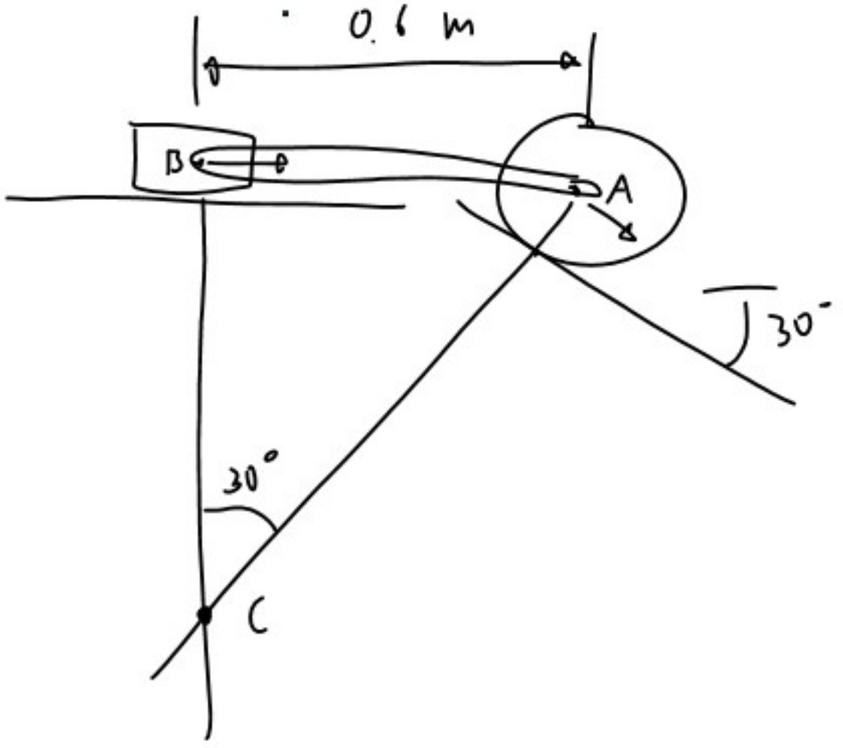
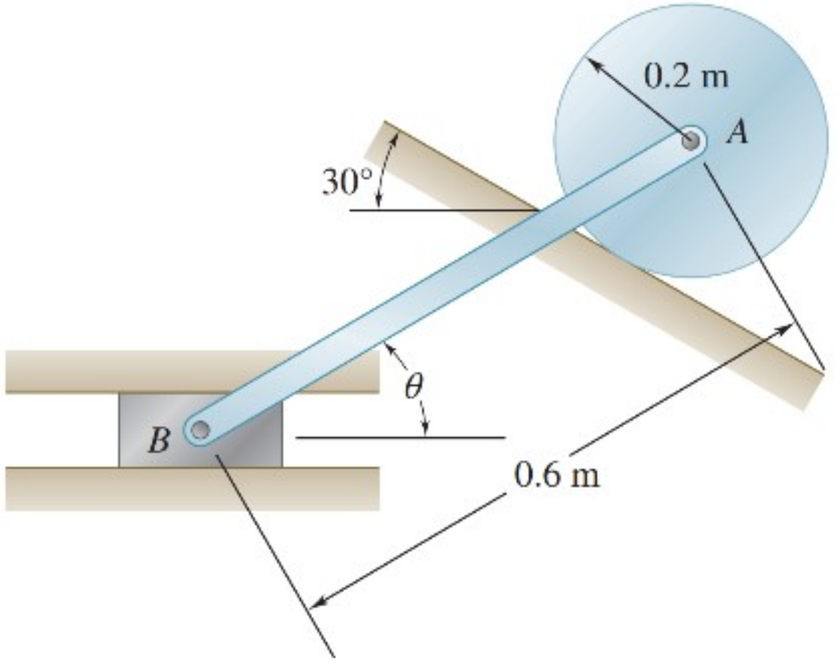
15.91 The disk is released from rest and rolls down the incline. Knowing that the speed of A is 1.2 m/s when $\theta = 0°$, determine at that instant (a) the angular velocity of the rod, (b) the velocity of B. (Only portions of the two tracks are shown.)





