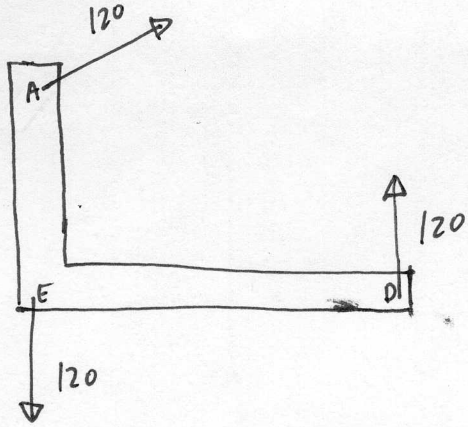
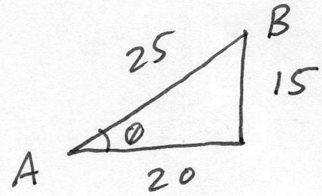
Problem 1

(A)





3-4-5 triangle

$\cos\theta = \frac{20}{25} = \frac{4}{5}$

$\sin\theta = \frac{15}{25} = \frac{3}{5}$

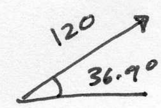
$\Sigma F_y \neq 0$! $\quad \Sigma F_y = 120 - 120 + 120\left(\frac{3}{5}\right) = 72$ lb

$\Sigma F_x = 120\left(\frac{4}{5}\right) = 96$ lb.

So: $\boxed{F_{resultant} = 96\hat{i} + 72\hat{j} \text{ lbs}}$

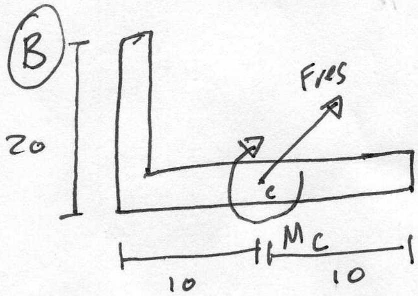
OR

$\boxed{120 \text{ lbs acting at } 36.9^\circ}$



Alternatively, you could see that the cable tension cancels the downward force @ E. So w/o calculation, the resultant is the cable tension @ A, acting @ same angle.

(B)



To find the couple M_c:

$$\circlearrowleft + \ \Sigma M_c = F_E(20) - F_A(20)(\cos\theta) - F_A(10).$$

$$= F_E\, 20 - F_A\, 20\left(\tfrac{4}{5}\right) - F_A\, 10\left(\tfrac{3}{5}\right)$$

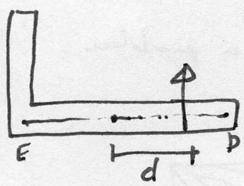
$$= 120(20) - 120(20)\left(\tfrac{4}{5}\right) - 120(10)\left(\tfrac{3}{5}\right)$$

$$= 2400 - 1920 - 720$$

$$= -240 \text{ lb ft.}$$

Force Couple System: $\boxed{F_{res}: 120 \text{ lb } @\ 36.9^\circ, \quad 240 \text{ lb-ft clockwise.}}$

(1 c) $M_C = F_{res}\, d$ but d is $\perp$ distance to F_{res}. Want d to be along ED, so $F_{res} \sin\phi$ is the the force.



$$M_C = F_{res} \sin\phi \, d$$

$$d = \frac{M_C}{F_{res} \sin\phi}$$

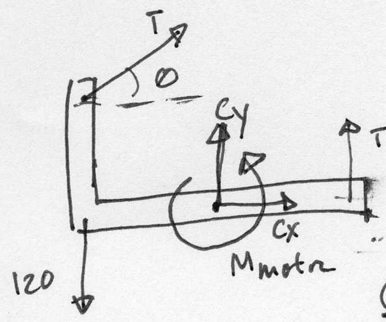
Now, this position of F_{res} must cancel the moment calculated in B.

$$d = \frac{240}{120\left(\frac{3}{5}\right)}$$

$240 \rightarrow$ positive to counteract the prev. momen[t]

$$\boxed{= 3.33 \text{ ft to the right of } C.}$$

(1d)



Take ΣM_C to eliminate unknown reactions.

$$\circlearrowleft + \; \Sigma M_C = 0 = M_{motor} + T(10) + 120(10) - T(\cos\phi)(20) - T(\sin\phi)(10)$$

$$\Sigma M_C = 0 = 2400 \sin 2\pi t + 10T + 1200 - T(16) - T(6)$$

$$12T = 2400 \sin 2\pi t + 1200$$

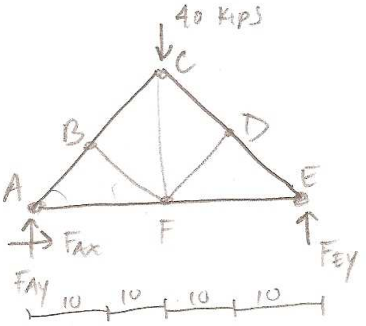
$$\boxed{T = 200 \sin 2\pi t + 100}$$

(1e) (Bonus): The cable tension is negative for a time interval, b[ut] Cables can only operate in tension – this is impossible so the system is not in equilibrium after $t = 7/12$.

