Problem 1

a) $\underline{P} = |\underline{P}| \, \underline{\lambda}_{BE}$

$$= 25\left(\frac{-8\underline{j} + 6\underline{k}}{\sqrt{8^2+6^2}}\right) = -20\underline{j} + 15\underline{k}$$

$$\boxed{\begin{aligned} P_x &= 0 \\ P_y &= -20 \\ P_z &= 15 \end{aligned}}$$

$$\boxed{\underline{P} = 0\underline{i} - 20\underline{j} + 15\underline{k}}$$

b) Force Couple System:

$\underline{F} = \underline{P} = -20\underline{j} + 15\underline{k}$

$\underline{M} = \underline{r} \times \underline{P}$ where $\underline{r} = \underline{FB}$

$$= (-12\underline{i} + 8\underline{j} + 9\underline{k}) \times (-20\underline{j} + 15\underline{k})$$

$$= 300\underline{i} + 180\underline{j} + 240\underline{k}$$

c) $\underline{\lambda}_{CF} = (-8\underline{j} - 9\underline{k}) / \sqrt{8^2+9^2}$

$\underline{M}_{CF} = (\underline{\lambda}_{CF} \cdot \underline{M}) \, \underline{\lambda}_{CF}$

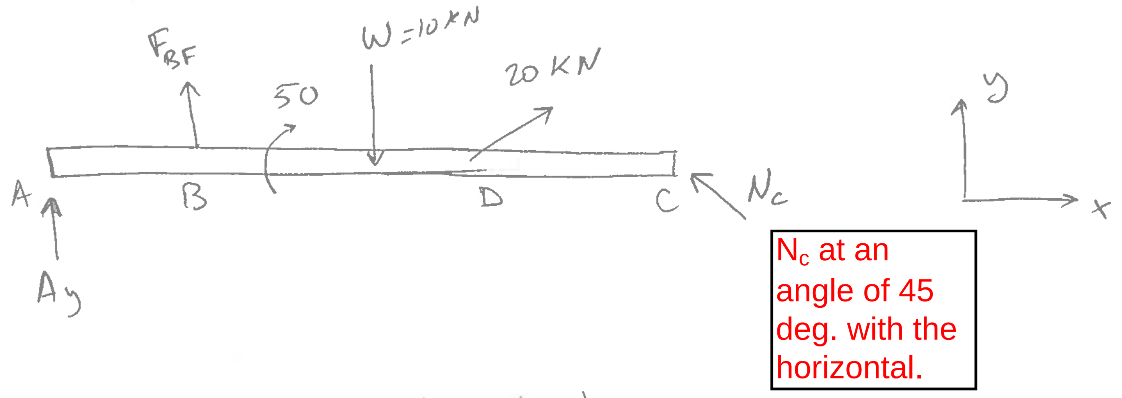
$$= (-299)\left(\frac{-8\underline{j} - 9\underline{k}}{\sqrt{8^2+9^2}}\right)$$

$$\boxed{\underline{M}_{CF} = +198.6\underline{j} + 223.44\underline{k}}$$

Problem 2

Part 1

a)



b) $\Sigma F_x = 0 \Rightarrow 20\cos(30) - N_c\cos(45) = 0$

$\Sigma F_y = 0 \Rightarrow A_y + F_{BF} - 10 + 20\sin 30 + N_c \sin(45) = 0$

$\circlearrowleft + \; \Sigma M_D = 0 \Rightarrow -A_y(3) - F_{BF}(2) - 50 + N_c(\cos 45)(2) + 10(0.5) = 0$

