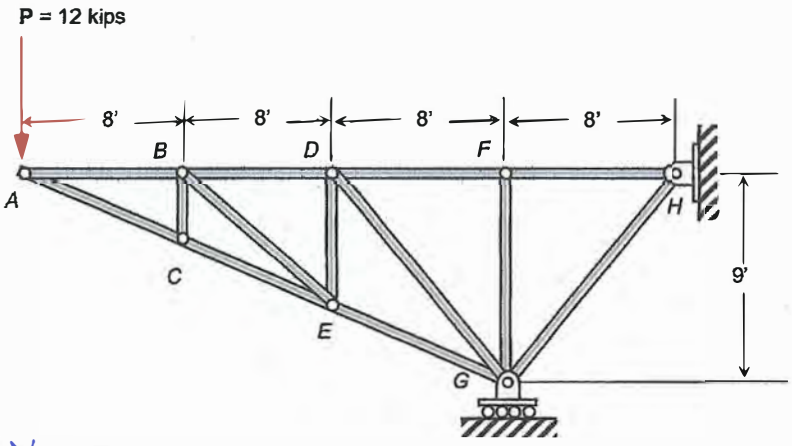
Example

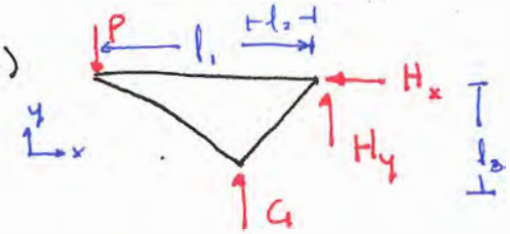
Consider the structure made up of thirteen weightless members that are connected to each other via smooth pins.

a) How many two-force members are in the structure?
b) Find the reactions at the pin *H* and the roller *G*.
c) Find the internal force in each two-force member you indentified in part a). (Hint: Draw an FBD for each individual *pin* that connects two-force members. Start at a location where there are only two unknowns, such as point *A*.)

a) ALL 13 MEMBERS ARE TWO-FORCE MEMBERS



b)



$\Sigma F_x = 0 \quad H_x = 0$

$\Sigma F_y = 0$

$-P + G + H_y = 0 \quad (1)$

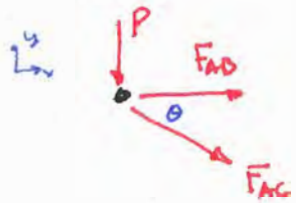
$\Sigma M_H = 0$

$l_1 P - l_2 G = 0 \quad G = \frac{l_1}{l_2} P = \frac{32'}{8'} 12\,\text{kip} =$ **48 kip**

FROM (1)

$H_y = P - G = 12 - 48 = -36\,\text{kips} =$ **36 kips ↓**

c) PIN A



$\theta = \tan^{-1}\left(\frac{9}{24}\right) = 20.56°$

$\Sigma F_y = 0$

$-P - F_{AC} \sin\theta = 0$

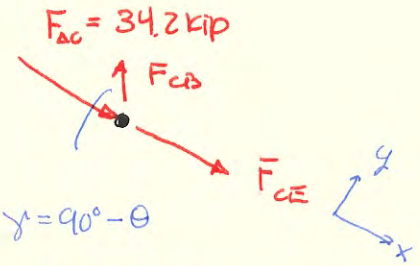
$F_{AC} = -P / \sin\theta = -12 / \sin 20.56° =$ **−34.18 kips** (C)

$\Sigma F_x = 0$

$F_{AB} + F_{AC} \cos\theta = 0 \quad F_{AB} = -F_{AC} \cos\theta = -(-34.18\,\text{kip}) \cos(20.56°) =$ **32 kips** (T)

GO TO B NEXT, OR C? GO TO C, B/C ONLY TWO UNKNOWNS THERE

FBD C



$\gamma = 90° - \theta$

$= 69.44°$

$\Sigma F_y = 0 \quad F_{CB} \sin\gamma = 0$

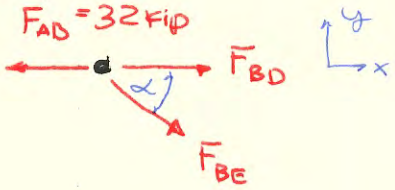
$\boxed{F_{CB} = 0}$!

— NOTE TILTED AXES. MAKES EQUIL EASIER.

