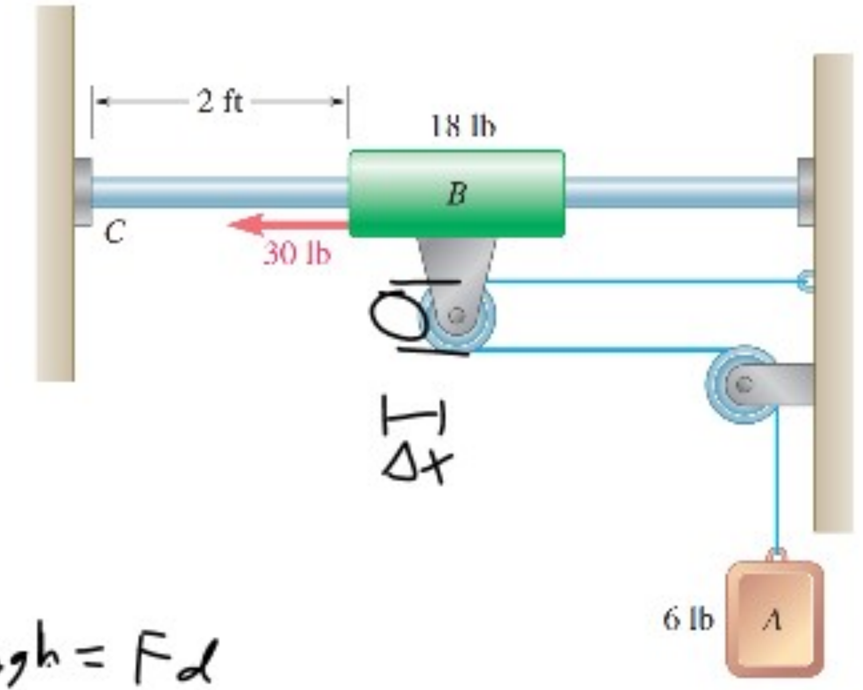
13.20 The system shown is at rest when a constant 30-lb force is applied to collar B. (*a*) If the force acts through the entire motion, determine the speed of collar B as it strikes the support at C. (*b*) After what distance d should the 30-lb force be removed if the collar is to reach support C with zero velocity?



$V_2 = m_A g h = Fd$

$L_1 + Imp_{1\to 2} = L_2$

$Imp_{1\to 2} = F\Delta t$

$\cancel{T_1}^{0} + \cancel{V_1}^{0} + U_{1\to 2} = T_2 + V_2$

$U_{1\to 2} = Fd$

$V_A = 2V_B$

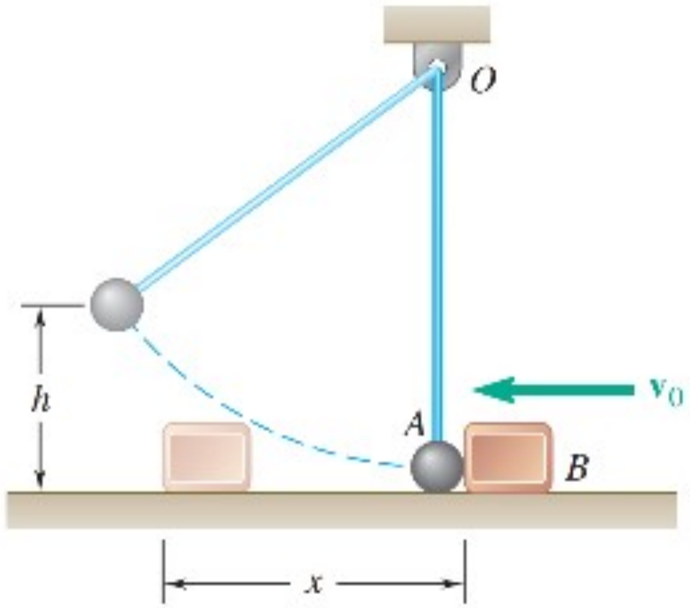
$Fd = \frac{1}{2} m_B V_B^2 + \frac{1}{2} m_A V_A^2 + m_A g h$