Problem 2

A) First solve for the reaction forces at point A and E

FBD:



$$\circlearrowleft + \; \Sigma M_E = (40)(20) - F_{AY}(40) = 0$$

$$F_{AY}(40) = (40)(20)$$

$$F_{AY} = 20 \text{ Kips}$$

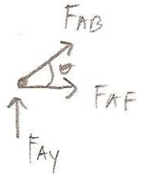
$$\Sigma F_y = F_{AY} + F_{EY} - 40 = 20 + F_{EY} - 40 = 0$$

$$F_{EY} = 20 \text{ Kips}$$

$$\Sigma F_x = F_{AX} = 0$$

Next, use the method of joints to solve for the forces in member CB and CF

Joint A

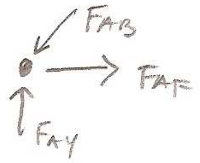


$\theta = 45°$ (given)

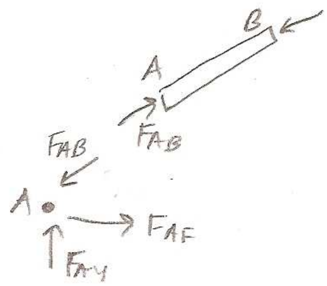
$$\Sigma F_y = F_{AY} + F_{AB}\sin\theta = 0$$

$$F_{AB} = -\frac{F_{AY}}{\sin\theta} = \frac{-20}{\frac{1}{\sqrt{2}}} = -20\sqrt{2}$$

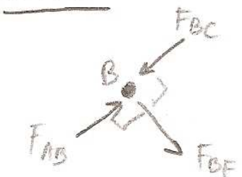
Since $F_{AB} = -20\sqrt{2}$, this implies the assumed direction of F_{AB} at pin A is reversed



Therefore member AB is under compression because of equal & opposite forces

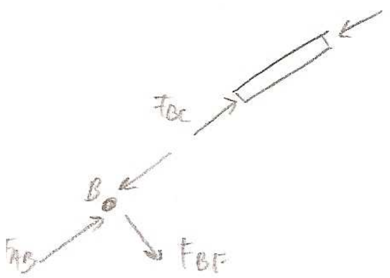


Joint B



We can assume F_{BF} is a zero-force member because member BF is orthogonal (perpendicular) to member AB & BC. This implies that there are no force components acting along member F_{BF}

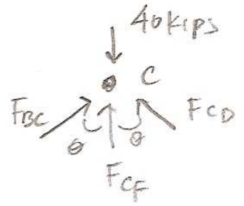
Therefore $|F_{AB}| = |F_{BC}|$



$F_{BC} = 20\sqrt{2}$ kips

member BC is under

Joint C



$F_{BC} = F_{CD}$ due to symmetry. By inspection, F_{CF} will be a zero force member.

You can also solve for F_{CF} and will produce same solution

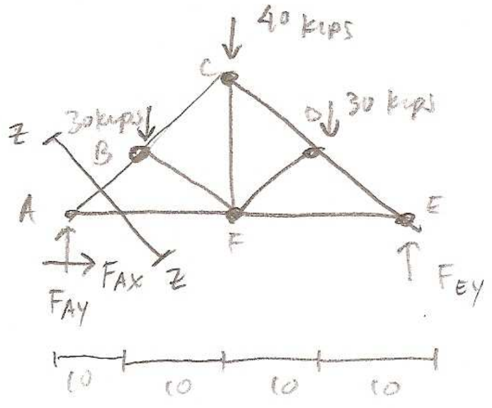
$$|F_{BC}| = |F_{CD}| = 20\sqrt{2}$$

$$\Sigma F_y = F_{BC}\sin\theta + F_{CD}\sin\theta - 40 + F_{CF} = 0$$

$$20\sqrt{2}\left(\tfrac{1}{\sqrt{2}}\right) + 20\sqrt{2}\left(\tfrac{1}{\sqrt{2}}\right) - 40 + F_{CF} = 0$$

$$40 - 40 + F_{CF} = 0$$

B) First, solve for the reaction forces



FBD*

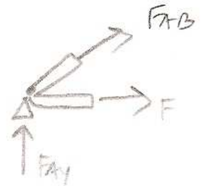
Solve for member AB

$\circlearrowleft^{+} \Sigma M_E = 30(10) + 40(20) + 30(30) - F_{AY}(40) = 0$

$$F_{AY} = \frac{300 + 800 + 900}{40} = 50 \text{ kips}$$

Next, using the method of sections, you can solve for the force in member AB by making the cut (Z-Z) as shown in FBD

