QUIZ#10- CHAPTER11
DATE: 19/11/18

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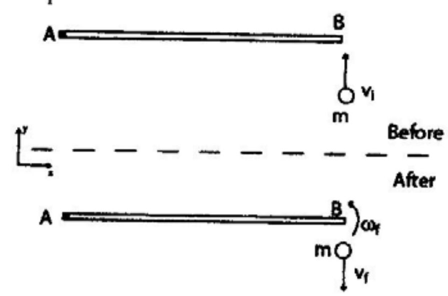
The figure shows a top view of a thin rod of mass M =2.0 kg and length L = 2.0 m which can rotate horizontally about a vertical axis through the end *A*. A particle of mass *m* = 2.0 *kg* traveling horizontally with a velocity v_i = 10 **j** m/s strikes the rod (which was initially at rest) at point *B*. The particle rebounds with a velocity v_f = – 6 **j** m/s . Calculate the angular speed ω_f of the rod just after collision.



$$L_i = L_f$$

$$L_i = l_{p_i} + l_{rod_i}$$

$$L_f = l_{p_f} + l_{rod_f}$$

$$l_{p_i} = m_p v_i r \sin\theta = (2)(10)(2)\sin 90^\circ = 40 \ kg\frac{m}{s^2}$$ direction out

$$l_{rd_i} = 0$$ (rod at rest initially)

$$l_{p_f} = m v r \sin\theta = (2)(6)(2)\sin 90^\circ = 24 \ kg\frac{m}{s^2}$$ direction in

$$l_{rod_f} = I_{new}\omega_f = \frac{1}{3}ML^2\omega_f = 2.67\omega_f$$ direction out

$$L_i = L_f$$

$$\Rightarrow 40 = -24 + 2.67\omega_f$$

$$\boxed{\omega_f = 24 \text{ rad/s}}$$

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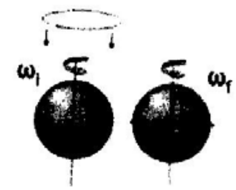
A solid sphere of mass M = 1.0 kg and radius R = 10 cm rotates about a frictionless axis at 4.0 rad/s (see the figure). A hoop of mass m=0.10 kg and radius R =10 cm falls onto the ball and sticks to it in the middle exactly.

Calculate the angular speed of the whole system about the axis just after the hoop sticks to the sphere.



$$L_i = L_f$$

$$L_i = I_{spher}\omega_i = \frac{2}{5}MR^2\omega_i$$

$$= 0.016 \ kg \cdot \frac{m}{s^2}$$

$$L_f = (I_{sphere} + I_{hoop})\omega_f = \left(\frac{2}{5}MR^2 + mR^2\right)\omega_f$$

$$= 0.005\,\omega_f$$

$$\boxed{\omega_f = 3.2 \ rad/s}$$

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A 2.0 kg particle is moving such that its position vector (r) relative to the origin is
$\mathbf{r} = (-2.0t^3\ \mathbf{i} + 3.0t\ \mathbf{j})$ m.

(a) What is the angular momentum of the particle at t = 2.0 s?

$$\vec{v} = \frac{d\vec{r}}{dt} = -6t^2\hat{i} + 3\hat{j} \qquad \vec{a} = -12t\,\hat{i}$$

$$\vec{l} = \vec{r} \times \vec{p} = m(\vec{r} \times \vec{v})$$

at $t = 2\,\text{sec}$

$$\vec{r} = -16\hat{i} + 6\hat{j}$$
$$\vec{v} = -24\hat{i} + 3\hat{j}$$

$$\vec{r} \times \vec{v} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -16 & 6 & 0 \\ -24 & 3 & 0 \end{vmatrix} = \hat{k}(96)$$

$$\vec{l} = m(\vec{r} \times \vec{v}) = \boxed{192\hat{k}\ \text{kg}\cdot\frac{m^2}{s}}$$

(b) What is the torque (about the origin) acting on the particle at t = 2.0 s?

$$\vec{\tau} = \vec{r} \times \vec{F} = m(\vec{r} \times \vec{a})$$

at $t = 2\,\text{sec}$

$$\vec{a} = -24\hat{i}$$

$$\vec{r} \times \vec{a} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -16 & 6 & 0 \\ -24 & 0 & 0 \end{vmatrix}$$

$$\vec{\tau} = m(\vec{r} \times \vec{a}) = \boxed{288\hat{k}\ \text{N.m}} = 144\hat{k}$$