Engineering Mechanics
(ME-100)
Assignment # 3

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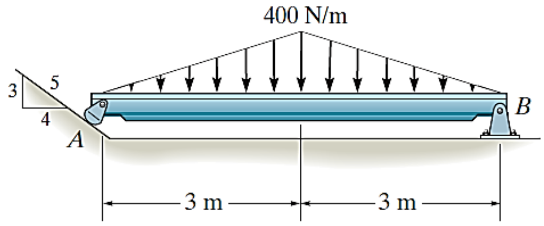
Paper Due Date

June 9th, 2021

Problem 5-11

Determine the reactions at the supports.

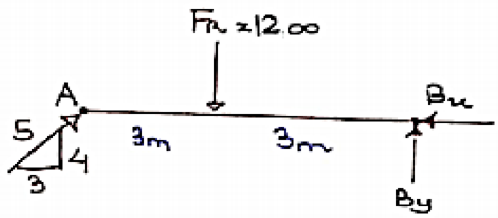


Solution

The resultant force of the distributed loading; of a triangle is its area

$$F_R = \frac{1}{2}(400)(6) = 1200\,N$$

- Finding Resultant Moment at B eliminates two unknowns;



$\Rightarrow \circlearrowleft + M_B = 1200(3) - \left(\frac{4}{5}\right)A(6) = 0 \quad \therefore \Sigma M_B = 0$

$\Rightarrow \boxed{A = 750\,N}$.

- Summing about A;

$\Rightarrow \circlearrowleft + \Sigma M_A = 0$

$\Rightarrow B_y(6) + (-1200)(3) = 0$

$\Rightarrow \boxed{B_y = 600\,N}$

- Lastly, for B_x, we can sum all the horizontal forces.

$\Rightarrow \Sigma F_x \xrightarrow{+} = 0$

$\Rightarrow \left(\frac{3}{5}\right)A - B_x = 0$

$$\Rightarrow \boxed{B_x = 450 N}$$

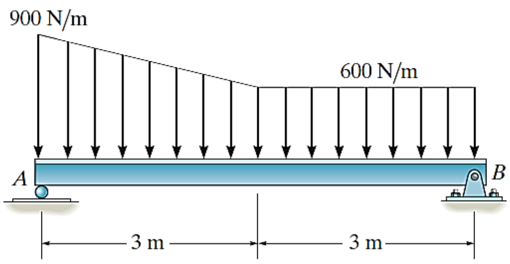
Ans; $A = 750 N$

$B_y = 600 N$

$B_x = 450 N$

Problem 5-13

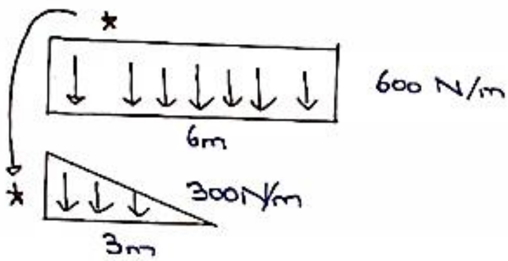
Determine the reactions at the supports.



Solution

The loading can be expressed as a sum of a rectangle and triangle.

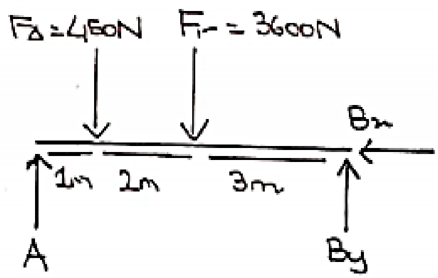
$\therefore F_r = 600(6)$



$\therefore F_\Delta = \frac{1}{2}(3)(300)$

And thus, the figure of FBD becomes;

- Once again, we can find A by summing moments about B.