Section Z-Z



$\theta = 45°$

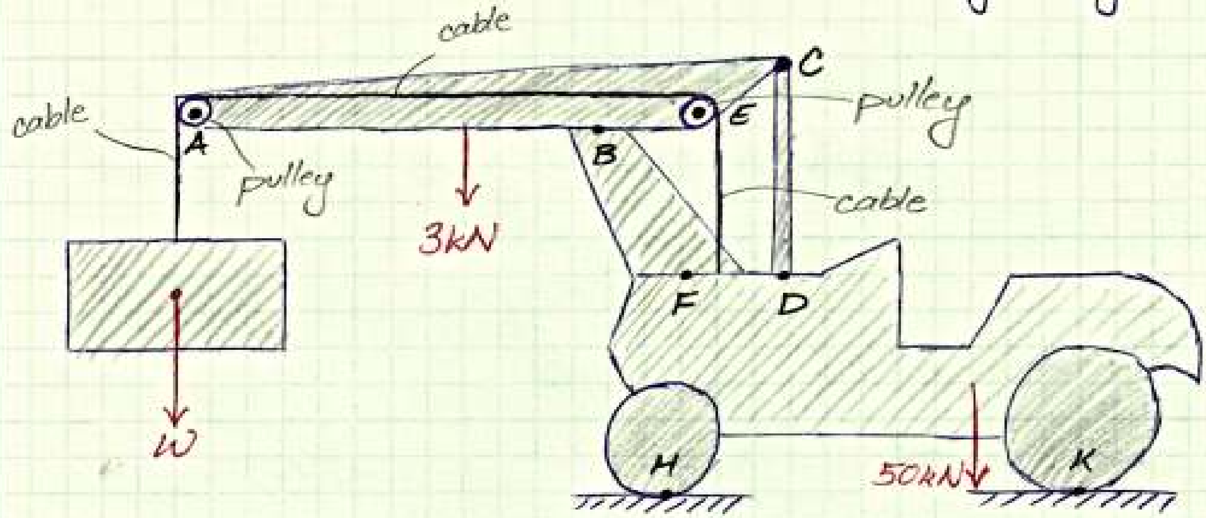
$\Sigma F_y = F_{AB} \sin\theta + F_{Ay} = 0$

$$F_{AB} = -\frac{F_{Ay}}{\sin\theta} = \frac{-50}{\frac{1}{\sqrt{2}}} = -50\sqrt{2}$$

$$\boxed{|F_{AB}| = 50\sqrt{2} \text{ kips}}$$

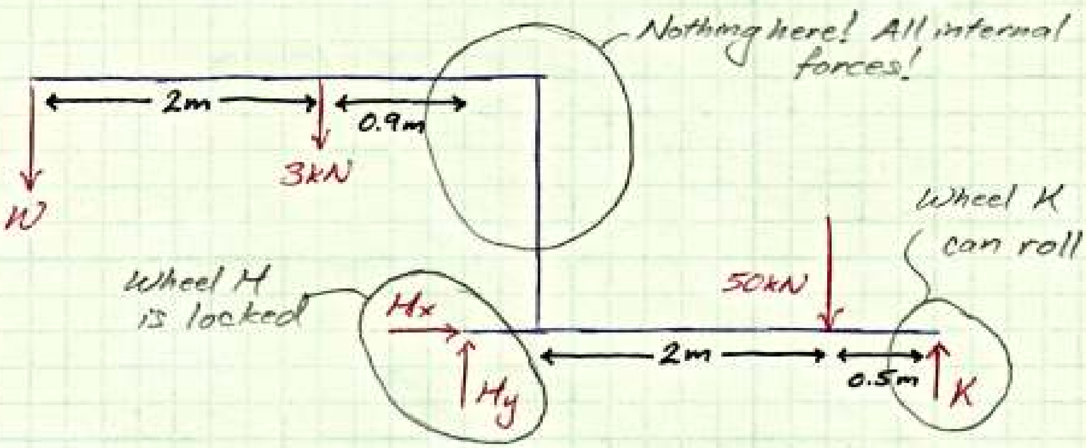
Problem 3 Solutions

drafted by Kenny 10/2010



a) Find maximum W so crane does not tip over.

