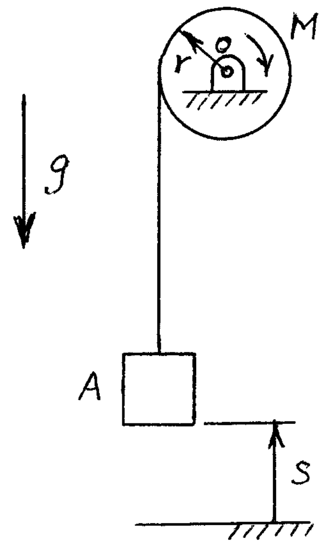
Problem 18.14. p. 454



Definitions

$$g := 32.2\cdot\frac{ft}{s^2} \qquad slug := \frac{lb\cdot s^2}{ft}$$

Drum

$$W_d := 30\cdot lb \qquad m_d := \frac{W_d}{g} \qquad m_d = 0.932\,slug$$

$$r := 1.5\cdot ft \qquad M := 120\,lb\cdot ft$$

$$k_0 := 0.8\cdot ft \qquad I_0 := m_d\cdot k_0^{2.} \qquad I_0 = 0.596\,slug\cdot ft^2$$

Crate

$$W_A := 15\cdot lb \qquad m_A := \frac{W_A}{g} \qquad m_A = 0.466\cdot slug$$

Motion

$$v_1 := 0\cdot\frac{ft}{s} \quad \text{when} \quad s_1 := 0\cdot ft$$

Find v_2 when $s_2 := 4\cdot ft$

$$U_{1>2} := \Delta T + \Delta V_g$$

$$U_{1>2} := M\cdot\left(\frac{s_2 - s_1}{r}\right) \qquad U_{1>2} = 320\cdot ft\cdot lb$$

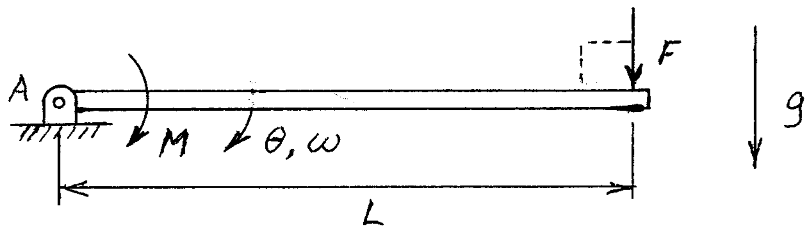
$$\Delta T := \frac{1}{2}\cdot I_0\cdot\left(\frac{v_2}{r}\right)^2 + \frac{1}{2}\cdot m_A\cdot v_2^2$$

$$\Delta V_g := W_A\cdot(s_2 - s_1) \qquad \Delta V_g = 60\cdot ft\cdot lb$$

$$v_2 := \sqrt{\frac{U_{1>2} - \Delta V_g}{\frac{1}{2}\cdot\left(\frac{I_0}{r^2} + m_A\right)}} \qquad v_2 = 26.7\cdot\frac{ft}{s}$$

<——— Ans.

Problem 18.16, p. 455



Definition $g := 9.81 \cdot \frac{m}{s^2}$

Rod $m_r := 4 \cdot kg$ $L := 3 \cdot m$ $I_A := \frac{1}{3} \cdot m_r \cdot L^2$ $I_A = 12\, m^2 \cdot kg$

Applied couple moment and force $M := 40 \cdot N \cdot m$ $F := 15 \cdot N$

Motion $\omega_1 := 6 \cdot \frac{rad}{s}$ when $\theta_1 := 0 \cdot rad$

Find ω_2 when $\theta_2 := \frac{\pi}{2} \cdot rad$

$$U_{1>2} := \Delta T + \Delta V_g$$

$$U_{1>2} := M \cdot (\theta_2 - \theta_1) + F \cdot L \cdot (\theta_2 - \theta_1) \qquad U_{1>2} = 133.5\, J$$

$$\Delta T := \frac{1}{2} \cdot I_A \cdot \left(\omega_2^2 - \omega_1^2\right)$$

$$\Delta V_g := -m_r \cdot g \cdot \frac{L}{2} \qquad \Delta V_g = -58.86\, J$$

$$\omega_2 := \sqrt{\frac{U_{1>2} - \Delta V_g + \frac{1}{2} \cdot I_A \cdot \omega_1^2}{\frac{1}{2} \cdot I_A}} \qquad \omega_2 = 8.25 \cdot \frac{rad}{s}$$ <-------- Ans.