$\Sigma F_x = 0 \quad F_{AC} + F_{CE} = 0$

$F_{CE} = -F_{AC} = \boxed{-34.18 \text{ kip}}$ 34.18 kip (C)

PROCEED TO B:



... ANALYSIS PROCEEDS IN SAME WAY YIELDING...

$F_{BD} = F_{AD} = 32 \text{ kip}$ 32 kip (T)

$F_{BE} = 0$

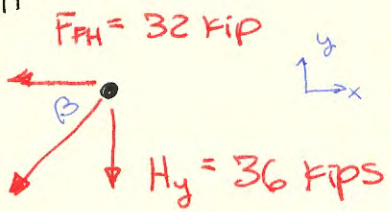
$F_{DF} = F_{FH} = 32 \text{ kip}$

$F_{DE} = F_{DG} = F_{FG} = 0$ ...

$F_{EG} = F_{CE} = -34.18 \text{ kip}$

34.18 kip (C)

H



$\beta = \tan^{-1}\frac{9}{8} = 48.36°$

$\Sigma F_x = 0$

$-32 \text{ kip} - F_{HG}\cos(\beta) = 0$

$F_{HG} = -F_{FH}/\cos\beta = -32 \text{ kip}/\cos 48.36°$

$= \boxed{-48.16 \text{ kip}}$

USE ΣF_y AS A CHECK:

$\Sigma F_y \stackrel{?}{=} 0$

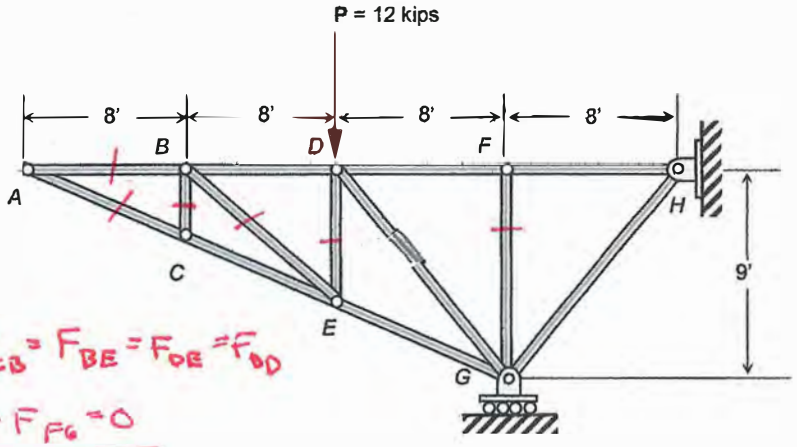
$-H_y - F_{HG}\sin\theta \stackrel{?}{=} 0$

$-36 \text{ kip} - (-48.16 \text{ kip})\sin(48.36) \stackrel{?}{=} 0 = 0$ ✓

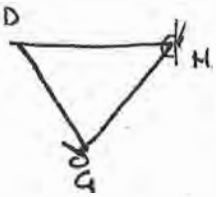
Example

Find the force in each member of the truss sown below and state whether it is in tension or compression.

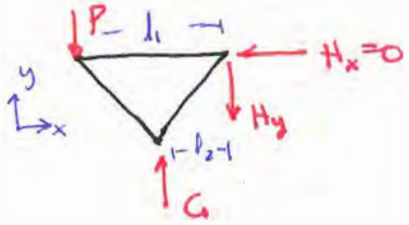
→ : ZERO FORCE MEMBERS



$F_{CB} = F_{BE} = F_{DE} = F_{BD} = F_{FG} = 0$



FBD WHOLE THING (LEFT)



$\Sigma M_H = 0$

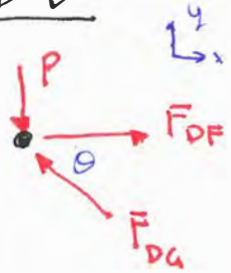
$l_1 P - l_2 G = 0$

$G = \frac{l_1}{l_2} P = \frac{16'}{8'} (12 \text{ kip}) = \boxed{24 \text{ kip}}$

$\Sigma F_y = 0 \quad -P + G - H_y = 0$

$H_y = G - P = 24 - 12 = \boxed{12 \text{ kip}}$

FBD D



$\tan\theta = \frac{9}{8} \quad \theta = 48.37°$

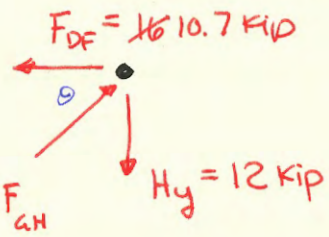
$\Sigma F_y = 0 \quad -P + F_{DG} \sin\theta = 0 \quad F_{DG} = \frac{P}{\sin\theta}$