$$\Rightarrow + \circlearrowright \sum M_B = 0$$

$\Rightarrow \quad A(6) - 450(5) - 3600(3) = 0$

$\Rightarrow \quad \boxed{A = 2175\ N}$

- Now that we have A, we can use it to find By: By $\Sigma M_A = 0$

$\Rightarrow \quad + \circlearrowleft \Sigma M_A = 0$

$\Rightarrow \quad 450(1) + 3600(3) - B_y(6) = 0$

$\Rightarrow \quad \boxed{B_y = 1875\ N}$

Since there isn't any horizontal forces on the body except B_x. We can write:

$\Rightarrow \quad \xrightarrow{+} \Sigma F_x = 0$

$\Rightarrow \quad \boxed{B_x = 0}$

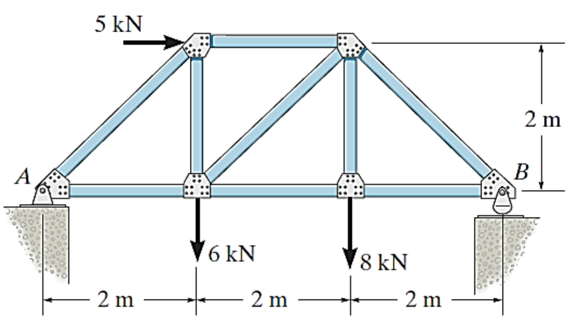
Answers; $A = 2175\ N$

$B_y = 1875\ N$

$B_x = 0\ N$

Problem 5-15

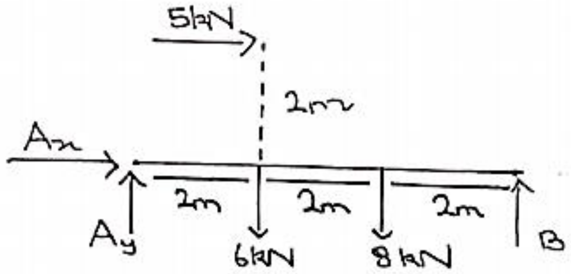
Determine the reactions at the supports.



Solution

- Firstly, we draw the FBD.

FBD:



- Observing this figure, we find that A_y and B are possible to determine by summation of moments.

→ <u>At B:</u>

$\Rightarrow \sum M_B \; C_{\circlearrowright}+ = 0$

$\Rightarrow (8)2 + (6)(4) - (5)(2) - A_y(6) = 0$

$\Rightarrow \boxed{A_y = 5\,kN}$

→ <u>At A:</u>

$\Rightarrow \sum M_A \; C_{\circlearrowright}+ = 0$

$\Rightarrow B(6) - 6(2) - 8(4) - 5(2) = 0$

$\Rightarrow \boxed{B = 9\,kN}$

- The x-component of A can be determined by summing all the forces on the x-axis.

$\Rightarrow \overset{+}{\rightarrow} \sum F_x = 0$

$\Rightarrow 5 + A_x = 0$

$\Rightarrow \quad A_x = -5\,kN$

or

$\Rightarrow \quad \boxed{A_x = 5\,kN \leftarrow}$

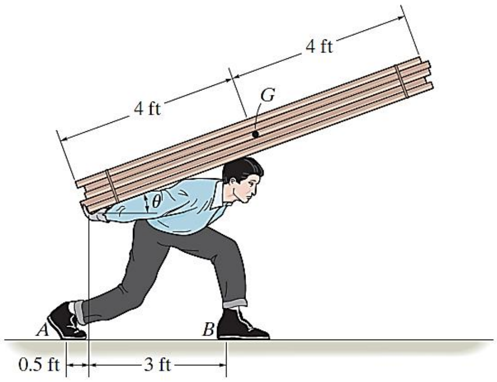
Answer; $A_y = 5\,kN$

$B = 9\,kN$

$A_x = 5\,kN$

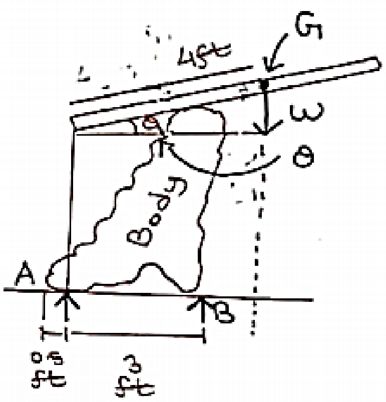
Problem 5-17

The man attempts to support the load of boards having a weight W and a centre of gravity at G. If he is standing on a smooth floor, determine the smallest angle θ at which he can hold them up in the position shown. Neglect his weight.