Problem 18.17

Find ω_2 when $\theta_2 := 2 \cdot \pi \cdot rad$

$$U_{1>2} := \Delta T + \Delta V_g$$

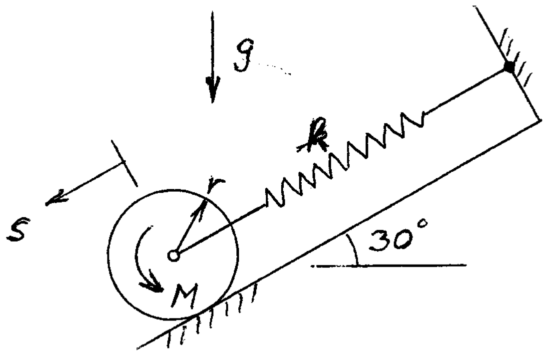
$$U_{1>2} := M \cdot (\theta_2 - \theta_1) + F \cdot L \cdot (\theta_2 - \theta_1) \qquad U_{1>2} = 534.1\, J$$

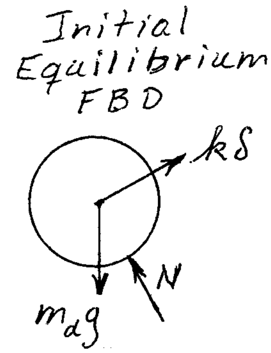
$$\Delta T := \frac{1}{2} \cdot I_A \cdot \left(\omega_2^2 - \omega_1^2\right)$$

$$\Delta V_g := 0$$

$$\omega_2 := \sqrt{\frac{U_{1>2} - \Delta V_g + \frac{1}{2} \cdot I_A \cdot \omega_1^2}{\frac{1}{2} \cdot I_A}} \qquad \omega_2 = 11.18 \cdot \frac{rad}{s}$$ <--------- Ans.

Problem 18.23, p. 456





Definition $g := 9.81 \cdot \frac{m}{s^2}$

Disk

$m_d := 20 \cdot kg$ $r := 0.2 \cdot m$ $M := 30 \cdot N \cdot m$

Spring

$k := 150 \cdot \frac{N}{m}$

Motion

$v_1 := 0 \cdot \frac{m}{s}$ when $s_1 := 0$ and disk is held in equilibrium by spring.

Let δ be the initial elongation of the spring at equilibrium.

$$\delta := \frac{m_d \cdot g \cdot \sin(30 \cdot deg)}{k} \qquad \delta = 0.654\,m$$

Find s_2 when $v_2 := 0 \cdot \frac{m}{s}$

$$U_{1>2} := \Delta T + \Delta V_g + \Delta V_e$$

$$U_{1>2} := M \cdot \left(\frac{s_2 - s_1}{r} \right)$$

$$\Delta T := 0 \cdot J$$

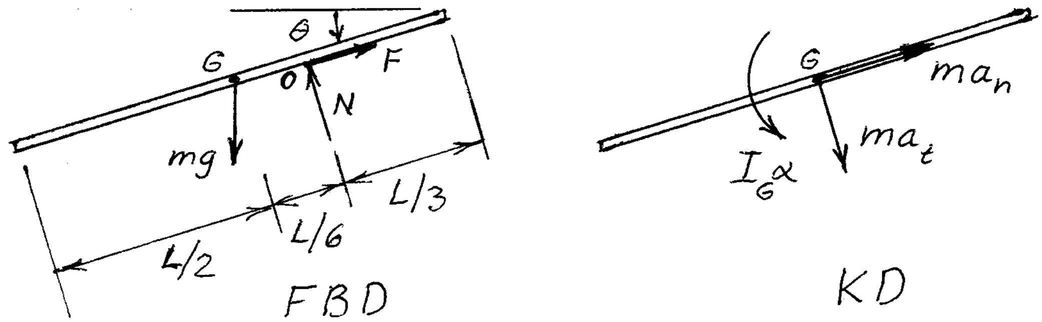
$$\Delta V_g := -m_d \cdot g \cdot (s_2 - s_1) \cdot \sin(30 \cdot deg)$$

