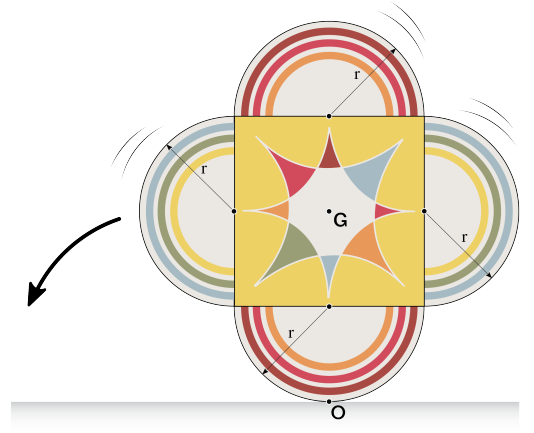


22-R-IM-JL-28

A toy is made of a square with 4 semi-circles of radius 14 cm attached. It has a mass of $m = 400$ g and a radius of gyration $k = 20$ cm about its center of mass G . If it rolls to the left without slipping and has 3 J of kinetic energy at this moment, find the linear momentum of the toy, the angular momentum about its center of mass G and its angular momentum about the point of contact with the ground O . The center of mass is directly above the point of contact with the ground.



Solution

First calculating its mass moment of inertia about G and O , we have:

$$I_G = m k^2 = 0.016 \text{ [kg}\cdot\text{m}^2\text{]}$$

$$I_O = I_G + m (2r)^2 = 0.04736 \text{ [kg}\cdot\text{m}^2\text{]}$$

Next, since it is rolling without slipping point O is the IC and we can find the angular velocity:

$$T = \frac{1}{2} I_{IC} \omega^2 \implies \vec{\omega} = \sqrt{\frac{2T}{I_O}} = 11.26 \hat{k} \text{ [rad/s]}$$

Now calculating the toy's momentum:

$$\vec{L} = m \vec{v}_G = m(\vec{\omega} \times \vec{r}_{G/O}) = -1.261 \hat{i} \text{ [kg}\cdot\text{m/s]} \quad \text{where } \vec{r}_{G/O} = 2r = 0.28 \hat{j}$$

$$\vec{H}_G = I_G \vec{\omega} = 0.1800 \hat{k} \text{ [kg}\cdot\text{m}^2/\text{s]}$$

$$\vec{H}_O = I_O \vec{\omega} = 0.5331 \hat{k} \text{ [kg}\cdot\text{m}^2/\text{s]}$$