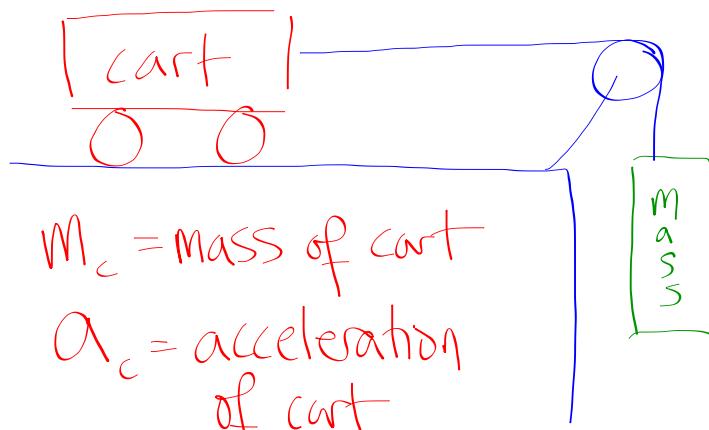


Test: Friday not Wednesday

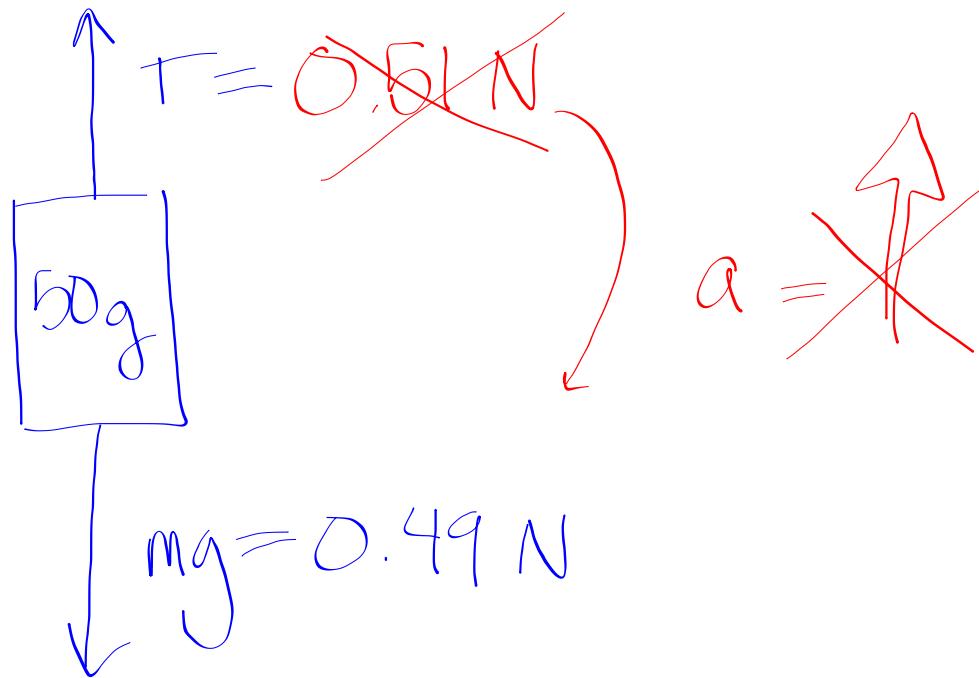
Lab: Turn in what you have now (if not already done)

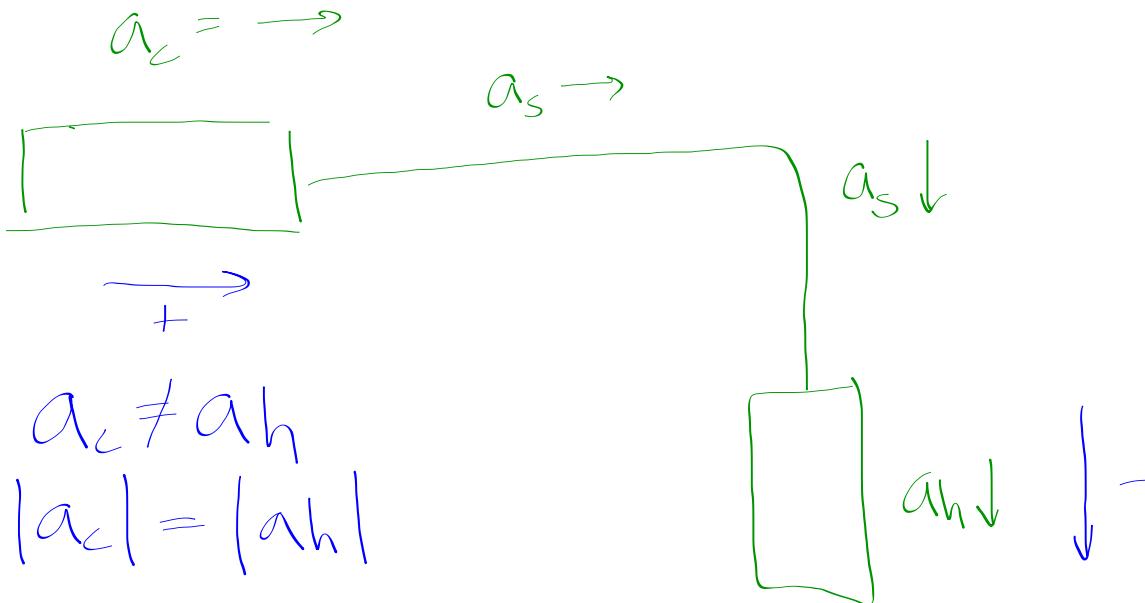


M_c = mass of cart
 a_c = acceleration of cart

m_h = mass of hanging mass
 a_h = acceleration of hanging mass

- ① Draw FBD for cart & mass
 g = acceleration due to gravity
- ② Use Newton's 2nd to solve for T for both cart & mass
 F_{Fr} = force of friction on cart
 T = tension in the string
- ③ Mathematical relationship between a_c and a_h