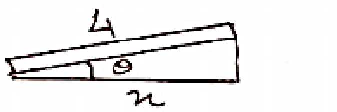
Solution

• Firstly, forming an equation. We could get rid of the normal force B by taking moment about B.



$\Rightarrow \quad \Sigma M_B \circlearrowright + = 0$

$\Rightarrow \quad N_A(3.5) + W(4\cos(\theta) - 3) = 0$



$x = 4\cos(\theta)$

- As θ becomes smaller, all the weight shifts towards the foot at B. Hence, $N_A \to 0$ as $\downarrow\theta$ ∴

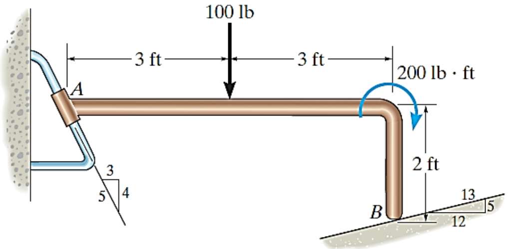
$\Rightarrow \quad W(4\cos(\theta) - 3) = 0$

$\Rightarrow \quad \cos\theta = 3/4$

$\Rightarrow \quad \boxed{\theta = 41.40^\circ}$

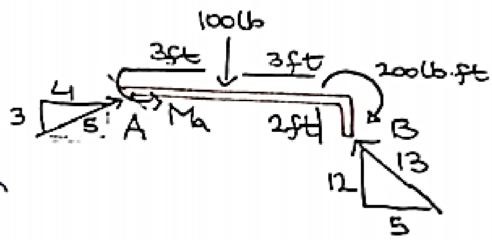
Problem 5-25

Determine the reactions on the bent rod which is supported by a smooth surface at B and by a collar at A, which is fixed to the rod and is free to slide over the fixed inclined rod.



Solution

- Since each connection features unknowns, we aim for a system of equation. We do this by finding summation of forces.



- $\underline{\Sigma F_x \overset{+}{\rightarrow} = 0}$

$\Rightarrow \quad \left(\frac{4}{5}\right)A - \left(\frac{5}{13}\right)B = 0$

- $\underline{\Sigma F_y \uparrow + = 0}$

$\Rightarrow \quad \left(\frac{3}{5}\right)A + \left(\frac{12}{13}\right)B = 100$

Solving this system yields;

$$\boxed{\begin{aligned} A &= 39.68 \text{ lb} \\ B &= 82.53 \text{ lb} \end{aligned}}$$

To find the moment at A, M_A, we find the summation of moment equation on A.

- $\underline{\sum M_A \circlearrowleft + = 0}$

$$\Rightarrow M_A - 100(3) - (200) + B\left(\frac{12}{13}\right)(6) - B\left(\frac{5}{13}\right)(2) = 0$$

