7) = (0.0007)\omega$

$\omega = 3.3571\ rad/s$

UbHs

5. $v_0 = 5\ m/s$. $\ell = 1.0m$. $m = 1\ kg$.

$m = 0.5\ kg$

$I = \frac{1}{12} ML^2$

$v = 2.5\ m/s$.

$m = 0.5\ kg$.

(a) before $\Rightarrow$ $5 \times 0.5 = 2.5$

after $\Rightarrow$

$$(0.5)(2.5) + \frac{1}{12}(1)(1)^2 \frac{1}{0.5}(\omega)$$

$$J = \frac{L}{R}.$$

$\therefore$ $2.5 = 1.25 + 0.167\omega$ $\therefore \omega = 7.5\ rad/s$

(b) K.E. before $= \frac{1}{2} \times 0.5 \times 5^2 = 6.25\ J$

KE. after $= \frac{1}{2} \times 0.5 \times 2.5^2 + \frac{1}{2}\left(\frac{1}{12}\right) 7.5^2 = 3.9\ J$

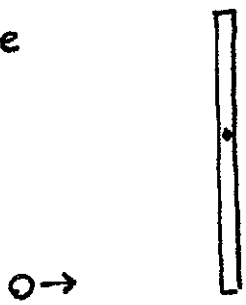
Energy loss.

ΔGHA

6. $M = 20\,kg$. $L = 1\,m$.

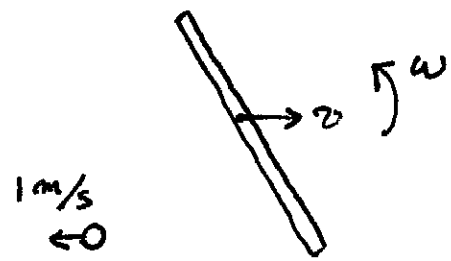
$m = 2\,kg$ $v = 5\,m/s$

Before



$\Sigma I\omega = (2)(5)(0.5) = 5.$

$\Sigma mv = 2 \cdot 5 = 10$



$\Sigma I\omega = (2)(-1)(0.5) + \frac{1}{12} \times 20 \times 1^2 \times \omega$

$\Sigma mv = (2)(-1) + (20) \cdot v.$

$\therefore \quad 5 = -1 + \frac{5}{3}\omega \rightarrow \omega = 3.6\ rad/s.$

$10 = -2 + 20v \rightarrow v = 0.6\ m/s.$

W6H8.

7.

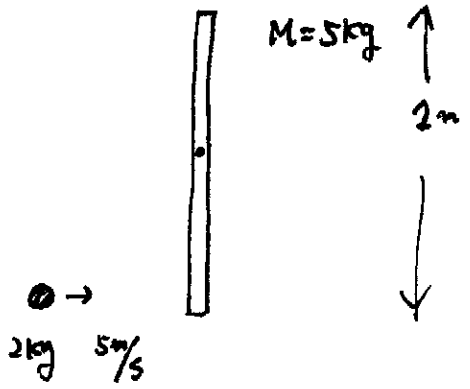
$\Sigma mv = 2 \times 5 = 10$. Before.

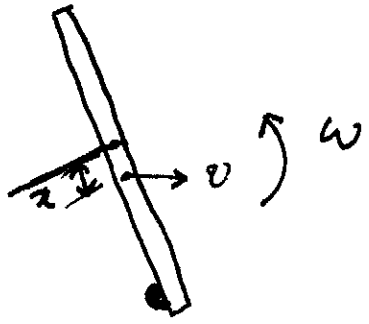
$\Sigma I\omega = 2 \times 5 \times (0.5 - 0.14) = 3.6$

$\Sigma mv = (5+2) \cdot v = 7v$ After.

$\Sigma I\omega = 0.77 \cdot \omega$

$$I = \frac{1}{12}ML^2 + mr^2 = \frac{1}{12}(5)1^2 + 5(0.14)^2 + (2)(0.5-0.14)^2$$
$$= 0.77$$





$(5+2)x = 2 \times 0.5$.

$x = 0.14$ m

① $10 = 7v$ $v = 1.43$ m/s

② $3.6 = 0.77\omega$ $\omega = 4.68$ rad/s.