$$a_c \neq a_h$$

$$|a_c| = |a_h|$$

$$a_c = -a_h; a_h = -a_c$$

$$\sum F_c = m_c a_c$$

$$-F_{Fr} + T = m_c a_c$$

$$T = m_c a_c + F_{Fr}$$

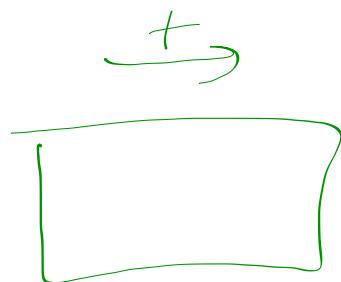
$$\sum F_h = m_h a_h$$

$$T - m_h g = m_h a_h$$

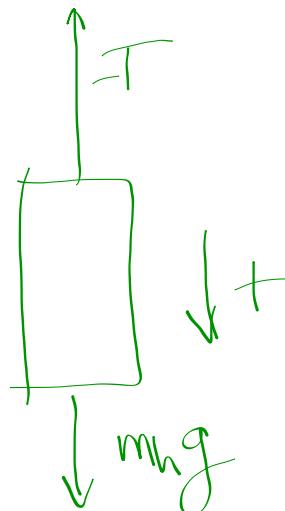
$$T = m_h a_h + m_h g$$

$$T = m_h (-a_c) + m_h g$$

$$T = m_h g - m_h a_c$$



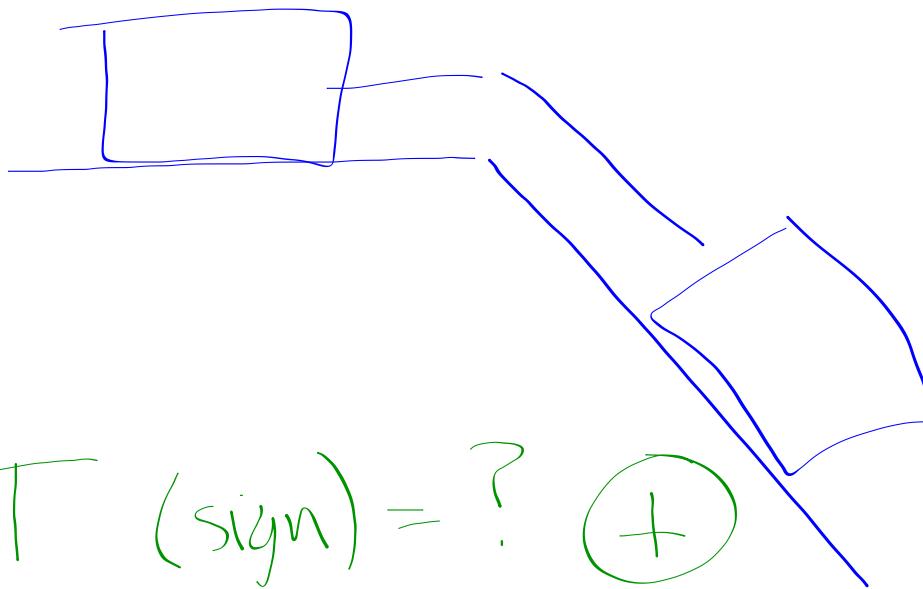
$$a_c = a_h = a$$



$$-F_f + T = m_c a$$

$$T = m_c a + F_f$$

$$\begin{aligned} -T + m_h g &= m_h a \\ T &= m_h g - m_h a \end{aligned}$$



T (sign) = ? +

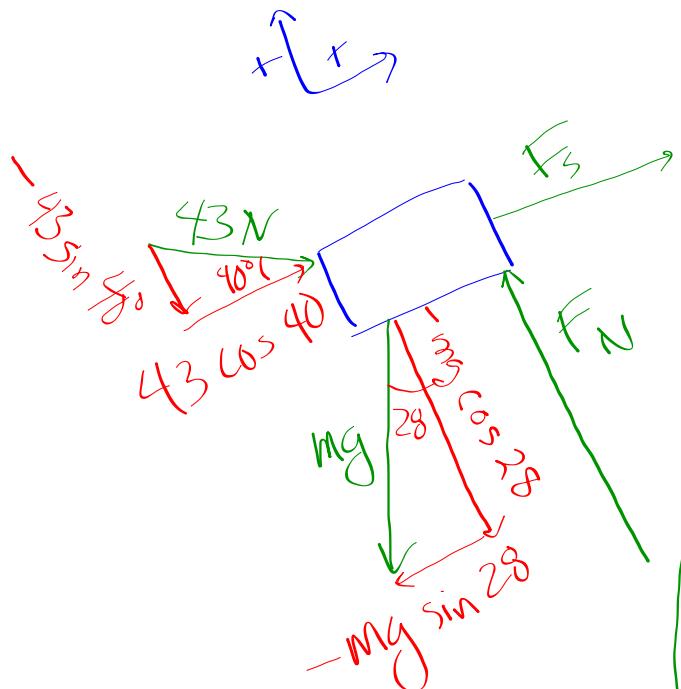
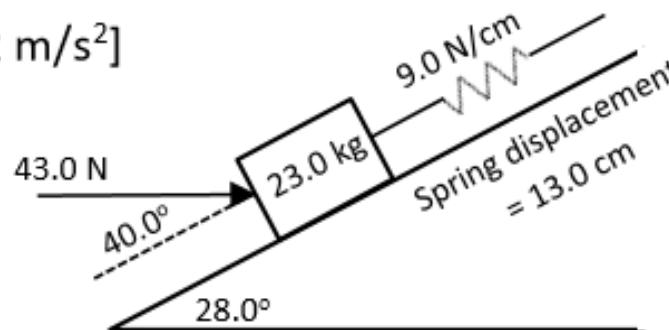
F_{Fr} (sign) = ? +

~~$T = 5N$~~

~~$F_{Fr} = 2.6N$~~

$$-F_{Fr} = -2.6N$$

13. Find the acceleration of the mass. [$a = 1.92 \text{ m/s}^2$]



$$F_s = kx \\ = (9)(13) = 117$$

$$\sum F_x = ma_x$$

$$43 \cos 40 - mg \sin 28 + F_s = ma_x \\ 43 \cos 40 - (23)(9.8) \sin 28 + F_s = a_x$$

$$a_x = 1.92 \text{ m/s}^2$$

(15)

Diagram shows a circular object with a tension force $T = 122 \text{ N}$ acting vertically downwards. Two springs are attached to the top edge: one to the left with stiffness 23.0 N/cm and one to the right with stiffness 30.0 N/cm . The left spring is at an angle of 32.0° from the vertical, and the right spring is at an angle of 51.0° from the vertical. A coordinate system is shown at the center of the circle.

