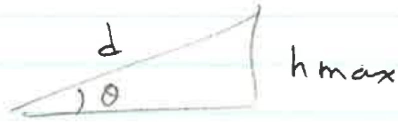
1.

a) $E_i = \frac{1}{2} k x^2$

$E_f = m g h_{max}$

$E_i = E_f \Rightarrow \boxed{h_{max} = \dfrac{k x^2}{2mg}}$

b) $E_i = \frac{1}{2} k x^2$



$E_f = m g h_{max} + f d$

$f = \mu_k N$

$= \mu_k m g \cos\theta$

$d = \dfrac{h_{max}}{\sin\theta}$

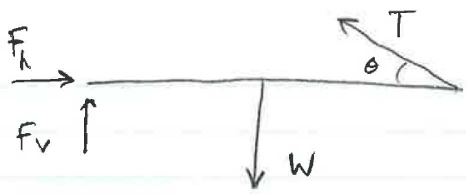
$\Rightarrow \frac{1}{2} k x^2 = m g h_{max} + \mu_k m g \cos\theta \dfrac{h_{max}}{\sin\theta}$

$= \left(1 + \dfrac{\mu_k}{\tan\theta}\right) m g h_{max}$

$\Rightarrow \boxed{h_{max} = \dfrac{k x^2}{2mg\left(1 + \mu_k/\tan\theta\right)}}$

2.

Forces on rod:



$\Sigma F_x = F_h - T\cos\theta = 0$

$$\Sigma F_y = T\sin\theta + F_v - W = 0$$

$$\Sigma \tau = -W\frac{L}{2} + T\sin\theta\, L = 0. \quad \text{(Hinge as pivot point.)}$$

(a) $\boxed{T = \dfrac{W}{2\sin\theta}}$

(b) $F_h = T\cos\theta \boxed{= \dfrac{W}{2\tan\theta}}$

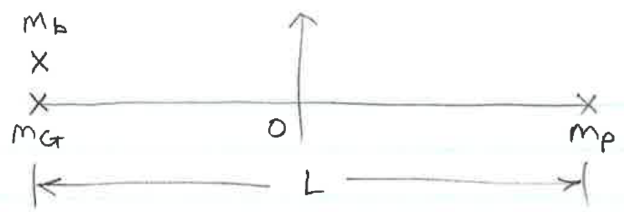
(c) $F_v = W - T\sin\theta = W - \dfrac{W}{2} = \boxed{\dfrac{W}{2}}$

(d) $\tau_{net} = W\dfrac{L}{2} = I\alpha = \left(\dfrac{1}{12}ML^2 + M\left(\dfrac{L}{2}\right)^2\right)\alpha$

$= \dfrac{1}{3}ML^2\alpha$

$\Rightarrow \boxed{\alpha = \dfrac{3g}{2L}}$

3.



$L = 3$ m

$m_G = 80.0$ kg

$m_p = 70.0$ kg

$m_b = 5.00$ kg

a) $$x_{com} = \frac{m_b(-L/2) + m_G(-L/2) + m_p(L/2)}{m_b + m_G + m_p}$$

$$= \frac{70 - 80 - 5}{70 + 80 + 5}(1.5\,m) = -.145\,m$$

$\boxed{\text{or } 14.5\,cm \text{ to left of center.}}$

b) Momentum of Glenn + ball is conserved:

$$p_i = p_f \Rightarrow 0 = m_G V_G + m_b V_b$$

$$\Rightarrow V_G = -\frac{m_b}{m_G} V_b$$

$$\boxed{= -.188\,m/s}$$

c) Glenn, Bob, & ball are an isolated system. Thus, the center mass remains stationary even if they are moving.

$\boxed{X_{cm} = -.145\,m \text{ like before}}$

d) $p_i = m_b V_b = p_f = (m_p + m_b)V \Rightarrow V = \frac{m_b V_b}{m_b + m_p} = \boxed{.2\,m/s}$

4.

$$p_i = mv = p_f = (M+m)V$$

$$V = \frac{m}{M+m}v$$

This K.E. is converted to P.E. of spring:

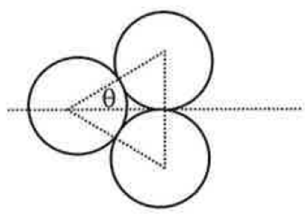
$$\frac{1}{2}(M+m)V^2 = \frac{1}{2}kx^2$$

$$\frac{1}{2}(M+m)\frac{m^2}{(M+m)^2}v^2 = \frac{1}{2}kx^2$$

$$\Rightarrow \boxed{x = \frac{mv}{\sqrt{k(M+m)}}}$$

5.