$= \ldots = \boxed{16.1 \text{ kip } (C)}$

$\Sigma F_x = 0 \quad F_{DF} - F_{DG} \cos\theta = 0$

$F_{DF} = F_{DG} \cos\theta = \ldots \boxed{10.7 \text{ kip } (T)}$

FBD H



$\theta = 48.36°$

$\Sigma F_x = 0 \quad -F_{DF} + F_{GH}\cos\theta = 0$

$F_{GH} = F_{DF}/\cos\theta = \ldots = \boxed{16.1 \text{ Kip}}$ (c)

CAN USE ΣF_y AS A CHECK.

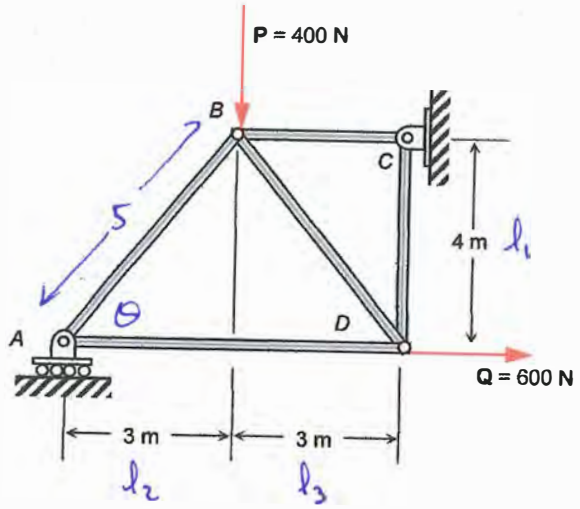
$\Sigma F_y \stackrel{?}{=} 0$

$F_{GH}\sin\theta - H_y \stackrel{?}{=} 0$

$(16.1 \text{ Kip})(\sin 48.36°) - 12 \stackrel{?}{=} 0$ ☑

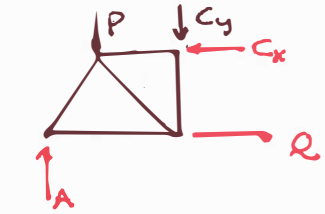
Example

Find the force in each member of the truss sown below and state whether it is in tension or compression.



NO ZERO-FORCE MEMBERS!

FBD WHOLE THING



$\sum F_x = 0$

$-C_x + Q = 0$

$Q = C_x = 600\,N$

$\sum M_c = 0$

$-(\ell_2+\ell_3)A + \ell_3 P + \ell_1 Q = 0$

$A = \dfrac{\ell_3 P + \ell_1 Q}{\ell_2+\ell_3} = \dfrac{(3\,m)(400\,N)+(4)(600)}{6\,m}$

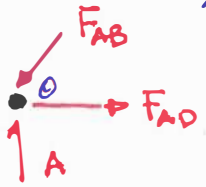
$= 600\,N$

$\sum F_y = 0$

$A - P - C_y = 0 \quad C_y = A - P$

$= 600 - 400 = 200\,N$

START AT A. WHY?



$\sum F_y = 0$

$A - F_{AB}\sin\theta = 0 \quad F_{AB} = \dfrac{A}{\sin\theta} = A\dfrac{5}{4} = 600\,N\,\dfrac{5}{4} =$

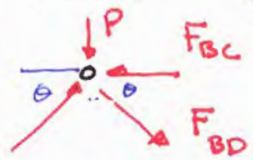
$= \boxed{750\,N\ (C)}$

$\sum F_x = 0$

$-F_{AB}\cos\theta + F_{AD} = 0 \quad F_{AD} = F_{AB}\cos\theta$

$= 750\,N\,\dfrac{3}{5} = \boxed{450\,N\ (T)}$

FBD B



$F_{AB} = 750\,N$

$\sum F_y = 0$

$-P + F_{AB}\sin\theta - F_{BD}\sin\theta = 0$

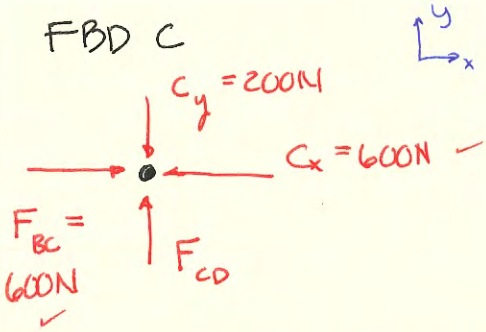
$F_{BD} = F_{AB} - P/\sin\theta = 750\,N - \dfrac{400\,N}{(4/5)} = \boxed{250\,N\ (T)}$

