MIDDLE EAST TECHNICAL UNIVERSITY

MECHANICAL ENGINEERING DEPARTMENT

ME 205 STATICS – FALL 2018

SECTION 1

HOMEWORK #4

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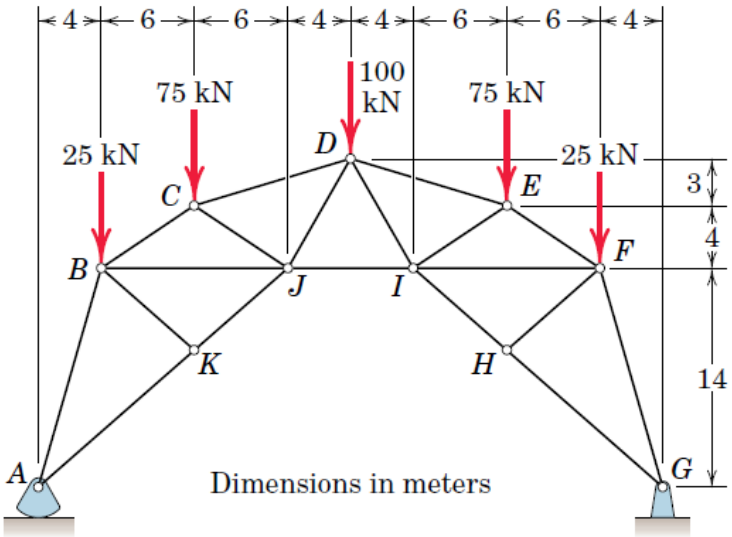
Assigned Date: 11.12.2018
Due Date: 18.12.2018
Due Time: 16.00
Grading Due Date: 01.01.2019

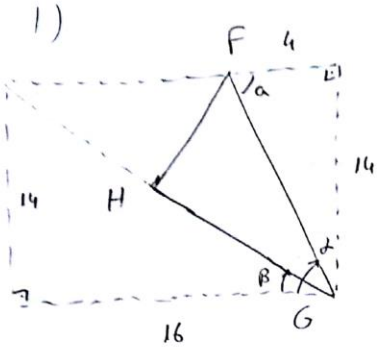
Please include your name, student ID, due date, a proper headline, page number with total page number, and units in your homework. Neatness will be graded.

1. Determine the forces in the members between *D* and *G* (i.e. *DE, DI, EI, EF, FI, HI, HF, HG,* and *FG)* and state whether these members are in tension or compression. Use method of joints. Other methods will not be graded. *(35 pts)*



Solution:

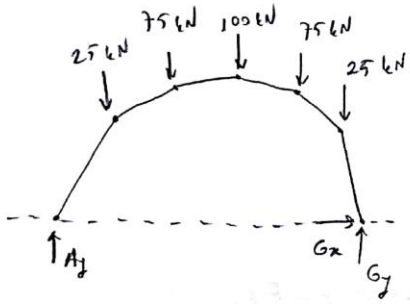
1)



$$\alpha = \tan^{-1}\left(\frac{14}{4}\right) = 74.1^\circ$$

$$\beta = \tan^{-1}\left(\frac{16}{16}\right) = 41.2^\circ$$

FBD of the whole truss



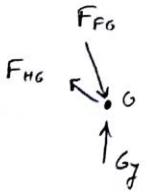
$$\Sigma F_x = 0 \; ; \quad G_x = 0$$

$$\Sigma M_A = 0 \; ; \quad (G_y)(40) - (25)(4) - (75)(10)$$

$$-(100)(20) - (75)(30) - (25)(36) = 0$$

$$\Rightarrow G_y = 170 \text{ kN}$$

FBD of the joint G



$$\Sigma F_x = 0 \; ; \quad F_{FG}\cos\alpha - F_{HG}\cos\beta = 0$$

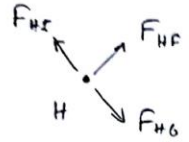
$$\Sigma F_y = 0 \; ; \quad G_y - F_{FG}\sin\alpha + F_{HG}\sin\beta = 0$$

$$\Rightarrow F_{FG} = 207.78 \text{ kN} \quad (\text{Compression})$$

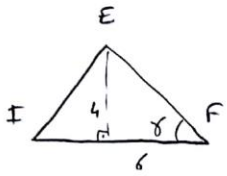
$$F_{HG} = 75.655 \text{ kN} \quad (\text{Tension})$$