- Since we know $B = 82.53$ lb; substituting

$$\Rightarrow \boxed{M_A = 106 \text{ lb.ft}}$$

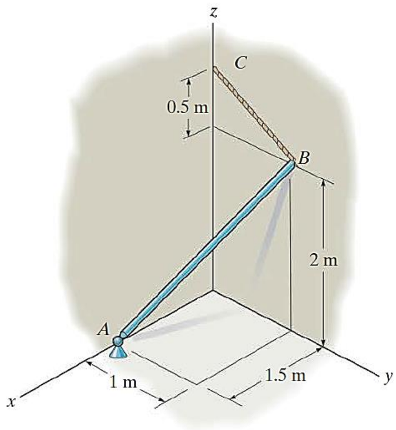
Answers; $A = 39.68$ lb

$B = 82.53$ lb

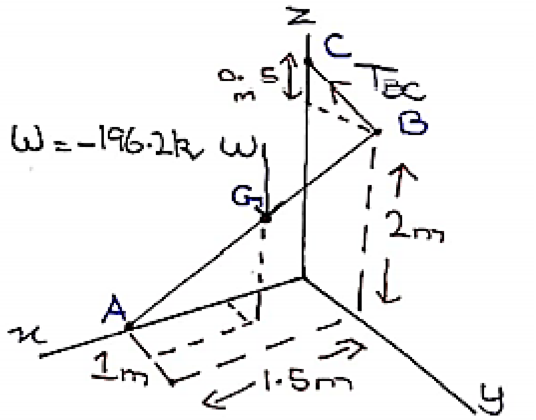
$M_A = 106$ lb.ft

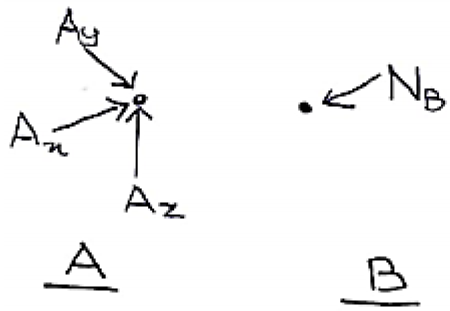
Problem 5-66

The smooth uniform rod AB is supported by a ball and socket joint at A, the wall at B, and cable BC. Determine the components of reaction at A, the tension in the cable, and the normal reaction at B if the rod has a mass of 20 kg.



Solution





A(1.5, 0, 0) m

B(0, 1, 2) m

C(0, 0, 2.5) m

G(0.75, 0.5, 1) m

- $\boxed{F_A = -A_x i + A_y j + A_z k}$

The two position vectors to find are r_{AG} and r_{AB} since they produce (a) moment.

$$r_{AB} = \{-1.5i + 1j + 2k\}\ m$$

$$r_{AG} = \{-0.75i + 0.5j + 1k\}\ m$$

The forces acting at B are N_B and T_{BC}; in cartesian form are:

$$\boxed{\overline{N_B} = N_B\, i}$$

$$\overline{T_{BC}} = T_{BC}\left(\frac{r_{BC}}{|r_{BC}|}\right) = \frac{T_{BC}\,(0i - 1j + 0.5k)}{\sqrt{0.5^2+1^2}}$$

$$\overline{T_{BC}} = \boxed{T_{BC}\left(\frac{-1}{\sqrt{1.25}}j + \frac{0.5}{\sqrt{1.25}}k\right)}$$

- Equations of Equilibrium can be now written:

$$\Sigma F = 0; \quad F_A + T_{BC} + N_B + W = 0$$

$$\Rightarrow (-A_x + N_B)i + \left(A_y - \frac{1}{\sqrt{1.25}}T_{BC}\right)j + \left(A_z + \frac{0.5}{\sqrt{1.25}}T_{BC} - 196.2\right)k = 0$$

- Separating i, j and k equations

$$\Rightarrow -A_x + N_B = 0$$

$$\Rightarrow A_y - 0.894T_{BC} = 0$$

$$\Rightarrow A_z + 0.447\,T_{BC} = 196.2$$

Which is 3 equations and 5 unknowns;

- To find more equations, we apply the Summation of moments

- $\Sigma M_A = 0;$

$$\Rightarrow r_{AG} \times W + r_{AB} \times (T_{BC} + N_B) = 0$$

$$\Rightarrow [-0.75i + 0.5j + 1k] \times [-196.2k]$$

$$+ [-1.5i + j + 2k] \times [N_B + T_{BC}] = 0$$

$$\Rightarrow \begin{vmatrix} i & j & k \\ -0.75 & +0.5 & 1 \\ 0 & 0 & -196.2 \end{vmatrix} + \begin{vmatrix} i & j & k \\ -1.5 & 1 & 2 \\ N_B & -0.894T_{BC} & 0.447T_{BC} \end{vmatrix} = 0$$

$$\Rightarrow \left(0.447 T_{BC} + 1.78\, T_{BC} - 98.1\right) i + \left(0.67\, T_{BC} + 2N_B - 147.15\right) j$$
$$+ \left(1.34\, T_{BC} - N_B\right) k = 0$$