$\sum F_x = M a_x = 0$

$$-F_1 \cos 32 + F_2 \cos 51 = 0$$

$\sum F_y = M a_y = 0$

$$F_1 \sin 32 + F_2 \sin 51 - 122 = 0$$

$\sum F = 0$

$$T - mg = 0$$

$$T = mg = 122 \text{ N}$$

$$F_1 = \frac{F_2 \cos 51}{\cos 32}$$

$$F_1 = \frac{122 - F_2 \sin 51}{\sin 32}$$

$$\frac{F_2 \cos 51}{\cos 32} = \frac{122 - F_2 \sin 51}{\sin 32}$$

$$F_2 (\cos 51)(\sin 32) = 122(\cos 32) - F_2 (\sin 51) \cos 32$$

$$F_2 [(\cos 51)(\sin 32) + (\sin 51)(\cos 32)] = 122(\cos 32)$$

$$F_2 = \frac{122 \cos 32}{[(\cos 51)(\sin 32) + (\sin 51)(\cos 32)]}$$

$$F_2 = \frac{103.46}{0.333 + 0.667} = 104.3 \text{ N}$$

$$F_1 = \frac{F_2 \cos 51}{\cos 32} = \frac{(104.3)(\cos 51)}{\cos 32} = 77.4 \text{ N}$$

Diagram shows the same setup but without the central mass. The left spring has stiffness 23.0 N/cm and the right spring has stiffness 30.0 N/cm . The left spring is at an angle of 32.0° and the right spring is at an angle of 51.0° .

$F_1 = k_1 x_1$

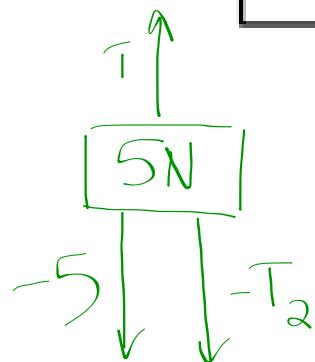
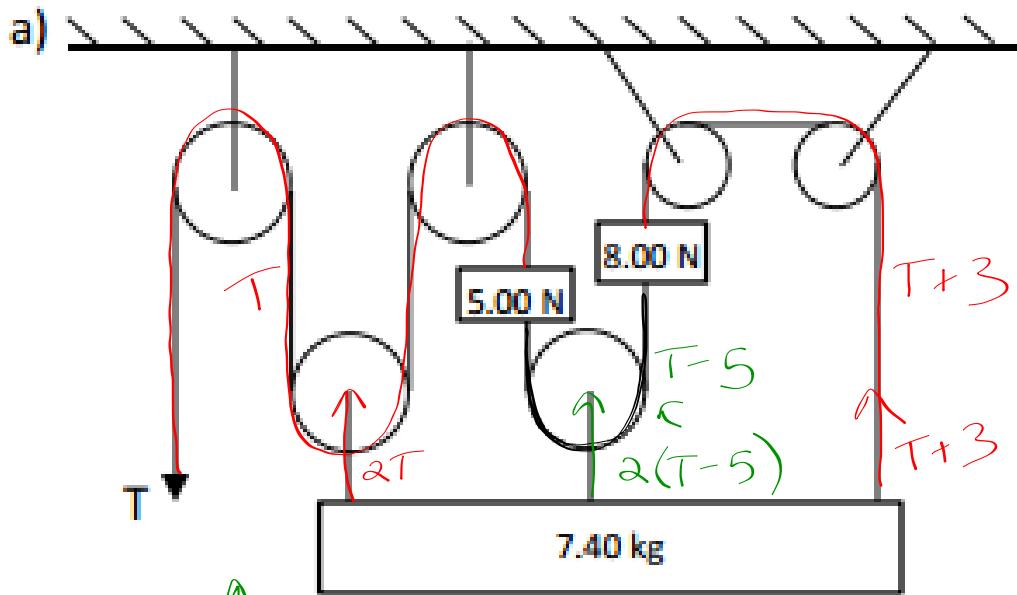
$$77.4 = 23 \text{ N/cm}(x_1)$$