When the balls make contact with each other, it looks like this



The lines joining their centers make an equilateral triangle. Thus $\theta = 30°$. The balls will move away along these lines. Let v be the velocity of the incoming ball. Let v_1 be the final velocity of the incoming ball. Since the problem is symmetric, the velocities of the stationary balls will be equal. Let that velocity be v_2 Conservation of linear momentum in both the x and y directions will require:

$$p_{xi} = p_{xf} \Rightarrow mv = mv_2\cos\theta + mv_2\cos\theta + mv_1$$

$$p_{yi} = p_{yf} \Rightarrow 0 = mv_2\sin\theta + mv_2\sin\theta$$

Conservation of kinetic energy will also require:

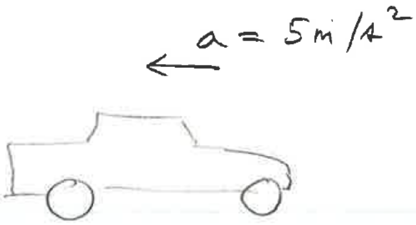
$$\frac{1}{2}mv^2 = \frac{1}{2}mv_2^2 + \frac{1}{2}mv_2^2 + \frac{1}{2}mv_1^2$$

Solving these equations we get:

$$v = -\frac{v}{5};\quad v_2 = \frac{2\sqrt{3}}{5}v$$

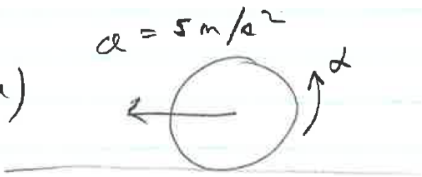
6.

5



$M = 1500\,kg$ ≡ mass of car.
$m = 50\,kg$ ≡ mass of wheel
$r = .30\,m$ ≡ radius of wheel.

a)



rolling w/o slipping: $-a = \alpha r$

$$\tau_{net} = I\alpha = \frac{1}{2}mr^2\left(\frac{-a}{r}\right) = \frac{-mra}{2}$$

$$\boxed{= -37.5\ Nm}$$

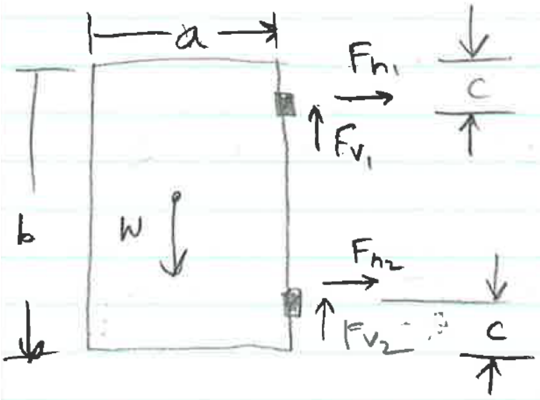
b) friction force is responsible for slowing car down:

$$-4f = -Ma \Rightarrow f = 1875\ N \text{ on each wheel.}$$

$$\tau_{net} = -fr + \tau_{axle}$$

$$\Rightarrow \tau_{axle} = \tau_{net} + fr = \boxed{600\ N\cdot m}$$

7.



$$F_{v_1} = F_{v_2} = \frac{W}{2} = \frac{mg}{2} = \boxed{147N}$$

$$\Sigma F_x = F_{h_1} + F_{h_2} = 0 \Rightarrow F_{h_1} = -F_{h_2}$$

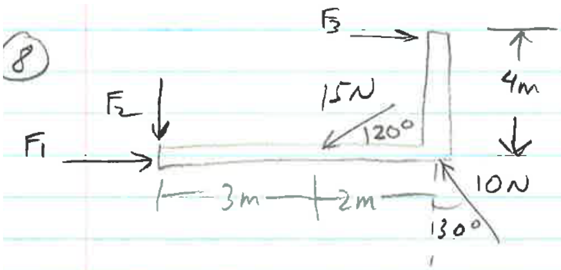
Choose bottom hinge as pivot:

$$\Sigma \tau = W\frac{a}{2} - F_{h_1}(b-2c) = 0$$

$$F_{h_1} = \frac{mg\,(1.0m/2)}{(2.0m - .50m)} = \boxed{98N \text{ (to right)}}$$

$$\boxed{F_{h_2} = -98N \text{ (to left)}}$$

8.