→ Separating i, j and k equations and solving give us:

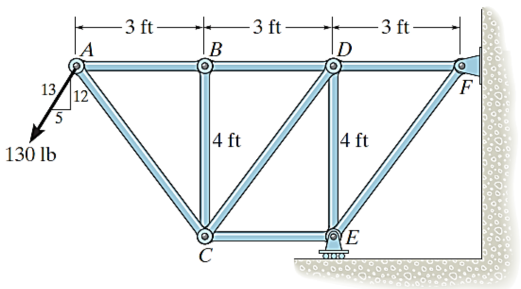
$$\boxed{\begin{aligned} T_{BC} &= 44.05\ \text{N} \\ N_B &= 59\ \text{N} \end{aligned}}$$

→ Substituting these in A unknowns yield:

$$\boxed{\begin{aligned} A_x &= N_B = 59\ \text{N} \\ A_y &= \frac{1}{\sqrt{1.25}} T_{BC} = 39.4\ \text{N} \\ A_z &= 196.2 - \frac{0.5}{\sqrt{1.25}} T_{BC} = 176.5\ \text{N} \end{aligned}}$$

Problem 6-3

Determine the force in each member of the truss. State if the members are in tension or compression.

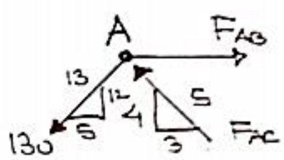


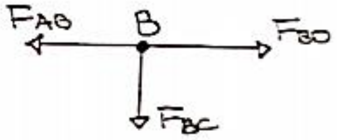
Solution

• A:

$$+\uparrow \Sigma F_y = 0; \quad \left(\frac{4}{5}\right) F_{AC} - \left(\frac{12}{13}\right) 130 = 0$$

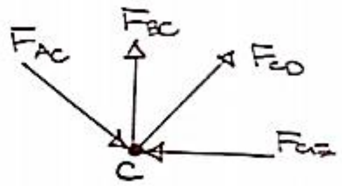
$$\boxed{F_{AC} = 150\ \text{lb}\ (C)}$$





$\xrightarrow{+} \sum F_x = 0;\ F_{AB} - \left(\frac{3}{5}\right) F_{AC} - \left(\frac{5}{13}\right) 130$

$$\boxed{F_{AB} = 140 \text{ lb } (T)}$$

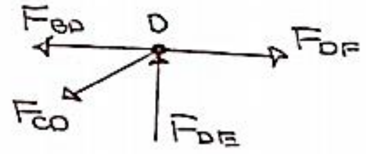


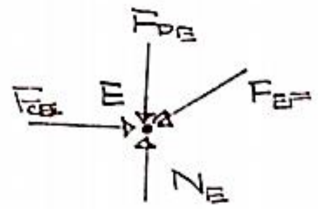
• B:

$+\uparrow \sum F_y = 0;\ \boxed{F_{BC} = 0}$

$\xrightarrow{+} \sum F_x = 0;\ F_{BD} - 140 = 0$

$$\boxed{F_{BD} = 140 \text{ lb } (T)}$$





• C:

$+\uparrow \sum F_y = 0;\ 0 + \left(\frac{4}{5}\right) F_{CD} - \left(\frac{4}{5}\right) F_{AC} = 0$

$$\boxed{F_{CD} = 150 \text{ lb } (T)}$$

$\xrightarrow{+} \sum F_x = 0;\ -F_{CE} + (3/5) F_{AC} + (3/5) F_{CD} = 0$

$$\boxed{F_{CE} = 180 \text{ lb } (C)}$$

• D:

