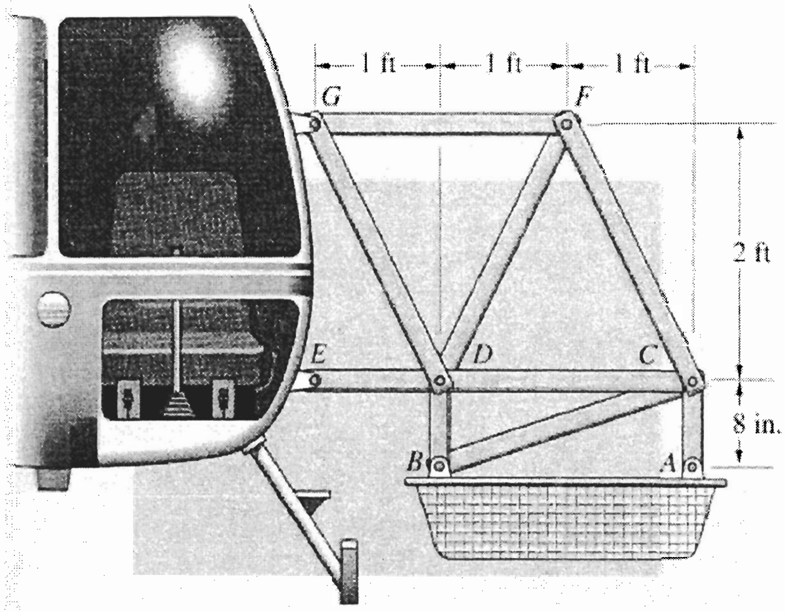
CE 201 (091) Section 3 & 4
H.W. # 9 Solution

Problem 1:

Given:

The figure shown

Vertical loads at A & B = 60 lb



Required:

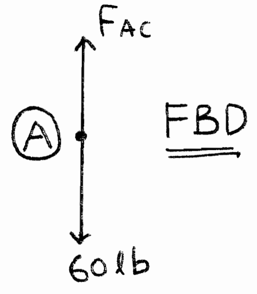
Axial forces in members CF, DF, and FG.

Solution:

Note that there are 2 (downward) vertical forces at joints A and B from the stretcher; each one equals to 60 lb.

To be able to solve the problem, we need to start with joint A, then B, then C or joint B then joint A, then C. (Why?!)

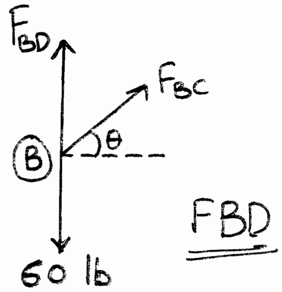
FBD of joint (A) as shown



$$+\uparrow \sum F_y = 0 \Rightarrow F_{AC} - 60 = 0 \Rightarrow$$

$$F_{AC} = 60\,lb.\ (T)$$

FBD of joint (B) as shown

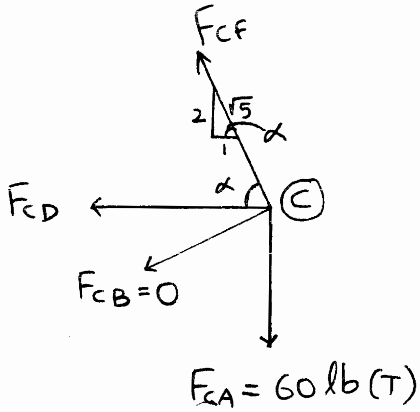


$$\overset{+}{\rightarrow} \sum F_x = 0 \Rightarrow F_{BC} \cos\theta = 0 \Rightarrow F_{BC} = 0$$

$+\uparrow \sum F_y = 0 \Rightarrow F_{BD} - 60 = 0 \Rightarrow$

$F_{BD} = 60 lb \ (T)$

FBD of joint Ⓒ as shown.



