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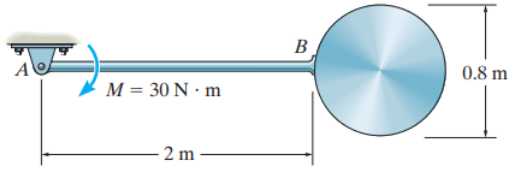
1) A pendulum consists of a 10 kg uniform disk and a 3 kg uniform slender rod. If it is released from rest in the position shown, determine its angular velocity when it rotates 90° (pendulum is straight down) ans = 3.16 rad/s



SOLUTION

Kinetic Energy. Since the assembly is released from rest, initially, $T_1 = 0$. The mass moment of inertia of the assembly about A is $I_A = \left[\frac{1}{12}(3)(2^2) + 3(1^2)\right] + \left[\frac{1}{2}(10)(0.4^2) + 10(2.4^2)\right] = 62.4\ \text{kg}\cdot\text{m}^2$. Thus,

$$T_2 = \frac{1}{2}I_A\omega^2 = \frac{1}{2}(62.4)\,\omega^2 = 31.2\,\omega^2$$

Work. Referring to the FBD of the assembly, Fig. *a*. Both $\mathbf{W}_r$ and $\mathbf{W}_d$ do positive work, since they displace vertically downward $S_r = 1$ m and $S_d = 2.4$ m, respectively. Also, couple moment $\mathbf{M}$ does positive work

$$U_{W_r} = W_r S_r = 3(9.81)(1) = 29.43\ \text{J}$$
$$U_{W_d} = W_d S_d = 10(9.81)(2.4) = 235.44\ \text{J}$$

$$U_M = M\theta = 30\left(\frac{\pi}{2}\right) = 15\pi\ \text{J}$$

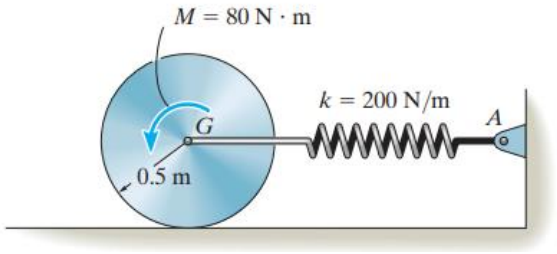
Principle of Work and Energy.

$$T_1 + \Sigma U_{1-2} = T_2$$

$$0 + 29.43 + 235.44 + 15\pi = 31.2\,\omega^2$$

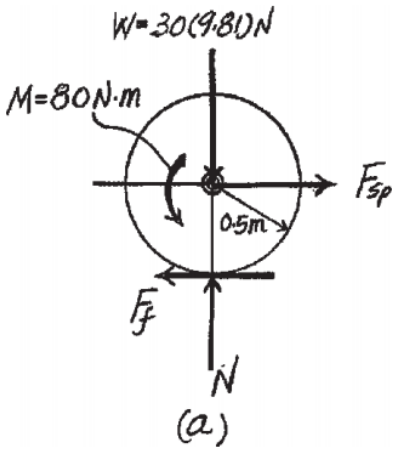
$$\omega = 3.1622\ \text{rad/s} = 3.16\ \text{rad/s}$$ **Ans.**

2) A 30 kg disk is originally at rest and the spring is unstretched. A couple moment of M – 80 Nm is applied. Determine its angular velocity when the mass center at G has moved 0.5m along the plane. The disk rolls without slipping . ans = 3.13 rad/s



Kinetic Energy. Since the disk is at rest initially, $T_1 = 0$. The disk rolls without slipping. Thus, $v_G = \omega_r = \omega(0.5)$. The mass moment of inertia of the disk about its center of gravity G is $I_G = \frac{1}{2}mr = \frac{1}{2}(30)(0.5^2) = 3.75\ \text{kg}\cdot\text{m}^2$. Thus,

$$T_2 = \frac{1}{2}I_G\omega^2 + \frac{1}{2}Mv_G^2$$
$$= \frac{1}{2}(3.75)\omega^2 + \frac{1}{2}(30)[\omega(0.5)]^2$$
$$= 5.625\,\omega^2$$



Work. Since the disk rolls without slipping, the friction $\mathbf{F}_f$ does no work. Also when the center of the disk moves $S_G = 0.5$ m, the disk rotates $\theta = \frac{s_G}{r} = \frac{0.5}{0.5} = 1.00$ rad. Here, couple moment **M** does positive work whereas the spring force does negative work.

$$U_M = M\theta = 80(1.00) = 80.0\ \text{J}$$

$$U_{F_{sp}} = -\frac{1}{2}kx^2 = -\frac{1}{2}(200)(0.5^2) = -25.0\ \text{J}$$

Principle of Work and Energy.

$$T_1 + \Sigma U_{1-2} = T_2$$
$$0 + 80 + (-25.0) = 5.625\,\omega^2$$
$$\omega = 3.127\ \text{rad/s} = 3.13\ \text{rad/s}$$ **Ans.**