Solve system $\Rightarrow$

$A_y = 24.28\ kN$

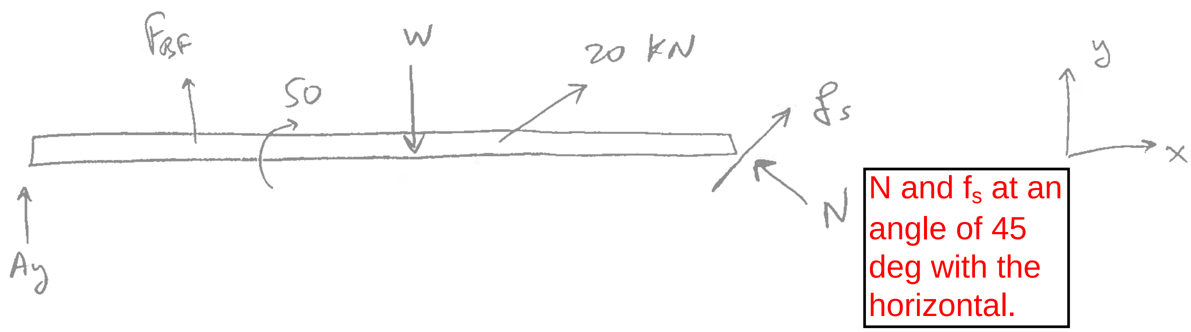
$F_{BF} = -41.6025\ kN$

$N_c = 24.5\ kN$

c) Since force of member BF on the bar points downward (pushing), it means member BF is in compression. Hence, it cannot be replaced by a rope since ropes only work in tension.

Part 2

a) bar about to slide down due to external loads ⇒ friction at C pointing upwards. (Reactions will be different to retain equilibrium).



b)

$\Sigma F_x = 0$ $\quad 20\cos(30) - N\cos(45) + f_s\cos(45) = 0$

$\Sigma F_y = 0$ $\quad A_y + F_{BF} + 20\sin(30) + N\sin(45) - 10 + f_s\sin(45) = 0$

$\Sigma M_D = 0$ $\quad -3A_y - 2F_{BF} - 50 + (0.5)(10) + 2N\cos(45) + 2f\sin(45) = 0$

$f_s = \mu_s N = 0.5\,N$

Solve system ⇒ $A_y = 162.8$ KN

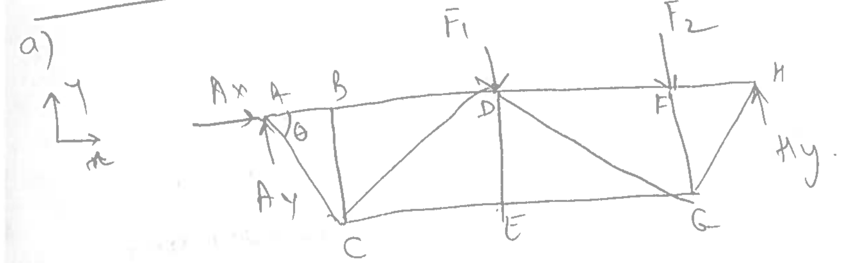
$\boxed{F_{BF} = -214.8 \text{ KN}}$

$N = 48.98$ KN

$f_s = 24.5$ KN

Problem 3

a)



$\theta = \tan^{-1}\left(\frac{7.5}{10}\right) = 36.87^\circ$

Taking moments about H. $\Sigma M_H = 0 = +F_1(AD) - F_2(AF) + H_y(AH) = 0$

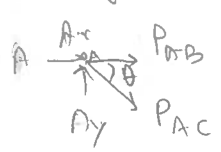
$\therefore H_y = \frac{(36)(20) + (36)(30)}{40} = \underline{45 \text{ kips}}$

$\Sigma F_x = 0 = A_x \Rightarrow \underline{A_x = 0 \text{ kips}}$

$\Sigma F_y = 0 = A_y - F_1 - F_2 + H_y = 0 \Rightarrow A_y = 36 + 36 - 45 = \underline{27 \text{ kips}}$

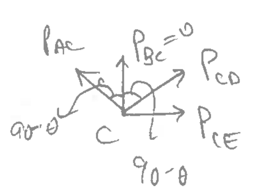
(b) Zero-force members: BC, DE.