FBD

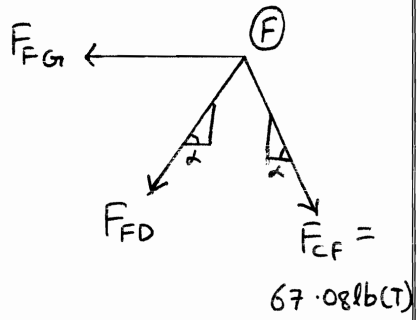
$+\uparrow \sum F_y = 0$ (Why start with y?!)

$\Rightarrow -60 + F_{CF} \sin\alpha = 0 \Rightarrow$

$-60 + F_{CF}\left(\frac{2}{\sqrt{5}}\right) = 0$

$\Rightarrow \boxed{F_{CF} = 67.08 lb \ (T)}$

Now joint Ⓕ



FBD

$+\uparrow \sum F_y = 0$ (Why start with y?!)

$\Rightarrow -67.08\left(\frac{2}{\sqrt{5}}\right) - F_{FD}\left(\frac{2}{\sqrt{5}}\right) = 0 \Rightarrow$

$\boxed{F_{FD} = -67.08 lb = 67.08 \ (C)}$

$\overset{+}{\rightarrow} \sum F_x = 0 \Rightarrow 67.08\left(\frac{1}{\sqrt{5}}\right) - \left[-67.08\left(\frac{1}{\sqrt{5}}\right)\right] - F_{FG} = 0$

note ⊖ sign!!

$\boxed{\Rightarrow F_{FG} = 60 lb \ (T)}$

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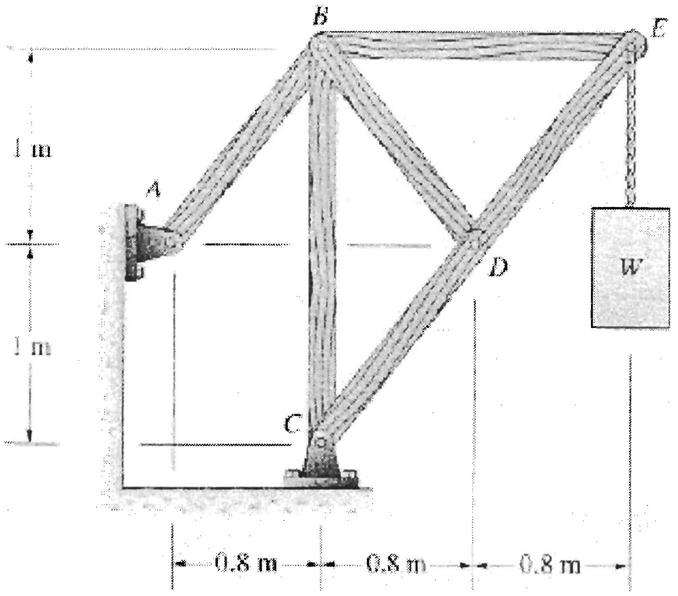
Problem 2:

Given:

The figure shown



Each member will safely support a tensile force of 6 kN and a compressive force of 2 kN.

Required:

Largest weight W the truss will safely support.

Solution:

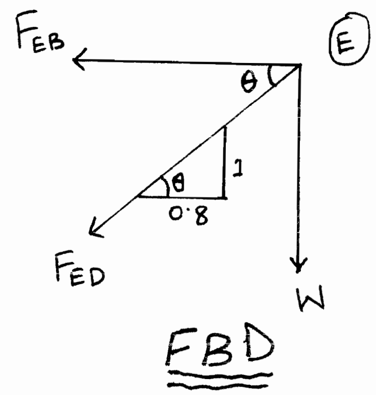
There are more than one method for solving this problem. One is to find the forces in all members as a function of W, then set the maximum tensile force (among all members) equal to the allowable (safe) tensile force. ⇒ Get W_1. Do the same thing for the compression force. ⇒ Get W_2 ⇒ Set $W_{max} = \min(W_1, W_2)$. (Why ?!)