$+\uparrow \sum F_y = 0;\ F_{DE} - \left(\frac{4}{5}\right) F_{CD} = 0$

$$\boxed{F_{DE} = 120 \text{ lb } (C)}$$

$\xrightarrow{+} \sum F_x = 0;\ F_{DF} - F_{BD} - (3/5) F_{CD} = 0$

$$\boxed{F_{DF} = 230 \text{ lb } (T)}$$

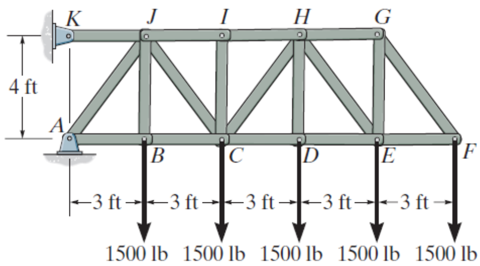
• E:

$$\xrightarrow{+} \sum F_x = 0; \quad F_{CE} - F_{EF}\left(\frac{4}{5}\right) = 0$$

$$\boxed{F_{EF} = 300 \text{ lb (C)}}$$

Problem 6-29

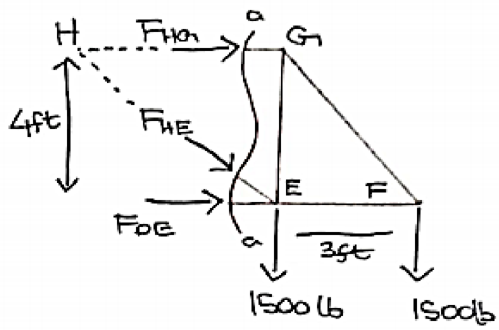
Determine the force in members HG, HE and DE of the truss, and state if the members are in tension or compression.



Solution

We utilize the method of sections to short it down so that the only unknowns are those in question.

We can find the member forces by taking equilibrium of moment on the joints.



• $\circlearrowleft + \sum M_E = 0;$

$\Rightarrow \quad F_{HG}(4) + 1500(3) = 0$

$\Rightarrow \quad F_{HG} = -1125 \text{ lb}$

$$\boxed{F_{HG} = 1125 \text{ lb (T)}}$$

• $\circlearrowleft + \Sigma M_{H} = 0;$

$\Rightarrow -F_{DE}(4) + 1500(3) + 1500(6) = 0$

$$\boxed{F_{DE} = 3375 \text{ lb (C)}}$$

• $\xrightarrow{+} \Sigma F_x = 0;$

$\Rightarrow F_{HE}\left(\frac{3}{5}\right) + F_{DE} + F_{HG} = 0$

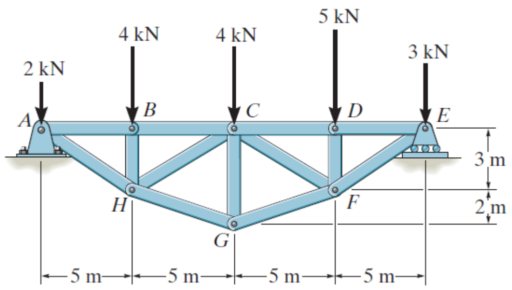
$\Rightarrow \frac{3}{5} F_{HE} + 3375 - 1125 = 0$

$\Rightarrow F_{HE} = -3750 \text{ lb}$

$$\boxed{F_{HE} = 3750 \text{ lb (T)}}$$

Problem 6-40

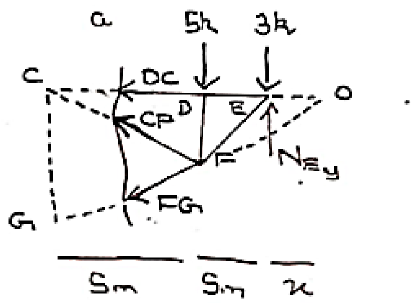
Determine the force in members *CD*, *CF*, and *CG* and state if these members are in tension or compression.



Solution

We, again, apply the method of sections since we are only concerned with only three force members; CD, CF and CG

• We find the support reacting by applying equilibrium equation to the original figure.



$\xrightarrow{+} \Sigma F_x = 0$;

$\Rightarrow \boxed{E_x = 0}$;

$\therefore \frac{5}{10+x} = \frac{3}{5+x} \Rightarrow x = 2.5m$

Since we do not know the unknown A_y, we apply moment about A to find E_y.