FBD of the joint H

Note that HF is a zero-force member

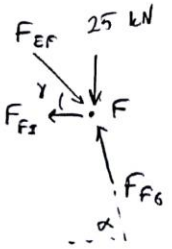


$\Rightarrow F_{HG} = F_{HI} = 75.655\ kN \quad (T)$



$\gamma = \tan^{-1}\left(\frac{4}{6}\right) = 33.7^\circ$

FBD of the joint F

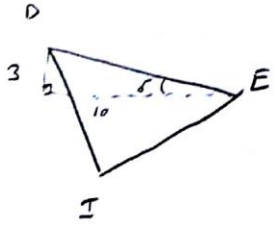


$\Sigma F_x = 0\ ;\ F_{EF}\cos\gamma - F_{FI} - F_{FG}\cos\alpha = 0$

$\Sigma F_y = 0\ ;\ F_{FG}\sin\alpha - F_{EF}\sin\gamma - 25 = 0$

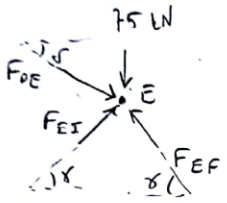
$\Rightarrow F_{EF} = 315.1\ kN \ (<)$

$F_{FI} = 205.2\ kN \ (T)$



$\delta = \tan^{-1}\left(\frac{3}{10}\right) = 16.7^\circ$

FBD of the joint E

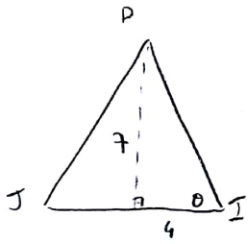


$\Sigma F_x = 0$; $F_{DE}\cos\beta + F_{EI}\cos\gamma - F_{EF}\cos\gamma = 0$

$\Sigma F_y = 0$; $-F_{DE}\sin\beta + F_{EI}\sin\gamma + F_{EF}\sin\gamma - 75 = 0$

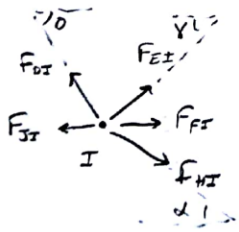
$\Rightarrow F_{DE} = 296.6$ kN (C)

$F_{EI} = -26.33$ (T)