$\sum F_x = 0$

$F_{AB}\cos\theta + F_{BD}\cos\theta - F_{BC} = 0$

$F_{BC} = (F_{AB} + F_{BD})\cos\theta = (750N + 250\,N)\,\dfrac{3}{5} = \boxed{600N\ (C)}$

FBD C

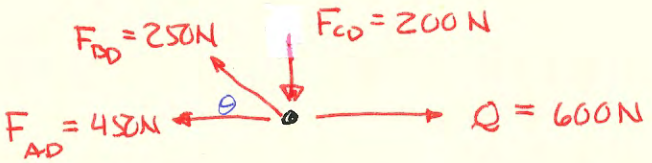


$\Sigma F_x = 0$ ✓

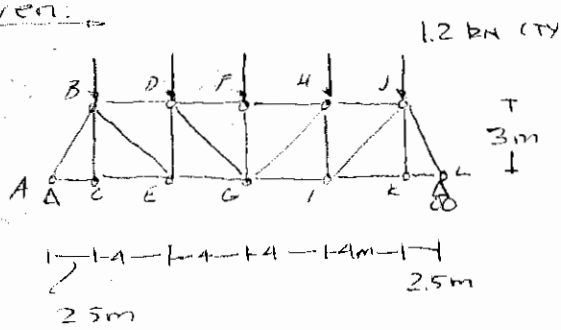
$\Sigma F_y = 0$

$F_{CD} = 200\,N$ (C)

CAN USE D AS A CHECK



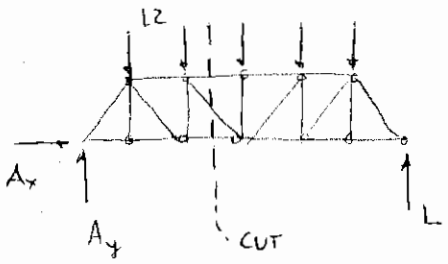
Given:



Find: FORCES IN DF, DG, & EG

Soln:

FBD WHOLE THING



$+\rightarrow \sum F_x = 0$ $\quad A_x = 0$

$\circlearrowleft + \sum M_A = 0$

$+(2.25)(1.2) - (6.25)(1.2) - (10.25)(1.2)$

$- (14.25)(1.2) - (18.25)(1.2)$

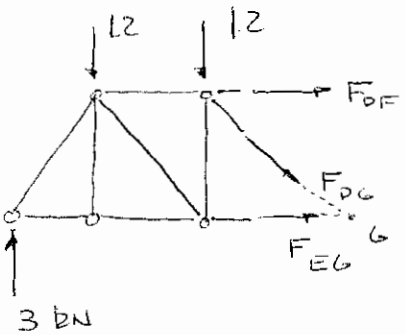
$+ (20)(L) = 0$ $\quad L = 3\,kN$

$\uparrow + \sum F_y = 0$

$A_y - 5 * 1.2 + L = 0$ $\quad A_y = 3\,kN$ (CIRCLED FROM SYM, VERT)

MAKE CUT AS SHOWN!

FBD of LEFT SECTION



$\circlearrowleft + \sum M_L = 0$

$-(10.25)(3) + (8)(1.2) + (4)(1.2)$

$- (3)(F_{DF}) = 0$

$F_{DF} = -5.45\,kN$

$\boxed{F_{DF} = 5.45\,kN\ \textcircled{C}}$

$\uparrow + \sum F_y = 0$

$3 - 1.2 - 1.2 - F_{DG}\left(\frac{3}{5}\right) = 0$

$\boxed{F_{DG} = 1\,kN\ \textcircled{T}}$

$+\rightarrow \sum F_x = 0$

$F_{EG} + F_{DG}\left(\frac{4}{5}\right) + F_{DF} = 0$

$\boxed{F_{EG} = 4.65\,kN\ \textcircled{T}}$