– Start w/ FBD of the crane (the whole thing!)



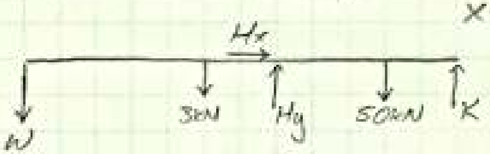
– To find W, $\sum M_H = 0$ (recognize for tip-over, $K=0$!)

Just like in HW!

$$\sum M_H = W(2.9m) + (3kN)(0.9m) - (50kN)(2m) = 0$$

$$W = \frac{97.3\,kNm}{2.9m} = \boxed{33.6\,kN}$$

FBD can be a simple as a line since no moment-causing force in x-direction.

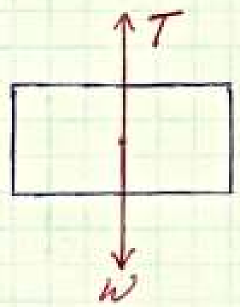


← Just like Prof Keaveny did in class.

Problem 3 Solutions cont.

b) Assuming $W = 25 kN$, find the tension T in the cable.

- Start w/ FBD of the load



$$\Sigma F_y = 0$$
$$= T - W = 0$$

$$T = W = \boxed{25 kN}$$

It becomes difficult to solve if a FBD of just the cable is drawn. Many students drew the following:

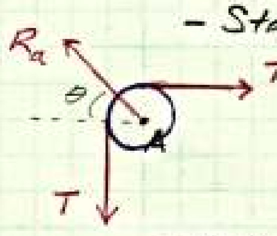
This is incorrect!

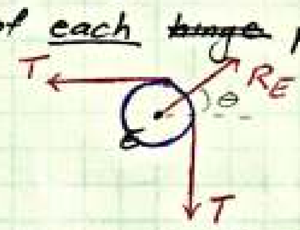
- Cable not shown in equilibrium! No reaction forces at A, E

Even if reaction forces were drawn in, there is not enough information to solve!

c) Find reaction forces at hinges A and E.

- Start w/ FBD of each ~~hinge~~ pulley





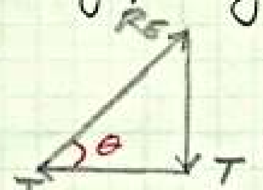
- Either solve component-wise or graphically

$\Sigma F_x = 0$: $R_a \cos\theta = T$

$\Sigma F_y = 0$: $R_a \sin\theta = T$

$\tan\theta = 1 \Rightarrow \theta = 45°$

$R_a = \frac{T}{\cos 45} = \boxed{35.4 kN}$



$\theta = 45°$

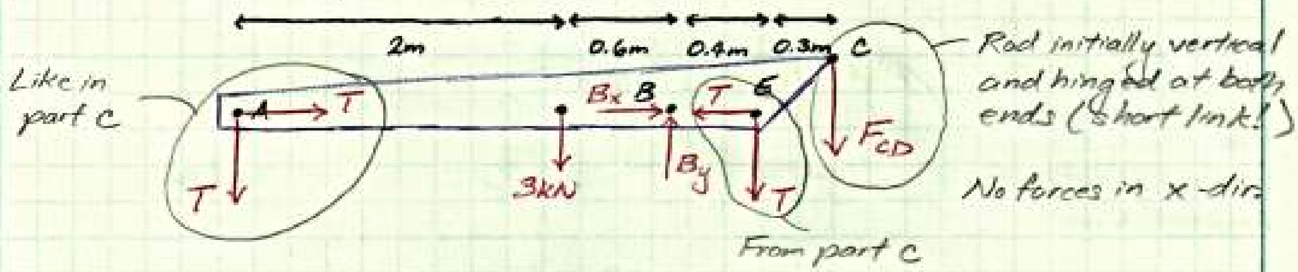
$R_E = T\sqrt{2}$

$\boxed{= 35.4 kN}$

Problem 3 Solutions cont.

d) Using FBD of boom ABC, find F_{CD}.

- Start w/ FBD of boom ABC



- To find F_{CD}, $\Sigma M_B = 0$.

$$\Sigma M_B = 0$$

$$= T(2.6m) + (3kN)(0.6m) - T(0.4m) - F_{CD}(0.7m)$$

$$F_{CD} = \frac{56.8\,kN\cdot m}{0.7m} = \boxed{81.1\,kN}$$

// End