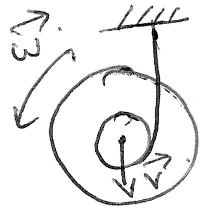
Hw #14 Solutions.

18.38

a) with the spring Present:



$$U_{1-2} = Wh = 6\times 6 = 36 \text{ lb.ft}.$$

$$V = r\omega \Rightarrow \omega = V/r = V/(2/12). \quad m = 6/32.2 \text{ lb. mass}$$

$$T_1 = 0.$$

$$T_2 = \frac{1}{2} I\omega_2^2 + \frac{1}{2} m V_2^2$$

$$= \frac{1}{2} m k^2 \omega_2^2 + \frac{1}{2} m V_2^2.$$

$$= \frac{1}{2} m k^2 \left(\frac{V_2^2}{4}\right)\times 144 + \frac{1}{2} m V_2^2.$$

$$= \frac{1}{2} m V_2^2 \left(\frac{144 k^2}{4} + 1\right) = \frac{1}{2} m V_2^2 \left(36\times\frac{(3.75)^2}{144} + 1\right)$$

$$= .4207\, V_2^2.$$

$$U_{1-2} = T_2 - T_1 = .4207 V_2^2 = 36.$$

$$V_2 = 9.25 \text{ ft/sec}.$$

b) In the absence of spring

we have fall under gravity.

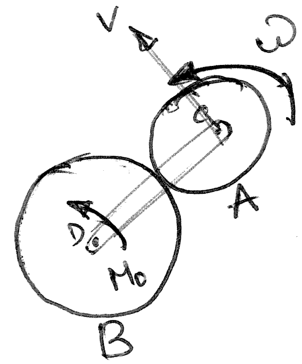
$$T_1 = 0 \qquad T_2 = \frac{1}{2} m V_2^2 \quad (\text{note } \omega = 0).$$

$$U_{1-2} = T_2 - T_1 = 36$$

$$V_2^2 = 386.4$$

$$V_2 = 19.657 \text{ ft/s}$$

18.56



For gear A, $\bar{V} = \overline{CD}\,\omega_{CD} = .32\,\omega_{CD}$.

$$\omega_A = \frac{\bar{V}}{R} = \frac{.32\,\omega_{CD}}{.12} = 2.667\,\omega_{CD}.$$

$$T = \frac{1}{2} I \omega^2 + \frac{1}{2} m v^2.$$

$$= \frac{1}{2}\left[4 \times .09^2 \times (2.667\,\omega_{CD})^2\right] + \frac{1}{2} \times 4 \times (.32\,\omega_{CD})^2$$

$$= .32\,\omega_{CD}^2.$$

$$T_2 = .32 \times \left(\frac{2\pi}{60} \times 320\right)^2.$$

$$T_1 = .32 \times \left(\frac{2\pi}{60} \times 200\right)^2.$$

$$U_{1-2} = M_0 \cdot \theta = M_0 \times 12\pi$$

$$U_{1-2} = T_2 - T_1 = .32\,(320^2 - 200^2)\left(\frac{2\pi}{60}\right)^2$$

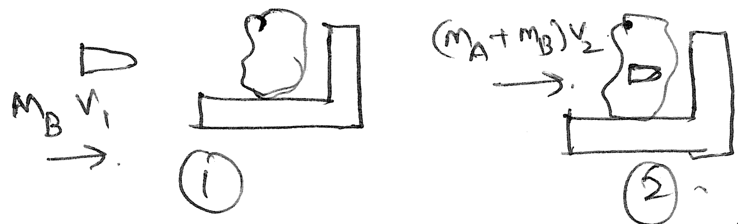
$$= 218.97 \text{ Nm}$$

$$M_0 \times 12\pi = 218.97$$

$$M_0 = 5.81 \text{ N.m.}$$

15-86

Let Position 1 refer to instant before impact and Position 2 refer to instant after impact.



There are no external impulsive forces during impact, so momentum is conserved.

$$(P_x)_1 = (P_x)_2 \Rightarrow m_B v_1 = (m_A+m_B)v_2$$

$$.018 \times v_1 = 15.018\, v_2$$

$$v_1 = 834.33\, v_2$$

Let 3 be the position when system is at rest.

By Conservation of mechanical energy,

$$V_2 + T_2 = V_3 + T_3$$

$$0 + \frac{1}{2}(m_A+m_B)v_2^2 = \frac{1}{2}k\delta^2$$

where δ is spring compression.

$$\delta = 0.125\ m.$$

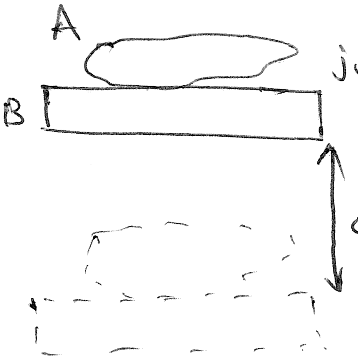
So $v_2 = .967$ m/s.