$$\Delta V_e := \frac{1}{2} \cdot k \cdot \left[(s_2 + \delta)^2 - \delta^2 \right] \qquad \Delta V_e := \frac{1}{2} \cdot k \cdot \left[s_2 \cdot (2 \cdot \delta + s_2) \right]$$

$$M \cdot \left(\frac{s_2}{r} \right) := -m_d \cdot g \cdot (s_2) \cdot \sin(30 \cdot deg) + \frac{1}{2} \cdot k \cdot \left[s_2 \cdot (2 \cdot \delta + s_2) \right]$$

$$s_2 := \frac{M \cdot \left(\frac{1}{r} \right) + m_d \cdot g \cdot (1) \cdot \sin(30 \cdot deg) - k \cdot \delta}{\frac{1}{2} \cdot k} \qquad s_2 = 2\,m \quad \text{<——— Ans.}$$

Problem 18.27, p. 457



Definitions

Bar mass: m

Bar length: L

Gravity: g

Coeff. of static friction: $\mu_s := 0.3$

Motion:

$$\omega_1 := 0\cdot\frac{rad}{s} \quad \text{when} \quad \theta_1 := 0\cdot rad$$

Find θ_2 when $F := \mu_s\cdot N$ and bar begins to slip.

Equations of motion

$$\Sigma F_n := m\cdot a_n \qquad F - m\cdot g\cdot \sin(\theta) := m\cdot a_n \qquad a_n := \frac{L}{6}\cdot\omega^2$$

$$F := m\cdot g\cdot\sin(\theta) + m\cdot\left(\frac{L}{6}\cdot\omega^2\right)$$

$$\Sigma F_t := m\cdot a_t \qquad -N + m\cdot g\cdot\cos(\theta) := m\cdot a_t \qquad a_t := \alpha\cdot\frac{L}{6}$$

$$N := m\cdot g\cdot\cos(\theta) - m\cdot\left(\alpha\cdot\frac{L}{6}\right)$$

$$\Sigma M_O := I_O\cdot\alpha \qquad m\cdot g\cdot\cos(\theta)\cdot\frac{L}{6} := I_O\cdot\alpha$$

$$I_O := \frac{1}{12}\cdot m\cdot L^2 + m\cdot\left(\frac{L}{2} - \frac{L}{3}\right)^2 \qquad I_O := \frac{1}{9}\cdot m\cdot L^2$$

$$\alpha := \frac{m\cdot g\cdot\cos(\theta)\cdot\frac{L}{6}}{\frac{1}{9}\cdot m\cdot L^2}$$

$$\alpha := \frac{3\cdot g\cdot\cos(\theta)}{2\cdot L}$$

Find ω^2

$$0 := \Delta T + \Delta Vg$$

$$0 := \frac{1}{2} \cdot I_O \cdot \omega^2 - m \cdot g \cdot \frac{L}{6} \cdot \sin(\theta) \qquad \omega^2 := \frac{m \cdot g \cdot \frac{L}{6} \cdot \sin(\theta)}{\frac{1}{2} \cdot \left(\frac{1}{9} \cdot m \cdot L^2\right)}$$

$$\omega^2 := \frac{3 \cdot g \cdot \sin(\theta)}{L}$$

Substitute the expressions for ω^2 and α In the equations for F and N, respectively.

$$F := m \cdot g \cdot \sin(\theta) + m \cdot \left(\frac{L}{6} \cdot \frac{3 \cdot g \cdot \sin(\theta)}{L}\right) \qquad F := \frac{3 \cdot g \cdot m \cdot \sin(\theta)}{2}$$

$$N := m \cdot g \cdot \cos(\theta) - m \cdot \left(\frac{3 \cdot g \cdot \cos(\theta)}{2 \cdot L} \cdot \frac{L}{6}\right) \qquad N := \frac{3 \cdot g \cdot m \cdot \cos(\theta)}{4}$$

Develop $F := \mu_s \cdot N$ and simpiify.

$$\frac{3 \cdot g \cdot m \cdot \sin(\theta)}{2} := 0.3 \cdot \frac{3 \cdot g \cdot m \cdot \cos(\theta)}{4}$$

$$\tan(\theta) := 0.3 \cdot \frac{\frac{3 \cdot g \cdot m}{4}}{\frac{3 \cdot g \cdot m}{2}}$$

$$\tan(\theta) := 0.15$$

$\theta := \text{atan}(0.15) \qquad \theta = 8.53 \cdot \text{deg}$ <——— Ans.