Another method is to assume the maximum tensile or compressive force to be in a certain member, then check other members. If "OK" then get W (from assumption above). If "not OK", then remark the problem (again) assuming another member controls (i.e. it will reach max. allowable / safe before others). Repeat the procedure (if needed) until you get the "right assumption".

Hence, the first method will be followed, as it is clear and "direct" for "beginners"! The other method should be covered in other courses.

Start with joint (E). (Why?!)

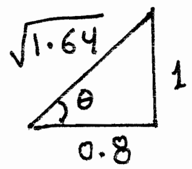
$+\uparrow \sum F_y = 0$ (Why start with y?!



$-W - F_{ED}\sin\theta = 0$

$\Rightarrow F_{ED} = -W / \frac{1}{\sqrt{1.64}}$

$\Rightarrow \underline{F_{ED} = -1.2806\,W = 1.2806\,W \ (C)}$



$\overset{+}{\rightarrow} \sum F_x = 0 \Rightarrow -F_{EB} - F_{ED}\cos\theta = 0 \Rightarrow$

$-F_{EB} - (-1.2806\,W)\left(\frac{0.8}{\sqrt{1.64}}\right)$

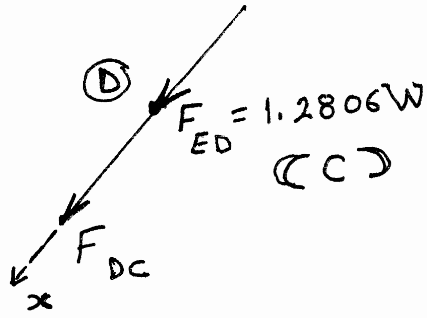
note ⊖ sign!

$\underline{F_{EB} = 0.8W \ (T)}$

Now joint (D) (Why?!)

$F_{DB} = 0$ (Why?!)

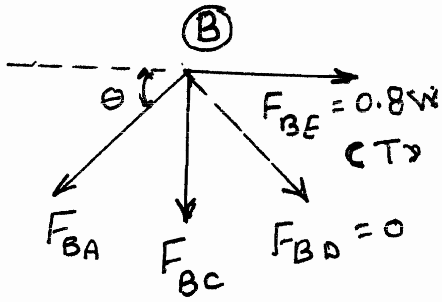
Note the direction of F_{ED}. (Why ?!)



$\overset{+}{\swarrow} \sum F_x = 0 \quad F_{DC} + F_{ED} = 0 \Rightarrow$

$F_{DC} = 1.2806\,W$ (C)

Then joint (B). Why?!



$\overset{+}{\rightarrow} \sum F_x = 0$ (Why start with x ?!)

$\Rightarrow \; 0.8W - F_{BA}\cos\theta = 0 \Rightarrow$

$F_{BA} = 1.2806\,W$ (T)

$+\uparrow \sum F_y = 0 \Rightarrow -F_{BC} - F_{BA}\sin\theta = 0 \Rightarrow$

$-F_{BC} - 1.2806\,W\left(\frac{1}{\sqrt{1.64}}\right) = 0 \Rightarrow$

$F_{BC} = -W = W$ [C]

From the answers above, the maximum tensile force is in member AB. $\Rightarrow$

$F^{T}_{max} = F_{AB} = 1.2806\,W$ (T)

$\equiv 6$ kN

$$\Rightarrow W_{max}^{①} = \frac{6}{1.2806} = \underline{\underline{4.685 \text{ kN}}}$$

The maximum compressive force is in members DE & CD.