So $v_1 = 834.33\, v_2 = 807.35$ m/s.

15.94

The springs are initially deformed due to the wait of platform B. $\delta_1 = \frac{W_B}{k}$.

When the sack falls on the platform and when the system eventually comes to rest, extension in spring to δ_2.



(1) just after the sack falls on the platform

$d = \delta_2 - \delta_1$

(2) after the system comes to rest.

At position (1), the scale reads zero.
So at position (2), the scale will read $F_2 - W_B$,
where $F_2 = k\delta_2$.

Apply work energy theorem between positions (1) and (2)

$$U_{1-2} = T_2 - T_1$$

$$(W_A + W_B)\,d - \frac{1}{2}k(\delta_2^2 - \delta_1^2) = 0.$$

$$(W_A + W_B)(\delta_2 - \delta_1) = \frac{1}{2}k(\delta_2 - \delta_1)(\delta_2 + \delta_1)$$

$$W_A + W_B = \frac{1}{2}(k\delta_2 + k\delta_1) = \frac{1}{2}(F_2 + W_B)$$

So $F_2 = 2W_A + 2W_B - W_B = 2W_A + W_B$.

So maximum reading $= 2W_A + W_B - W_B = 2W_A = 120\,lb$.

15-106

Consider two instants, (1) just before impact and (2) just after impact.

$(V_A)_1 = 5 \text{ m/s}$

$(V_A)_2 = 2.5 \text{ m/s}$

Momentum is conserved due to the absence of external impulsive forces.

(1) – (2) Conservation of momentum

$$(P_x)_1 = (P_x)_2$$

$$M_A (V_A)_1 = -M_A (V_A)_2 + M_B (V_B)_2$$

$$.25 \times 5 = -.25 \times 2.5 + 1.25 \times (V_B)_2$$

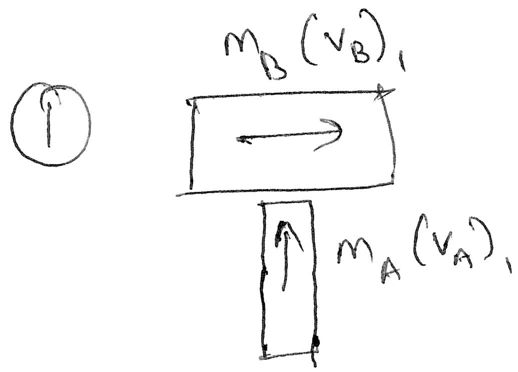
$$\Rightarrow (V_B)_2 = 1.5 \text{ m/s}$$

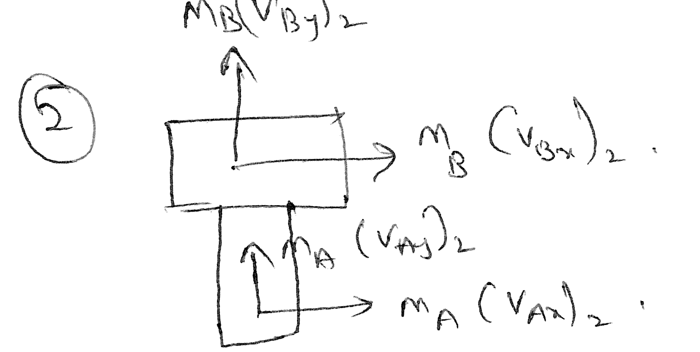
Coefficient of restitution $= e$.

$$e = \frac{(V_B)_2 - (-V_A)_2}{(V_A)_1 - 0} = \frac{(V_B)_2 + (V_A)_2}{(V_A)_1}$$

$$= \frac{1.5 + 2.5}{5} = 0.8$$

15.110





There are no external forces along x direction.
So momentum is conserved along x direction.

so for Car A, $(V_{Ax})_2 = (V_{Ax})_1 = 0$.

for Car B, $(V_{Bx})_2 = (V_{Bx})_1 = 20$ ft/s.

Along y direction, there are no forces external to the system. So momentum is conserved along y direction.

$$m_A (v_A)_1 = m_A (v_{Ay})_2 + m_B (v_{By})_2$$

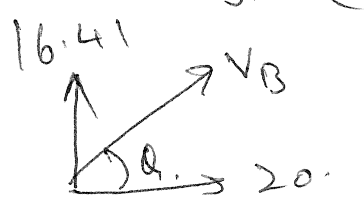
$$\frac{2800}{g}(30) = \frac{2800}{g}(v_{Ay})_2 + \frac{3600}{g}(v_{By})_2$$

So $28 (v_{Ay})_2 + 36 (v_{By})_2 = 840$.

$$\frac{(v_{By})_2 - (v_{Ay})_2}{(v_A)_1} = e = .25$$

$$(v_{By})_2 - (v_{Ay})_2 = 7.5$$

Solving, $(v_{By})_2 = 16.41$ ft/s, $(v_{Ay})_2 = 8.91$ ft/s



$v_B = 25.87$ ft/s.

$\theta = 39.36°$.