$Fd - m_A g h = \frac{1}{2} m_B V_B^2 + \frac{1}{2} m_A 4 V_B^2$

$\sqrt{\dfrac{Fd - m_A g h}{\frac{1}{2} m_B + 2 m_A}} = V_B$

$\sqrt{\dfrac{30\text{ lb } 2\text{ ft} - 6\text{ lb } 4\text{ ft}}{\frac{1}{2}\frac{18\text{ lb}}{32.2\text{ ft/s}^2} + 2\frac{6\text{ lb}}{32.2\text{ ft/s}^2}}} \boxed{= 7.93\text{ ft/s}}$

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.



$$\cancel{m_A V_A}^{0} + m_B V_B = m_A V_A' + m_B V_B'$$

$$1\,\text{kg}\ 2\,\tfrac{m}{s} = 0.5\,\text{kg}\ V_A' + 1\,\text{kg}\ V_B'$$

$$(V_A - V_B)e = (V_B' - V_A')$$

$$2\,\tfrac{m}{s}\ 0.8 = (V_B' - V_A')$$

$$V_A' = 2.4\,\tfrac{m}{s}$$

$$V_B' = 0.8\,\tfrac{m}{s}$$

$V_A' = 2.4\ m/s$

$$T_1 + \cancel{V_1}^{0} + \cancel{U_{1\to2}}^{0} = \cancel{T_2}^{0} + V_2$$

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

$$\frac{1}{2}\frac{V_A'^2}{g} = h \qquad \frac{1}{2}\frac{(2.4)^2}{9.8} = \boxed{0.3\ m}$$