$\Sigma M_A \circlearrowleft + = 0$;

$\Rightarrow E_y(20) - 4(5) - 4(10) - 5(15) - 3(20) = 0$

$\Rightarrow \boxed{E_y = 9.75 \, kN}$

→ Now applying equilibrium equation to the section:

$\Sigma M_c \circlearrowleft + = 0$;

$\Rightarrow (9.75)(10) - (5)(5) - (3)(10) - \frac{5}{\sqrt{29}} F_{FG}(5) = 0$

$\Rightarrow \boxed{F_{FG} = 9.155 \, kN \, (T)}$

• $\Sigma M_F \circlearrowleft + = 0$;

$\Rightarrow -(3)(5) + F_{DC}(3) + (9.75)(5) = 0$

$\Rightarrow F_{DC} = -11.25 \, kN$

$\Rightarrow \boxed{F_{DC} = 11.25 \, kN \, (C)}$

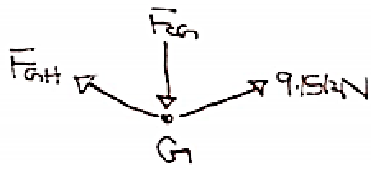
• $\Sigma M_o \circlearrowleft + = 0$;

$$\Rightarrow \quad (3)(2.5) - (9.75)(2.5) + (5)(7.5) - \frac{3}{\sqrt{34}} F_{CF}(7.5) - \frac{5}{\sqrt{34}}(3) F_{CF} = 0$$

$$\Rightarrow \quad (3)(2.5) - (9.75)(2.5) + (5)(7.5) - 6.49 F_{CF} = 0$$

$$\Rightarrow \quad \boxed{F_{CF} = 3.21 \text{ kN (T)}}$$

• G: For F_{CG}



$$\xrightarrow{+} \Sigma F_x = 0;$$

$$\Rightarrow \quad \boxed{F_{GH} = 9.155 \text{ kN}}$$

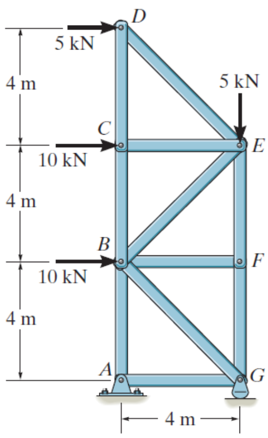
$$+\uparrow \Sigma F_y = 0;$$

$$\Rightarrow \quad \frac{2}{\sqrt{29}}(9.155)(2) - F_{CG} = 0$$

$$\Rightarrow \quad \boxed{F_{CG} = 6.80 \text{ kN (C)}}$$

Problem 6-45

Determine the force in members BF, BG, and AB, and state if the members are in tension or compression.



Solution

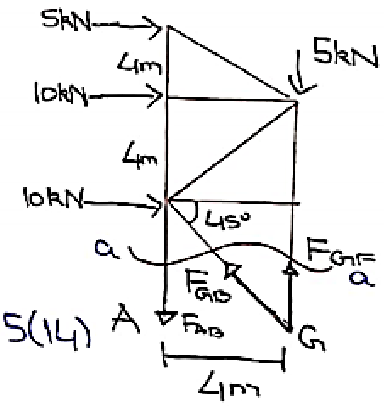
• Just by observing the truss, we can deduce that:

$\Rightarrow \boxed{F_{BF} = 0}$;

Since it is a zero-force member ; a single joint on two collinear ones.

- Section a-a:

Taking sum of moments about ...:



$\circlearrowright + \sum M_G = 0$;

$\Rightarrow -F_{AB} \cdots + 10(4) + 10(8) + 5(14) = 0$

$\Rightarrow \boxed{F_{AB} = 45 \text{ kN (T)}}$

- $\sum F_x = 0$;

$\Rightarrow 5 + 10 + 10 - F_{GB}\cos(45) = 0$

$\Rightarrow \boxed{F_{GB} = 35.4 \text{ kN (C)}}$