$$\sin 30 = \frac{0.6\ m}{l_{AC}}$$

$$\cos 30 = \frac{l_{BC}}{l_{AC}}$$

$$l_{AC} = \frac{0.6\ m}{\sin 30} = 1.2\ m$$

$$l_{BC} = l_{AC}\cos 30 = 1.2\cos 30 = 1.04\ m$$

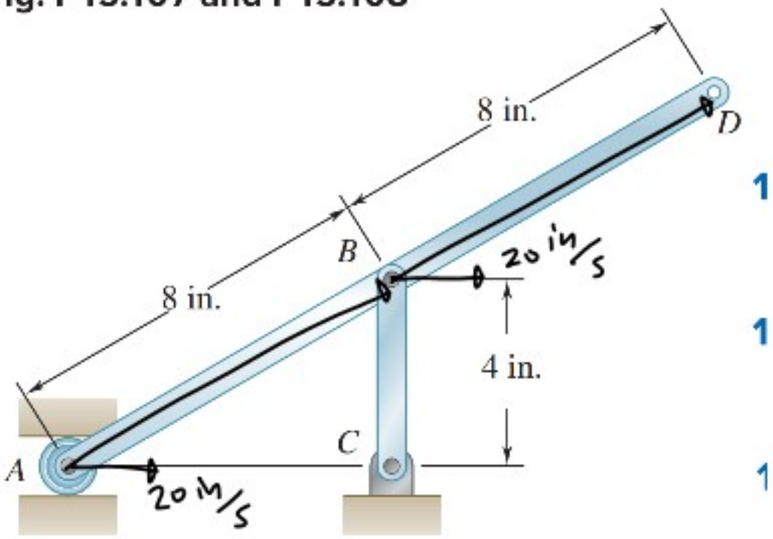
$$\omega_{AB} = \frac{v_A}{l_{AC}} = \frac{1.2\ m/s}{1.2\ m} = 1\ rad/s$$

$$\omega_{AB} = \frac{v_B}{l_{BC}}$$

$$v_B = \omega_{AB} l_{BC} = 1\ rad/s \cdot 1.04\ m$$

$$= 1.04\ m/s$$

Fig. P15.107 and P15.108



15.109 Knowing that point A is moving to the right at a constant speed of 20 in./s, determine the acceleration of (a) point B, (b) point D.

$$a_B = -\omega_{BC}^2 r_{B/C} + \alpha_{BC} k \times r_{B/C} + \cancel{\alpha_A}^{\,0}$$

$$= -(5)^2 (4j) + \alpha_{BC} k \times 4j = -4\alpha_{BC} i - 100 j$$

$$\omega_{BC} = \frac{20 \text{ in/s}}{4 \text{ in}} = 5 \text{ rad/s}$$

$$r_{B/C} = 4j$$

$$a_B = \cancel{a_A}^{\,0} - \cancel{\omega_{AB}^2 r_{B/A}}^{\,0} + \alpha_{AB} k \times r_{B/A}$$