$$x_1 = 3.37 \text{ cm}$$

$F_2 = k_2 x_2$

$$104.3 = 30 \text{ N/cm} x_2$$

$$x_2 = 3.48 \text{ cm}$$



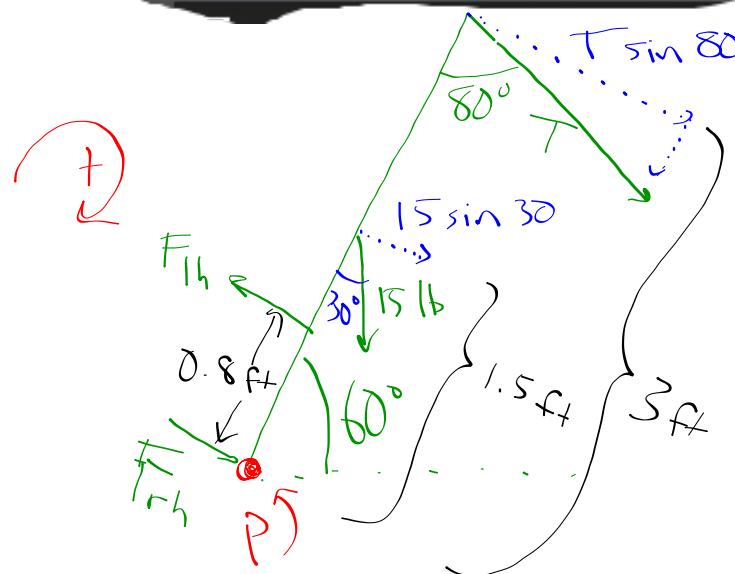
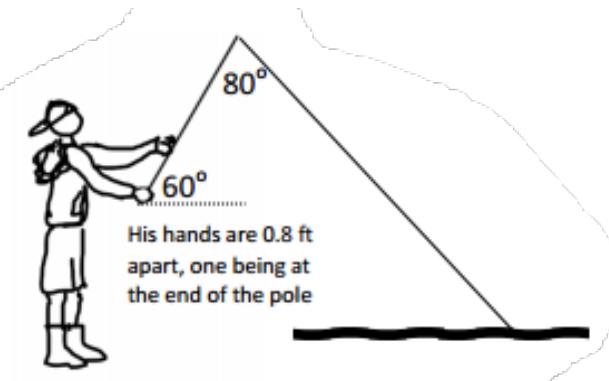
$$\sum F = 0$$

$$T - 5 - T_2 = 0$$

$$T_2 = T - 5$$

$$\begin{aligned} \sum F &= 0 \\ -8 - (T-5) + T_3 &= 0 \\ T_3 &= T-3 \end{aligned}$$

11. Cole LaDrinque snags a big one, which exerts a 30.0 pound tension in his line. What force must he apply (perpendicular to the pole) with the upper hand to support his 15.0-lb, 3.00-ft long pole as well as the fish? (Cole holds the pole at 60.0 degrees to the horizontal). [F = 125 lb]

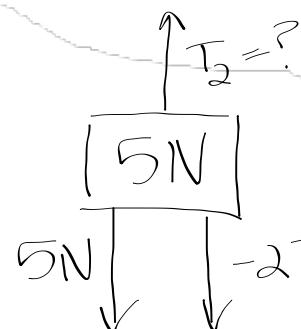
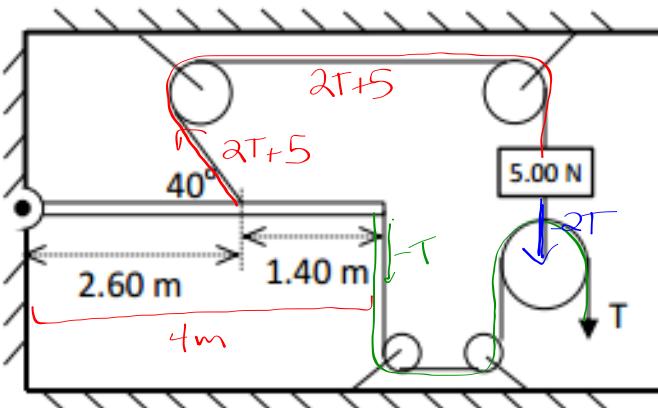


$$\sum T = 0$$

$$(F_m)(0) - (F_{Lh})(0.8) + (15 \sin 30)(1.5) + (T \sin 80)(3) = 0$$

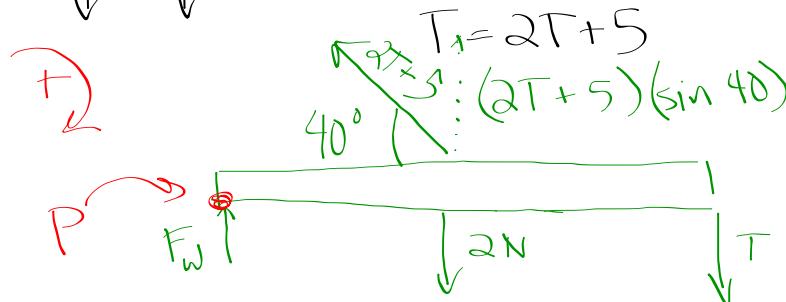
8. Find the tension in the string. [0.588 N]

Uniform bar with mass of 2.00 N



$$\sum F = \emptyset$$

$$-5N + -2T + T_2 = 0$$



$$\sum \tau = \emptyset$$

$$(F_w)(\emptyset) + -(2T + 5)(\sin 40)(2.6) + (2)(2) + T(4) = \emptyset$$

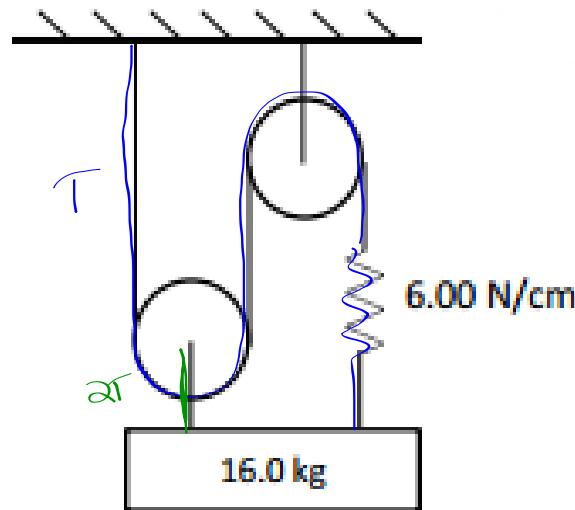
$$-2T(\sin 40)(2.6) - 5(\sin 40)(2.6) + 4 + 4T = \emptyset$$

12. Find the stretch in each spring:

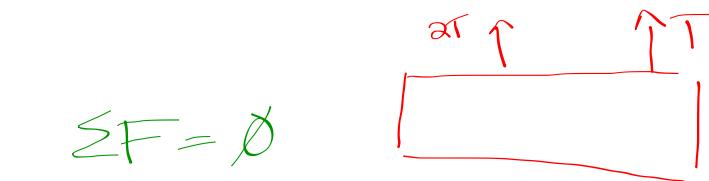
[Answers: a) $x = 8.71 \text{ cm}$; b) $x = 3.33 \text{ cm}$]

$$\begin{aligned} T &= F_S \\ F_S &= kx \\ 52.27 &= (6 \text{ N/cm})x \\ x &= 8.71 \text{ cm} \end{aligned}$$

a)