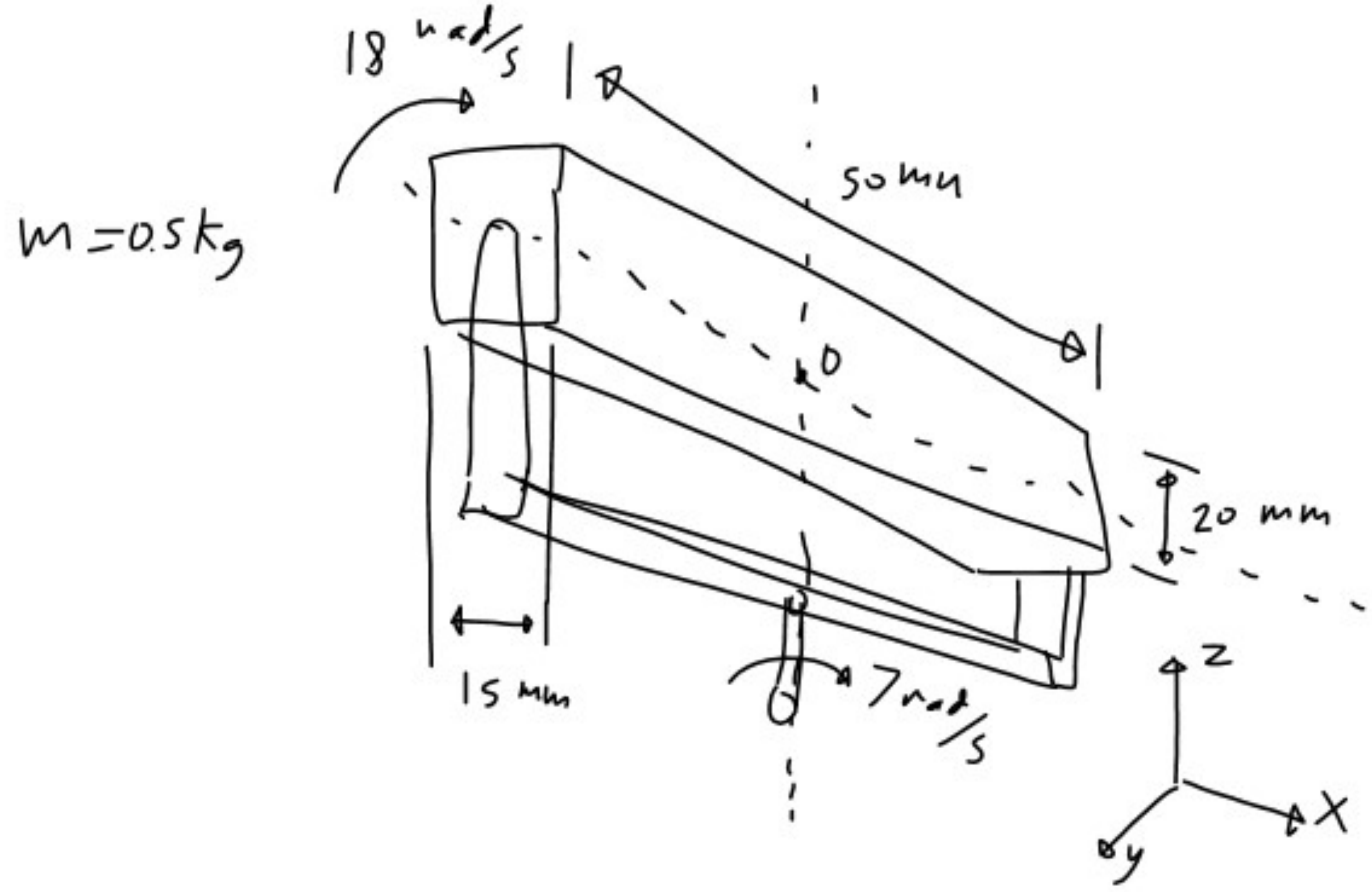
$V_B' = 0.8\ m/s$

$$T_1 + \cancel{V_1}^{0} + U_{1\to2} = \cancel{T_2}^{0} + \cancel{V_2}^{0}$$

$$\frac{1}{2} m_B V_B'^2 + F d = 0$$

$$F = N\mu_K = m_B g \mu_K = 1\,kg\ 9.8\,m/s^2\ 0.6$$
$$= -5.886\ N$$

$$d = \frac{\frac{1}{2} m_B V_B'^2}{-F} = \frac{\frac{1}{2}\,1\,kg\,(0.8\,m/s)^2}{5.886\ N} = 0.0544\ m = \boxed{54\ mm}$$



$H_0 =$

$$I = \begin{bmatrix} I_x & 0 & 0 \\ 0 & I_y & 0 \\ 0 & 0 & I_z \end{bmatrix}$$

$w_x = 18 \text{ rad/s}$

$w_y = 0$

$w_z = 7 \text{ rad/s}$

$$w = \begin{bmatrix} 18 \text{ rad/s} \\ 0 \\ 7 \text{ rad/s} \end{bmatrix}$$

$$I_x = \frac{1}{12} m (b^2 + c^2)$$
$$= \frac{1}{12} 0.5\,kg\,(15mm^2 + 20mm^2)$$
$$= 26\ kg\,mm^2$$

$$I_y = \frac{1}{12} m (a^2 + c^2)$$
$$= \frac{1}{12} 0.5\,kg\,(20\,mm^2 + 50\,mm^2)$$
$$= 121\ kg\,mm^2$$

$$I_z = \frac{1}{12} m (a^2 + b^2)$$
$$= \frac{1}{12} m (15\,mm^2 + 50\,mm^2)$$
$$= 114\ kg\,mm^2$$

$$I = \begin{bmatrix} 26 & 0 & 0 \\ 0 & 121 & 0 \\ 0 & 0 & 114 \end{bmatrix} \text{ Kg mm}^2$$

$$H_{ox} = I_x w_x + I_{xy} w_y + I_{xz} w_z$$

$$H = Iw = \begin{bmatrix} 26 & 0 & 0 \\ 0 & 121 & 0 \\ 0 & 0 & 114 \end{bmatrix} \begin{bmatrix} 18 \\ 0 \\ 7 \end{bmatrix} = \begin{bmatrix} 26 \cdot 18 \\ 121 \cdot 0 \\ 114 \cdot 7 \end{bmatrix} = \begin{bmatrix} 468 \\ 0 \\ 798 \end{bmatrix} \frac{\text{Kg mm}^2}{s}$$