$$\Rightarrow F_{max}^{c} = 1.2806\, W$$

$$\equiv 2 \text{ kN}$$

$$\Rightarrow W_{max}^{②} = \frac{2}{1.2806} = \underline{\underline{1.562 \text{ kN}}}$$

$$W_{max\ allowable} = \min\left(W_{max}^{①}, W_{max}^{②}\right) \quad \text{(Why?!)}$$

$$\Rightarrow \boxed{W_{max\ allow} = 1.562 \text{ kN}}$$

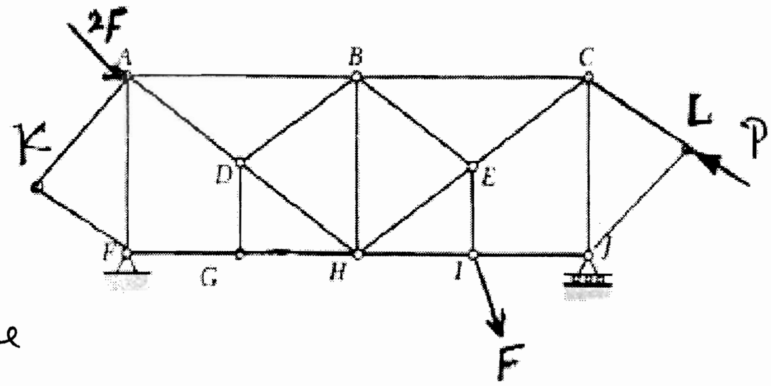
Note: Since $F_{max}^{T} = F_{max}^{C}$, we can conclude that

$F_{max.\,allowed}^{c}$ controls as $F_{max\ allow}^{T} = 6\text{ kN}$ and $F_{max\ allow}^{c} = 2 \text{ kN}$ (Why?!)

Problem 3:

Given:

The figure shown



Required:

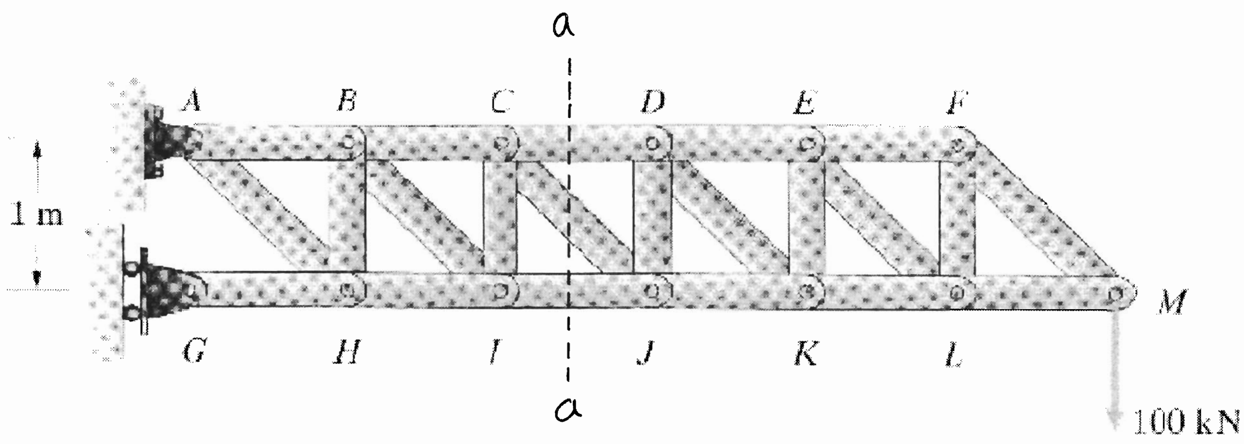
All zero-force members in the truss. (by inspection)

Solution:

By inspection, the zero-force members are

KA ; KF ; GD ⇒ DB ; LJ (How ?!) ⇒ JI (why ?!)

