Name_____

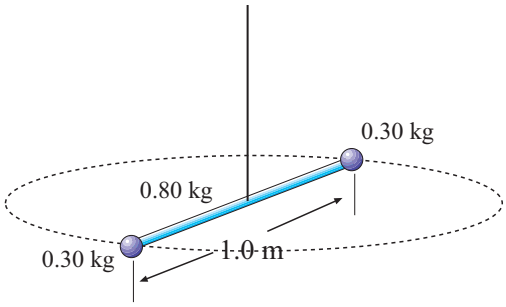
Nov. 29, 2006

Quiz #3 — Fall 2006

Phys 2010, NSCC

1. A uniform rod of length 1.0 m and mass 0.80 kg has small 0.30 kg attached to either end. It is made to rotate in a horizontal plane about an axis through its center.

The system starts from rest and after 8.0 s it is rotating at $5.0\frac{\text{rev}}{\text{s}}$.



a) What is the object's angular acceleration (in $\frac{\text{rad}}{\text{s}^2}$)?

Final rotation rate is

$$\omega = (5.0\tfrac{\text{rev}}{\text{s}})\left(\frac{2\pi \text{ rad}}{1 \text{ rev}}\right) = 31.4\tfrac{\text{rad}}{\text{s}}$$

Angular ecceleration is

$$\alpha = \frac{\omega - \omega_0}{t} = \frac{(31.4\frac{\text{rad}}{\text{s}} - 0)}{(8.0 \text{ s})} = 3.93\ \tfrac{\text{rad}}{\text{s}^2}$$

b) How many revolutions did the object make in the 8.0 s it was speeding up?

We can use $\theta = \frac{1}{2}(\omega_0 + \omega)t$, so

$$\theta = \tfrac{1}{2}(31.4\tfrac{\text{rad}}{\text{s}} - 0)(8.0 \text{ s}) = 125.6 \text{ rad}$$

which in revolutions is

$$\theta = (126 \text{ rad})\left(\frac{1 \text{ rev}}{2\pi \text{ rad}}\right) = 20.0 \text{ rev}$$

c) What is the moment of inertia of the object?

Object is a stick rotating around the middle with point masses at the ends so add up the corresponding moments of inertia:

$$I = \tfrac{1}{12}ML^2 + 2mr^2 = \tfrac{1}{12}(0.80 \text{ kg}(1.0 \text{ m})^2 + 2(0.30 \text{ kg})(0.50 \text{ m})^2 = 0.217 \text{ kg} \cdot \text{m}^2$$

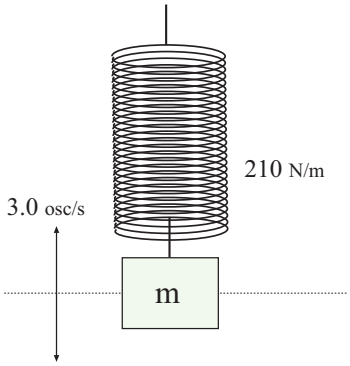
d) What was the net torque exerted on the object as it was speeding up?

$$\tau_{\text{net}} = I\alpha = (0.217 \text{ kg} \cdot \text{m}^2)(3.93\ \tfrac{\text{rad}}{\text{s}^2}) = 0.853 \text{ N} \cdot \text{m}$$

e) What was the kinetic energy of the object at the end of the 8.0 s?

$$\text{KE}_{\text{rot}} = \tfrac{1}{2}I\omega^2 = \tfrac{1}{2}(0.217\ \text{kg}\cdot\text{m}^2)(31.4\tfrac{\text{rad}}{\text{s}})^2 = 107\ \text{J}$$

2. What mass should we hang from a vertical spring with force constant 210 $\frac{\text{N}}{\text{m}}$ so that it oscillates at a rate of 3.00 Hz?



For the mass-spring system,

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

So

$$f^2 = \frac{1}{4\pi^2}\frac{k}{m} \qquad \Longrightarrow \qquad m = \frac{k}{4\pi^2 f^2}$$

Plug in numbers:

$$m = \frac{(210\ \frac{\text{N}}{\text{m}})}{4\pi^2(3.00\ \text{s}^{-1})^2} = 0.591\ \text{kg}$$

You must show all your work and include the right units with your answers!

$$\omega = \omega_0 + \alpha t \qquad \theta = \omega_0 t + \tfrac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_0^2 + 2\alpha\theta \qquad s = r\theta \qquad v_T = r\omega$$

$$a_T = r\alpha \qquad a_c = r\omega^2 \qquad \tau = Fr\sin\phi \qquad \tau = I\alpha \qquad \text{KE}_{\text{rot}} = \tfrac{1}{2}I\omega^2$$

$$I_{\text{disk}} = \tfrac{1}{2}MR^2 \qquad I_{\text{sph}} = \tfrac{2}{5}MR^2 \qquad I_{\text{rod, end}} = \tfrac{1}{3}ML^2 \qquad I_{\text{rod, mid}} = \tfrac{1}{12}ML^2$$

$$F_{\text{spr},x} = -kx \qquad \text{PE}_{\text{spr}} = \tfrac{1}{2}kx^2 \qquad T = \frac{1}{f} \qquad \omega = 2\pi f$$

$$\omega = \sqrt{\frac{k}{m}} \qquad v_{\text{max}} = \omega A \qquad a_{\text{max}} = \omega^2 A \qquad \omega = \sqrt{\frac{g}{L}} \qquad \omega = \sqrt{\frac{I}{mgL}}$$