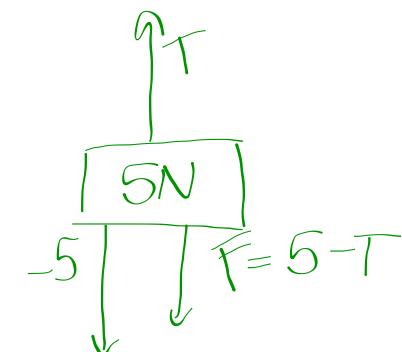
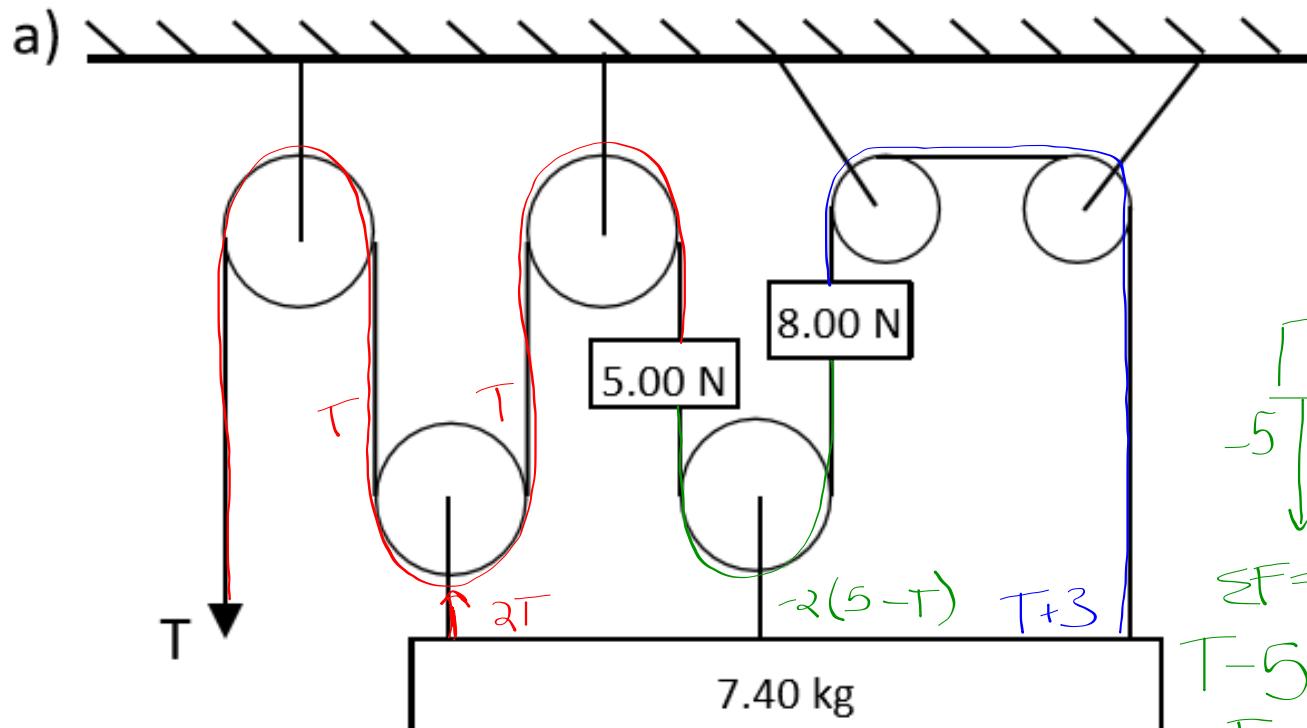
$$\sum F = \emptyset$$



$$2T + T - mg = \emptyset$$

$$3T = (16)(9.8)$$

$$T = 52.27 \text{ N}$$



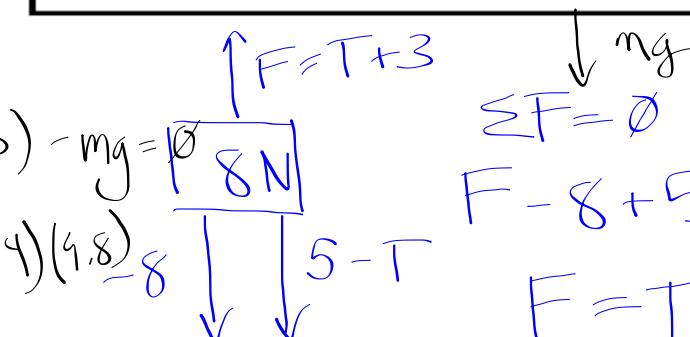
$$\begin{aligned}\sum F &= \emptyset \\ T - 5 + F &= \emptyset \\ F &= 5 - T\end{aligned}$$