$$v_{B/A} = 6.9i + 4j$$

$$= \alpha_{AB} k \times (6.9i + 4j) = 6.9\alpha_{AB} j - 4\alpha_{AB} i$$

$$-4\alpha_{BC} i - 100 j = 6.9\alpha_{AB} j - 4\alpha_{AB} i$$

$$-100 = 6.9\alpha_{AB} \Rightarrow \alpha_{AB} = -14.43 \text{ rad/s}^2$$

$$-4\alpha_{BC} = -4\alpha_{AB} \qquad \alpha_{BC} = -14.43 \text{ rad/s}^2$$

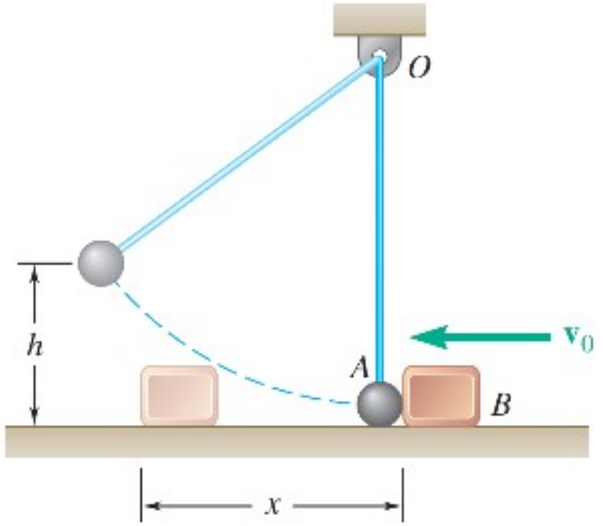
$$8^2 = AC^2 + 4^2$$

$$AC^2 = 8^2 - 4^2$$

$$AC = \sqrt{8^2 - 4^2} = \sqrt{64 - 16}$$

$$= \sqrt{48} = 6.9 \text{ in}$$

13.175 A 1-kg block B is moving with a velocity $\mathbf{v}_0$ of magnitude $v_0 = 2$ m/s as it hits the 0.5-kg sphere A, which is at rest and hanging from a cord attached at O. Knowing that $\mu_k = 0.6$ between the block and the horizontal surface and $e = 0.8$ between the block and the sphere, determine after impact (a) the maximum height h reached by the sphere, (b) the distance x traveled by the block.



$$m_A v_A + m_B v_B = m_A v_A' + m_B v_B'$$

$$1\,\text{kg}\ 2\ \text{m/s} = 0.5\,\text{kg}\ v_A' + 1\,\text{kg}\ v_B'$$

$$(v_A - v_B)e = v_A' + v_B'$$

$$-2\ \text{m/s}\ 0.8 = v_A' + v_B'$$

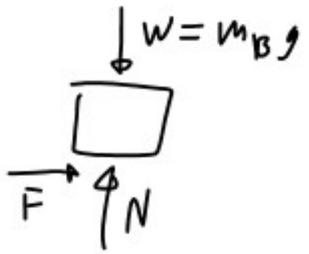
$$v_B' = 0.8\ \text{m/s}$$

$$v_A' = 2.4\ \text{m/s}$$

$$T_1 + V_1 + U_{1\to 2} = T_2 + V_2$$

$$\frac{1}{2} m_A v_A'^2 = m_A g h$$

$$\frac{v_B'^2}{2g} = h \qquad \frac{(2.4)^2}{2(9.8)} = \boxed{0.3\ m}$$



$$F = N\mu_K = m_B g \mu_K = 5.886\ N$$

$$T_1 + V_1 + U_{1\to 2} = T_2 + V_2$$

$$\frac{1}{2} m_B v_B'^2 + Fx = 0$$

$$x = \frac{-m_B v_B'^2}{2F} = \frac{-1 kg (0.8\ m/s)^2}{2(5.886\ N)} = -0.054\ m$$

$$= \boxed{-54\ mm}$$

$$a_B = -4\alpha_{BC} i - 100 j$$

$$= -4(-19.43) i - 100 j$$

$$= 57.7 \text{ in/s}^2 i - 100 \text{ in/s}^2 j$$

$$\omega_{BD} = 0$$

$$r_{D/B} = r_{A/B} = 6.9 i + 4 j$$

$$\alpha_{BD} = -19.43 \text{ rad/s}^2$$

$$a_D = a_B + a_{D/B} = a_B + \alpha_{BD} k r_{D/B} - \omega_{BD}^2 r_{D/B}$$

$$= 57.7 \text{ in/s}^2 i - 100 \text{ in/s}^2 j - 19.43 \text{ rad/s}^2 k \times (6.9 \text{ in } i + 4 \text{ in } j)$$

$$= (57.7 + 19.43 \cdot 4) i + (-100 - 19.43 \cdot 6.9) j$$

$$= 115.42 i - 200 j \text{ in/s}^2$$

$$\begin{vmatrix} i & j & k \\ 0 & 0 & -19.43 \\ 6.9 & 4 & 0 \end{vmatrix} \quad \begin{matrix} i & j \\ 0 & 0 \\ 6.9 & 4 \end{matrix}$$

$$j(-19.43)(6.9) - i(-19.43)(4)$$