Problem 4:



Given:

The figure shown

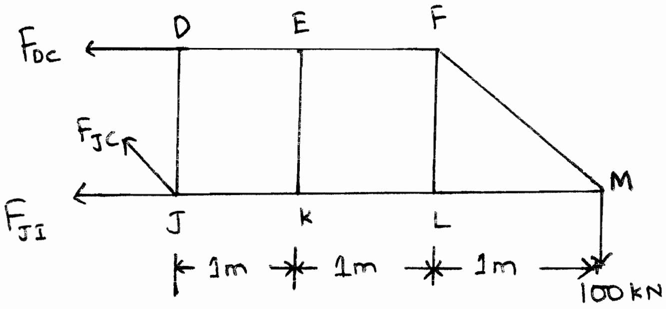
length of horizontal members = 1m

Required:

Force in member CJ = F_{CJ}

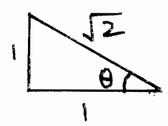
Solution:

The easiest method for the solution is to make Section a-a as shown in the figure, then take the FBD of the right part:



Now take $+\uparrow \sum F_y = 0$ (why?!)

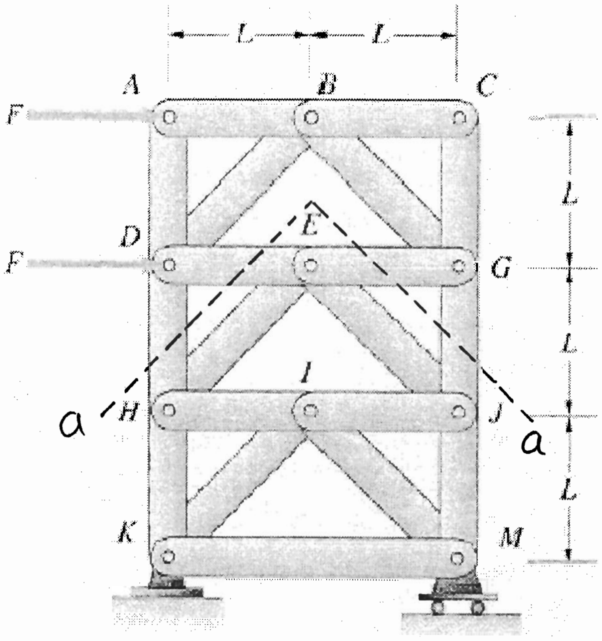
$-100 + F_{JC} \cos\theta = 0 \Rightarrow$



$F_{JC} = 100 / \frac{1}{\sqrt{2}} \Rightarrow$

$$\boxed{F_{JC} = F_{CJ} = 141.4 \text{ kN (T)}}$$

Problem 5:



Given:

The figure shown

$F = 50\ kN$

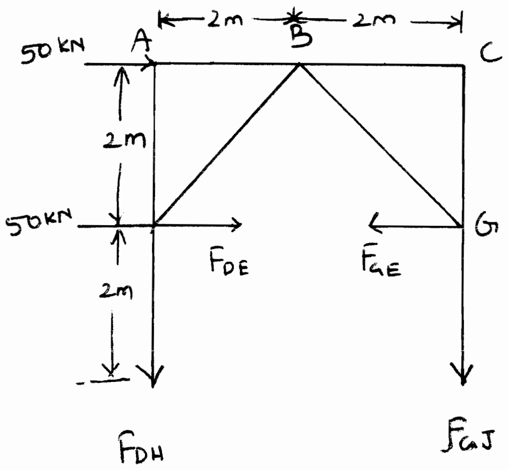
$L = 2\ m$

Required:

F_{DH} & F_{GJ} by the method of Sections.

Solution:

The easiest way to solve this problem is to make cut / section in the figure above. (Why?!) Remember this is a k-truss. Now the FBD is drawn for the upper part. (Why?!)



Take $\circlearrowleft + \sum M_G = 0$ (Why?!)

$\Rightarrow -50(2) + F_{DH}(4) = 0$

$\Rightarrow F_{DH} = 25\ kN\ (T)$

$+\uparrow \sum F_y = 0 \Rightarrow -F_{DH} - F_{GJ} = 0 \Rightarrow$

$F_{GJ} = -25\ kN = 25\ kN\ (C)$

It came out to be an easy problem! isn't it ?!!