$$\sum F = \emptyset$$

$$2T + -2(5-T) + (T+3) - mg = \emptyset$$

$$5T = 10 - 3 + (7.4)(9.8)$$

$$T = 15.9 \text{ N}$$



$$\sum F = \emptyset$$

$$F - 8 + 5 - T = \emptyset$$

$$F = T + 3$$

$$-42.84 + \frac{12.35 \cos \theta}{\sin \theta} = 0$$

$$\frac{12.35 \cos \theta}{\sin \theta} = 42.84$$

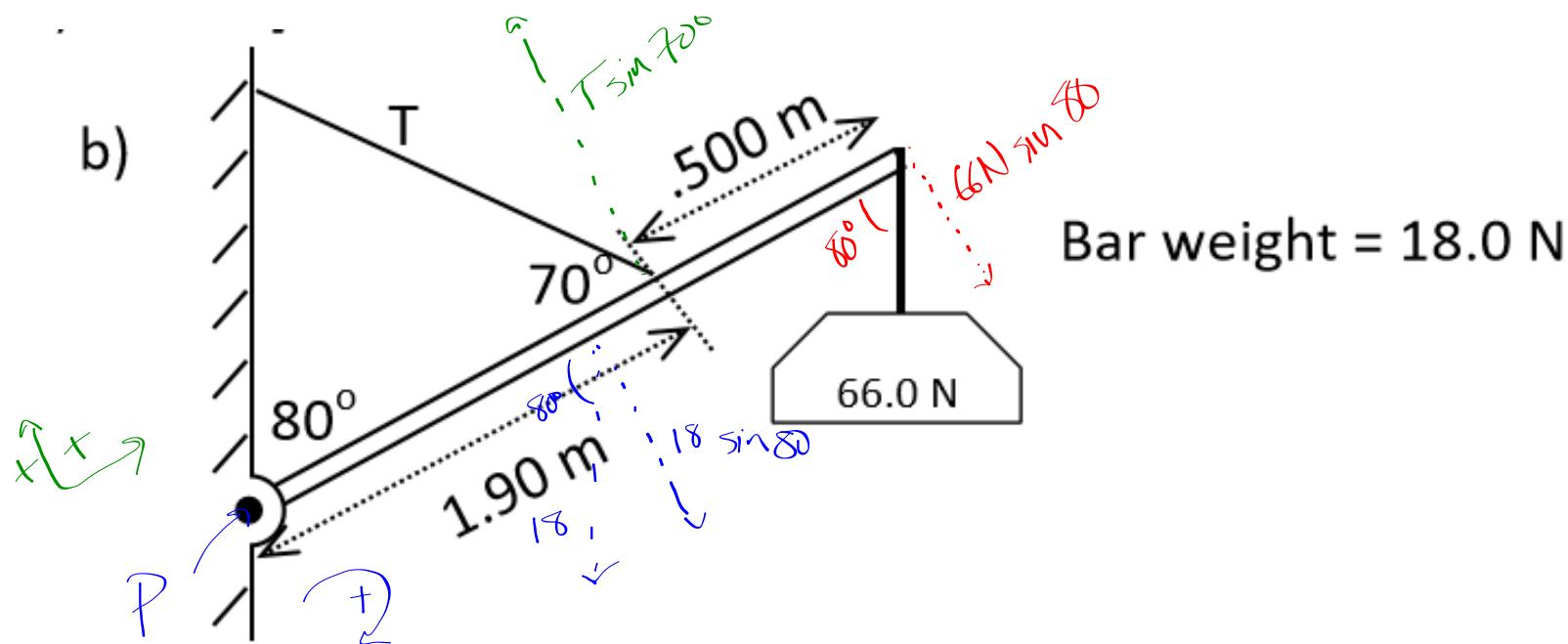
$$\frac{\cos \theta}{\sin \theta} = 3.5$$

$$\frac{\sin \theta}{\cos \theta} = \frac{1}{3.5} = 0.286 = \tan \theta$$

$$\theta = \tan^{-1} 0.286 = \boxed{15.9^\circ}$$

$$\frac{\frac{\theta}{h}}{\frac{a}{h}} = \frac{\theta}{a}$$

$$\frac{\sin \theta}{\cos \theta} = \tan \theta$$



$$\sum \tau = 0$$

$$(18 \sin 80) \left(\frac{1.9 + .5}{2} \right) - T \sin 70 (1.9) + (66 \sin 80)(2.4) = 0$$

① Draw a FBD (clear, labeled drawings)

Show frame of reference

Break forces into components

② Apply Newton's 2nd Law

$\sum F_x = ma_x$

$\sum F_y = ma_y$

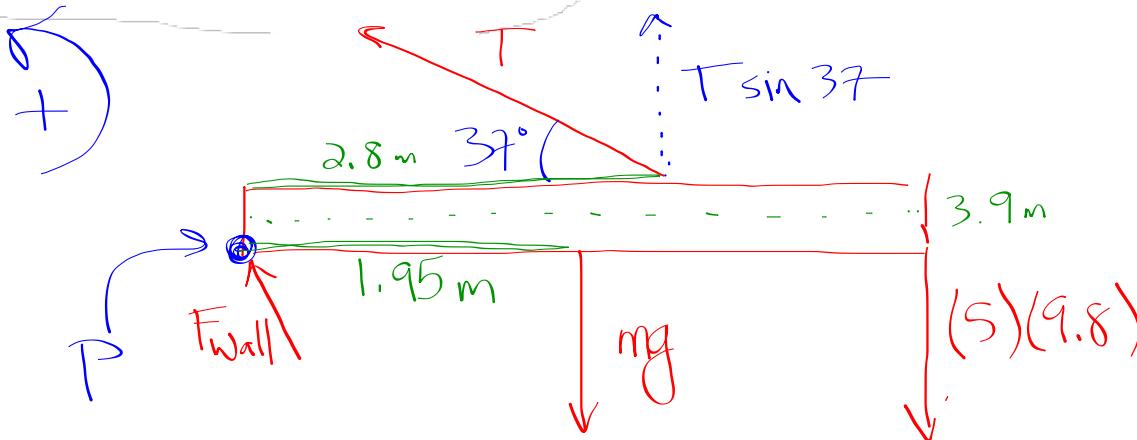
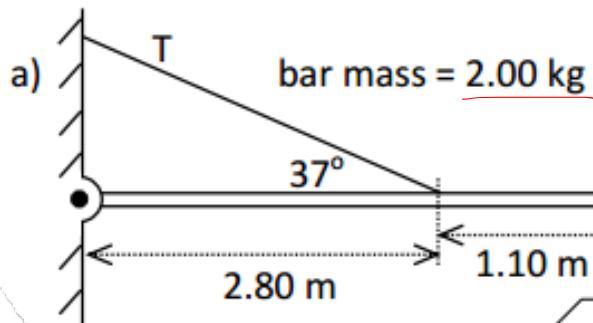
$\sum \tau = \emptyset$

Show me formulas!

Show me initial substitutions!