(c) FBD of joint A:



$\Sigma F_y = 0 = A_y - P_{AC}\sin\theta \Rightarrow P_{AC} = \frac{27}{\sin(36.87^\circ)} = 45 \text{ kips}$

FBD of joint C:

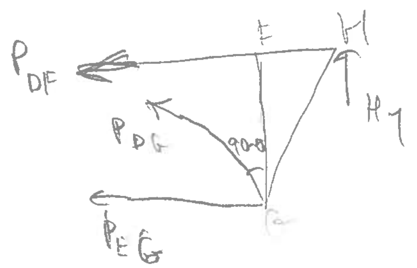


$\Sigma F_y = 0 = P_{AC}\sin\theta + P_{CD}\sin\theta \Rightarrow P_{CD} = -P_{AC} = \underline{-45 \text{ kips}}$

$\therefore$ Member CD is in compression

d) Take a vertical cut cutting through members DF DG & EG

FBD of right hand section:



$\Sigma F_y = 0 = H_y + P_{DG}\sin\theta \Rightarrow P_{DG} = \frac{-45}{\sin 36.87} = \underline{-75 \text{ kips}}$

Member DG is in compression

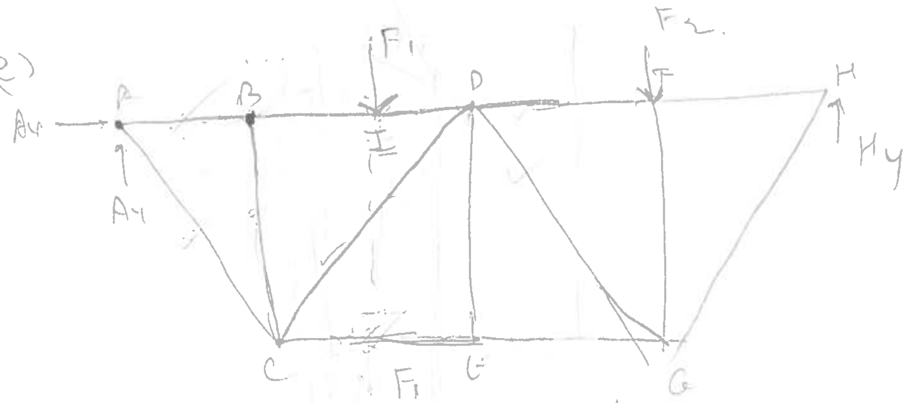
Taking moment about F

$\sum M_a = 0 = H_y(FH) + P_{DF}(FG) = 0$

$\Rightarrow P_{DF} = -\dfrac{(45)(10)}{7.5} = \underline{-60 kips}$

∴ Member DF is in compression

e)



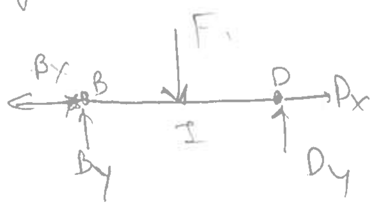
$\sum F_x = 0 = A_x \Rightarrow A_x = 0$ kips

$\sum M_A = 0 \Rightarrow -(AI)F_1 - (AF)(F_2) + (AH) H_y = 0$

$\Rightarrow H_y = \dfrac{(15)(36) + (30)(36)}{40} = 40.5 kips$

$\sum F_y = 0 \Rightarrow A_y - F_1 - F_2 + H_y = 0 \Rightarrow A_y = 32.5 \underline{kips}$

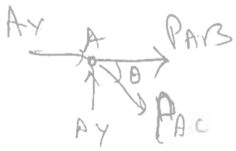
FBD of member BD



$\Sigma M_D = 0 \Rightarrow -B_y(DB) + F_1(DI) = 0$

$\Rightarrow B_y = \frac{\cancel{2}F_1}{2} = 18$ kips

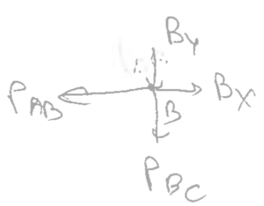
FBD of joint A:



$\Sigma F_y = 0 \Rightarrow A_y - P_{AC}\sin\theta = 0 \Rightarrow P_{AC} = \frac{32.5}{\sin 36.87} = 62.5$ kips

$\Sigma F_x = 0 \Rightarrow A_x + P_{AB} + P_{AC}\cos\theta = 0 \Rightarrow P_{AB} = -54$ kips

FBD of joint B:



$\Sigma F_y = 0 \Rightarrow -B_y - P_{BC} = 0$

$\Rightarrow P_{BC} = -B_y = -18$ kips

member BC is in compression