$$\Sigma F_x = F_1 - 15N\cos 20° - 10N\sin 30° + F_3 = 0$$

$$\Sigma F_y = -F_2 - 15N\sin 20° + 10N\cos 30° = 0$$

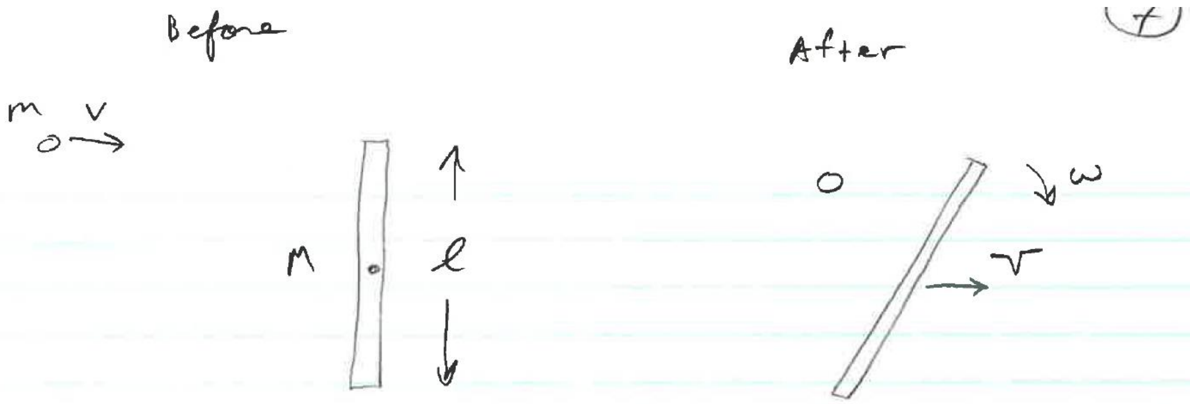
$$F_2 = -15N\sin 20° + 10N\cos 30° = \boxed{3.5\,N}$$

$$\Sigma\tau = -15N(3m)\sin 20° + 10N(5m)\cos 30° - F_3(4m) = 0$$

$$\boxed{F_3 = 7.0N}$$

$$\Rightarrow \quad \boxed{F_1 = 12.1\,N}$$

9.

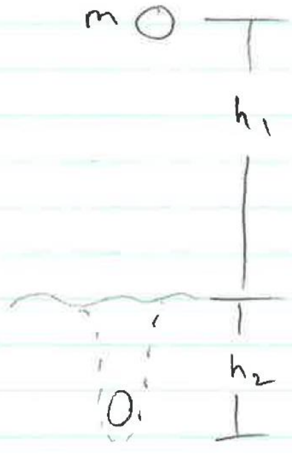


$$P_i = P_f$$
$$mv = MV \quad \Rightarrow \quad \boxed{V = \frac{m}{M} v}$$

$$L_i = L_f$$
$$mv\frac{\ell}{2} = I\omega \quad \Rightarrow \quad \omega = \frac{mv\ell}{2I} = \frac{mv\ell}{2(\frac{1}{12}M\ell^2)}$$

$$\boxed{= 6\frac{m}{M}\frac{v}{\ell}}$$

10.



$$W_{nonc} = \Delta E$$

$$W_{sand} = \Delta K + \Delta U = \Delta U = 0 - mg(h_1+h_2)$$

a) $W_{sand} = \boxed{-mg(h_1+h_2)}$

b) $W_{sand} = -f_s \cdot h_2 = -mg(h_1+h_2)$

$$\Rightarrow f_s = mg\frac{(h_1+h_2)}{h_2}$$

$$f_s - mg = ma$$

$$\Rightarrow a = \frac{f_s - mg}{m} = \frac{g(h_1+h_2)}{h_2} - g$$

$$\boxed{= g\frac{h_1}{h_2}}$$