... Use additional equations as needed

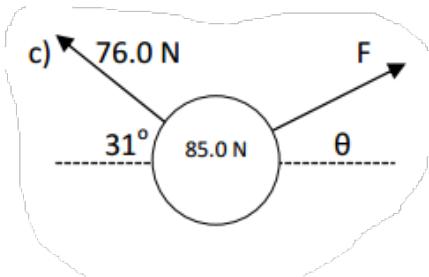
7. Find the tensions T in each case. [a) 136 N; b) 99.3 N]



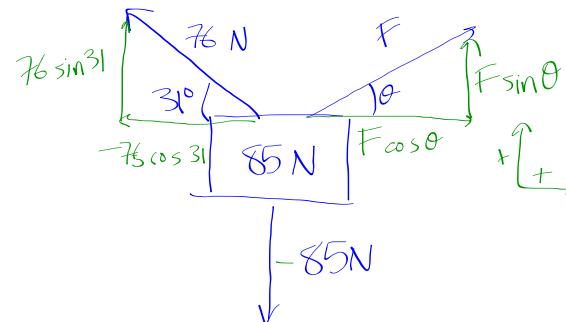
$$\sum T = \emptyset$$

$$F_{\text{wall}}(\emptyset) + -(mg)(1.95) + T(\sin 37)(2.8) + -(5)(9.8)(3.9) = \emptyset$$

$$T = \frac{(2)(9.8)(1.95) + (5)(9.8)(3.9)}{(\sin 37)(2.8)} = 136 \text{ N}$$



$$\sum F_x = Ma_x = 0$$



$$-76 \cos 31 + F \cos \theta = 0 \rightarrow F = \frac{76 \cos 31}{\cos \theta}$$

$$76 \sin 31 + F \sin \theta - 85 = 0 \rightarrow F = \frac{85 - 76 \sin 31}{\sin \theta}$$

$$\frac{76 \cos 31}{\cos \theta} = \frac{85 - 76 \sin 31}{\sin \theta}$$

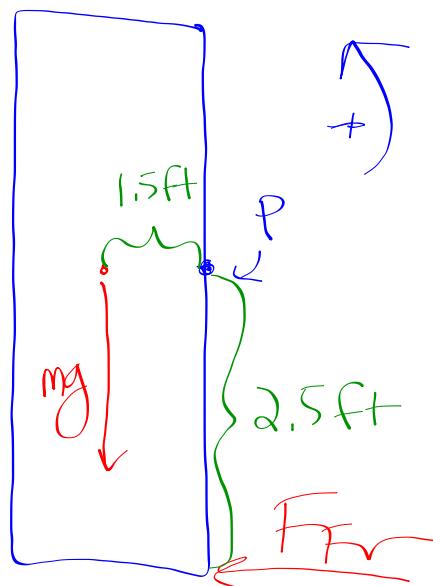
$$\frac{\sin \theta}{\cos \theta} = \frac{85 - 76 \sin 31}{76 \cos 31} = \frac{45.86}{65.14}$$

$$\tan \theta = 0.704$$

$$\theta = \tan^{-1} 0.704 = 35.1^\circ$$

$$F = \frac{76 \cos 31}{\cos \theta} = \frac{65.14}{\cos 35.1} = 79.62 \text{ N}$$

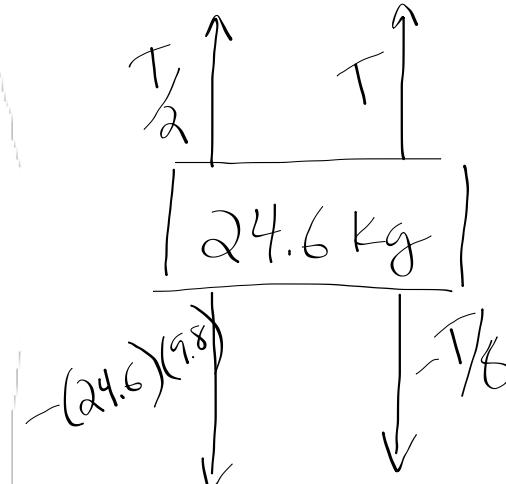
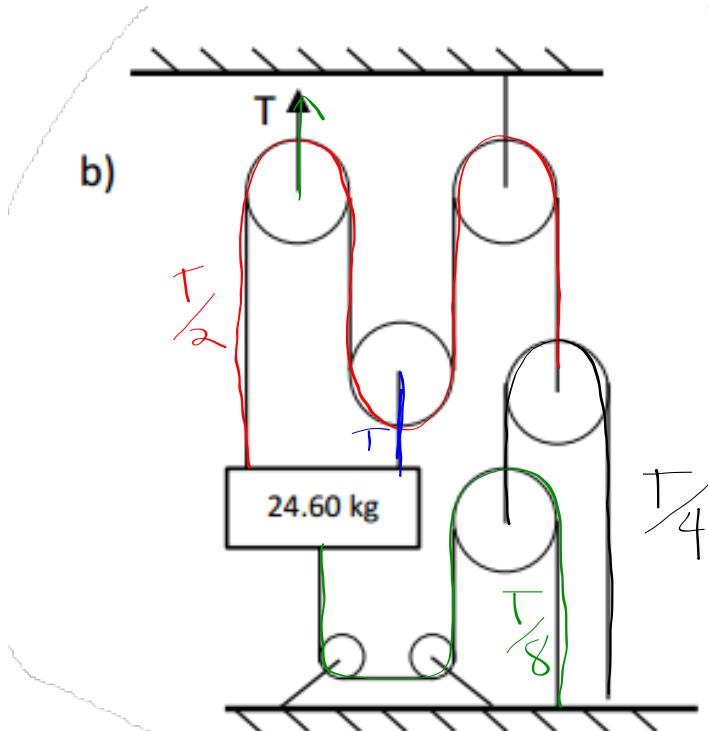
24. A 94 lb crate, 3.0-feet wide and 5.0 feet high, ~~cruises serenely across a frictionless icy surface~~. When it strikes a ~~frictional region~~, it tips over. What is the minimum μ that will tip it? (Think rotation). [.60]



$$\sum \tau = \emptyset$$

$$(mg)1.5 - (F_{Fr})2.5 = \emptyset$$

$$F_{Fr} = \mu F_N$$



$$\sum F = \emptyset$$

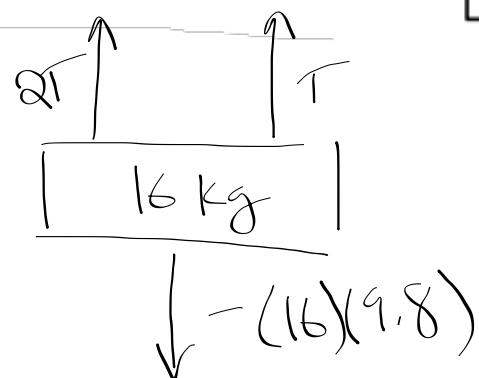
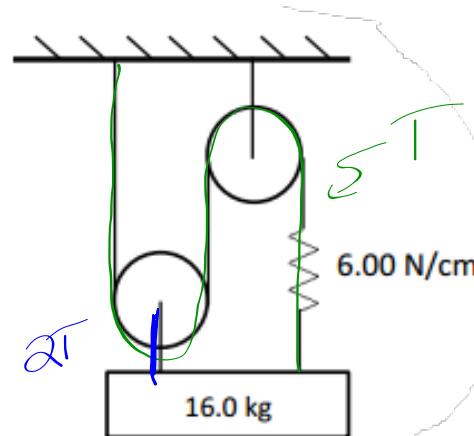
$$\frac{T}{2} + T - \frac{T}{8} - (24.6)(9.8) = \emptyset$$

$$\frac{1}{8}T = (24.6)(9.8)$$

$$T = 1753 \text{ N}$$

12. Find the stretch in each spring: a)

[Answers: a) $x = 8.71 \text{ cm}$; b) $x = 3.33 \text{ cm}$]



$$\sum F = 0$$

$$T = \frac{(16.0)(9.8)}{3} = 52.27 \text{ N}$$

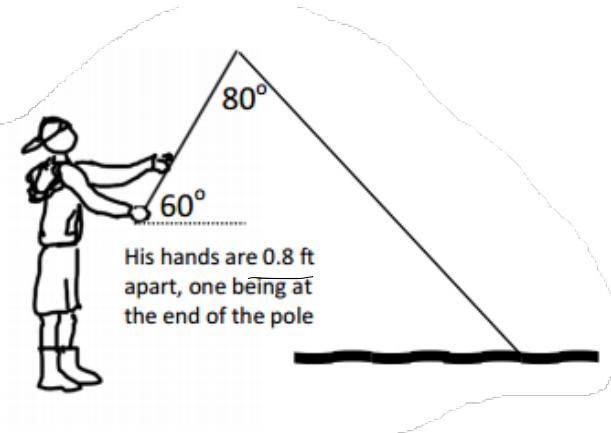
$$F_s = kx$$

$$52.27 = 6 \text{ N/cm} \cdot x$$

$$x = 8.71 \text{ cm}$$

$$52.27 \text{ N}$$

11. Cole LaDrinque snags a big one, which exerts a 30.0 pound tension in his line. What force must he apply (perpendicular to the pole) with the upper hand to support his 15.0-lb, 3.00-ft long pole as well as the fish? (Cole holds the pole at 60.0 degrees to the horizontal). [F = 125 lb]



Free body diagram of the pole:

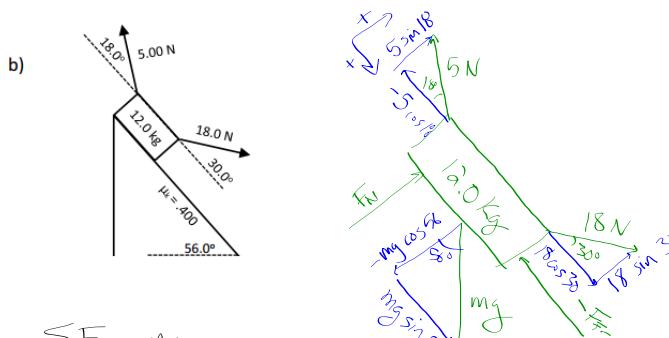
- Vertical force F (tension in the line)
- Horizontal force F_{RH} (applied by the right hand)
- Weight mg acting downwards
- Normal force F_{LH} (applied by the left hand)
- Friction force f_x (parallel to the pole)
- Reaction force $1.5f_x$ (normal to the pole)
- Angle 60° between the pole and the horizontal
- Angle 80° between the pole and the vertical
- Angle 30° between the vertical and the reaction force
- Angle 10° between the vertical and the friction force

$\sum T = \emptyset$

$$\emptyset = (F_{LH})(0.8) - mg(\cos 60)(1.5) - T(\cos 10)(3)$$

$$F_{LH} = \frac{(15)(\cos 60)(1.5) + (30)(\cos 10)(3)}{0.8}$$

$$= 124.9 \text{ lb}$$



$$\sum F_x = m a_x$$

$$-5 \cos 18 - F_{Fr} + mg \sin 56 + 18 \cos 30 = m a_x$$

$$\sum F_y = m a_y = 0$$

$$5 \sin 18 + 18 \sin 30 + F_N - mg \cos 56 = 0$$

$$F_N = 55.22 \text{ N}$$

$$F_{Fr} = \mu F_N = (0.4)(55.22)$$

$$= 22.1 \text{ N}$$

$$\frac{-4.76 - 22.1 + 97.5 + 15.59}{12} = a_x$$

$$a = 7.19 \text{ m/s}^2$$

$$x_0 = 0$$

$$x = 48$$

$$v_0 = 0$$

$$v = 26.27 \text{ m/s}$$

$$a = 7.19$$

$$t = 3.65 \text{ s}$$

$$v^2 = v_0^2 + 2a(\Delta x)$$

$$v = \sqrt{2(7.19)(48)} = 26.27 \text{ m/s}$$

$$v = v_0 + at$$

$$26.27 = (7.19)t$$

$$t = 3.65 \text{ s}$$