$\theta = \tan^{-1}\left(\frac{7}{4}\right) = 60.255^\circ$

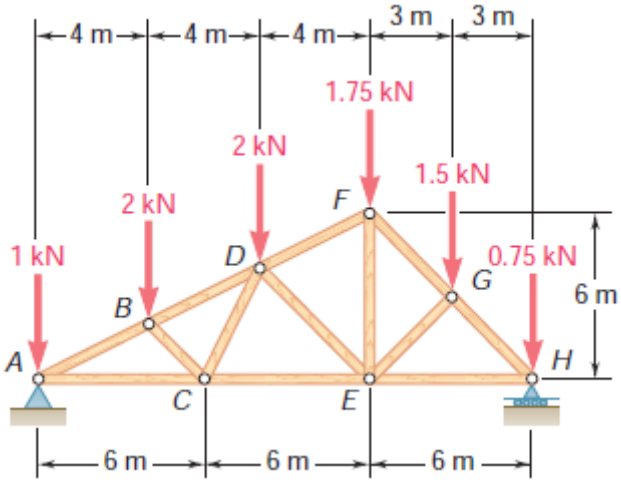
FBD of the joint I



$\Sigma F_y = 0$; $F_{DI}\sin\theta + F_{EI}\sin\gamma - F_{HI}\sin\alpha = 0$

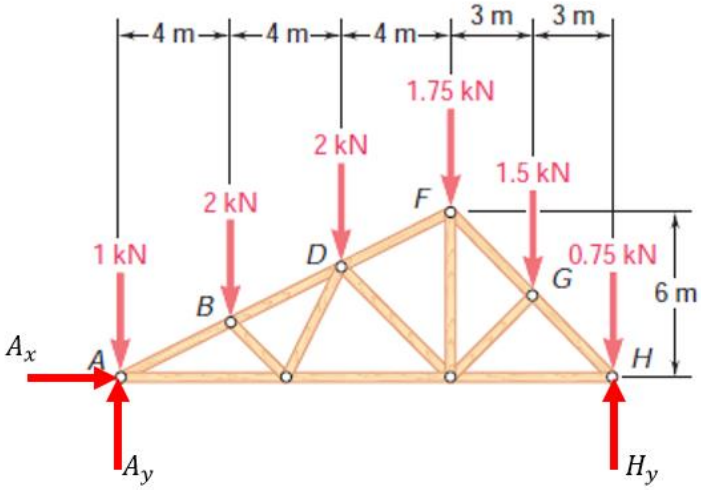
$\Rightarrow F_{DI} = 67$ kN (T)

2. Determine the forces in the members *DF, DE,* and *CE* and state whether these members are in tension or compression. Use method of sections. Other methods will not be graded. *(25 pts)*



Solution:

FBD of the whole truss:



$$\sum F_x = 0;\ \ A_x = 0$$

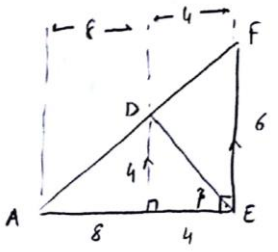
$$\sum M_A = 0;\ \ H_y(18) - (2)(4) - (2)(8) - (1.75)(12) - (1.5)(15) - (0.75)(18) = 0$$

$$H_y = 4.5\ kN$$

$$\sum F_y = 0;\ \ A_y + H_y - 1 - 2 - 2 - 1.75 - 1.5 - 0.75 = 0$$

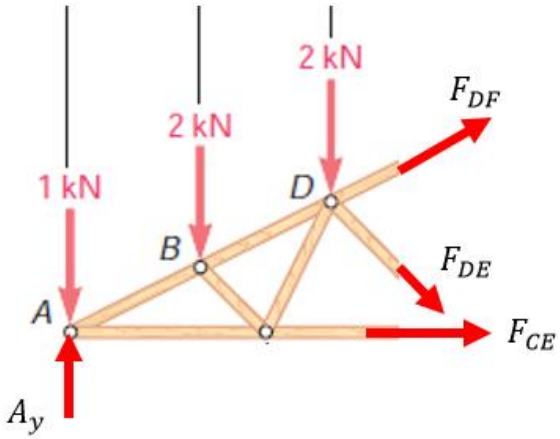
$$A_y = 4.5\ kN$$

Let $\angle FAE = \alpha$, then $\tan\alpha = \frac{6}{12} \rightarrow \alpha = 26.565°$ and let $\angle DEA = \beta$, then



$\beta = \tan^{-1}\left(\frac{4}{4}\right) = 45°$

Taking a section that goes through *FD, DE,* and *CE*:



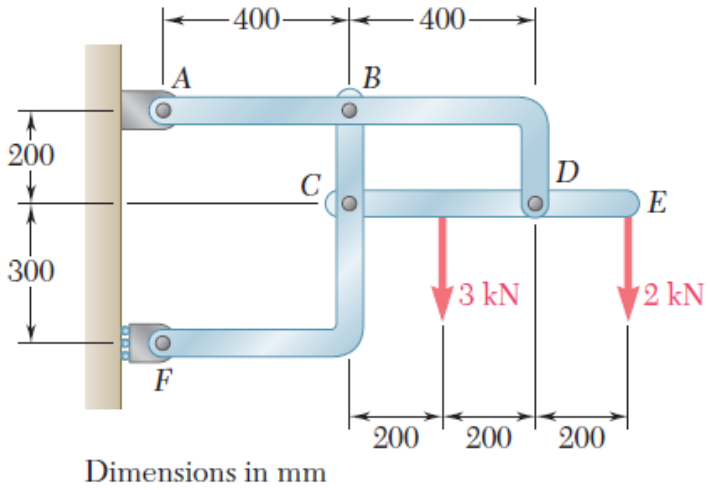
$$\sum F_x = 0;\ \ F_{DF}\cos\alpha + F_{DE}\cos\beta + F_{CE} = 0$$

$$\sum F_y = 0;\ \ A_y + F_{DF}\sin\alpha - F_{DE}\sin\beta - 1 - 2 - 2 = 0$$

$$\sum M_D = 0;\ -A_y(8) + F_{CE}(4) + (1)(8) + (2)(4) = 0$$

$$F_{CE} = 5\ kN$$
$$F_{DF} = -3.35\ kN$$
$$F_{DE} = -2.83\ kN$$

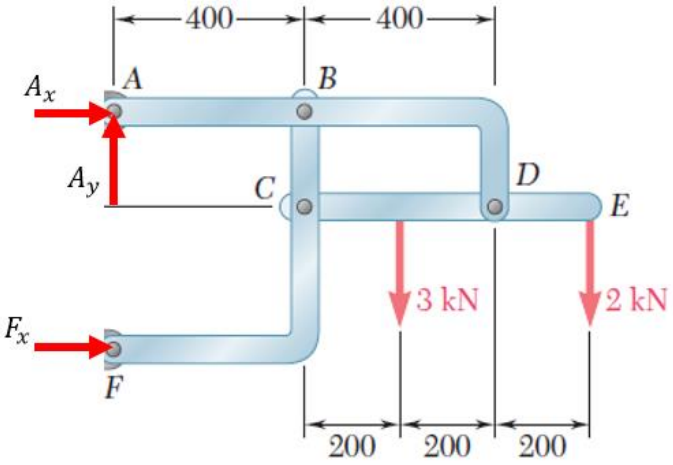
3. Determine the forces applying on *ABD.* The masses of the links are negligible. *(15 pts)*



Dimensions in mm

Solution:

FBD of the whole frame:



$$\sum F_y = 0;\ \ A_y - 3 - 2 = 0$$

$$A_y = 5\ kN$$

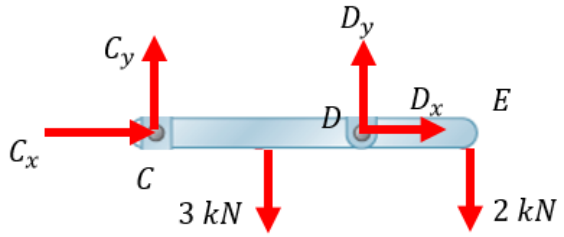
$$\sum M_A = 0;\ \ F_x(0.5) - (3)(0.6) - (2)(1) = 0$$

$$F_x = 7.6\ kN$$

$$\sum F_x = 0;\ \ A_x + F_x = 0$$

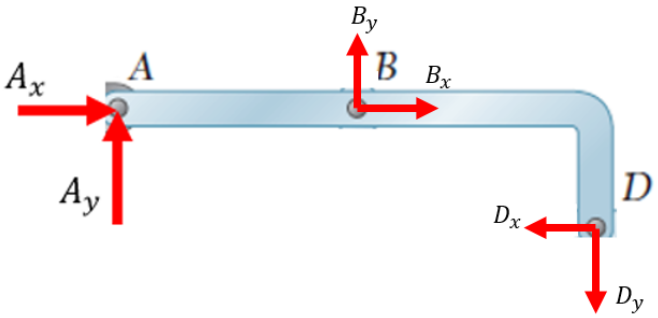
$$A_x = -7.6\ kN\ \ (\leftarrow)$$

FBD of the member *CE*:



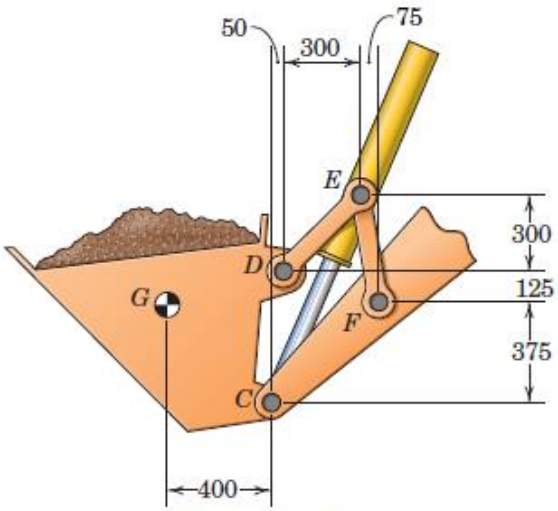
$$\sum M_C = 0;\ D_y(0.4) - (3)(0.2) - (2)(0.6) = 0$$
$$D_y = 4.5\ kN$$

FBD of the member *ABD*:

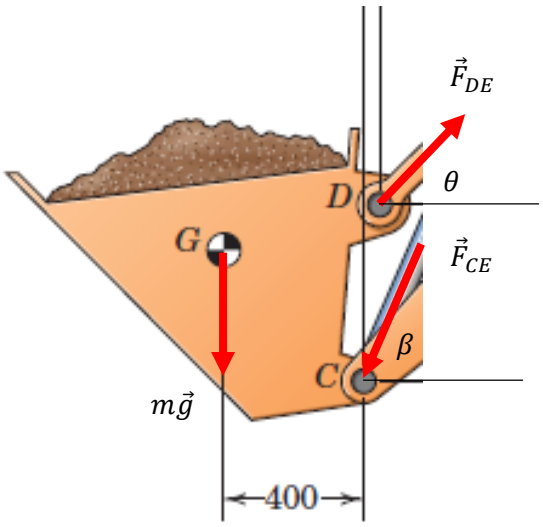


$$\sum M_B = 0;\ -D_x(0.2) - D_y(0.4) - A_y(0.4) = 0$$
$$D_x = -19\ kN\ (\rightarrow)$$
$$\sum F_x = 0;\ -D_x + A_x + B_x = 0$$
$$B_x = -11.4\ kN\ (\leftarrow)$$
$$\sum F_y = 0;\ A_y - D_y + B_y = 0$$
$$B_y = -0.5\ kN\ (\downarrow)$$

4. If the total mass of the bucket and the load together is 1000 kg, determine the force in the hydraulic cylinder *CE*. The center of mass of the bucket and the load is *G,* and the masses of the other members are negligible. *(25 pts)*



Solution:



Let θ be the angle between *DE* and horizontal, and β be the angle between *CE* and horizontal.

Then,

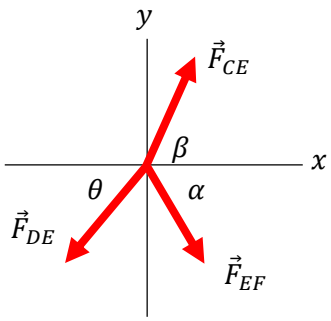
$$\tan\theta = \frac{300}{300} \rightarrow \theta = 45°$$

$$\tan\beta = \frac{800}{350} \rightarrow \beta = 66.37°$$

$$\circlearrowleft \sum M_C = 0; \quad (1000)(9.81)(400) + F_{DE}\sin 45°\,(50) - F_{DE}\cos 45°\,(500) = 0$$

$$F_{DE} = 12.332\ kN$$

The FBD of the joint E:



Let α be the angle between *EF* and horizontal. Then,

$$\tan\alpha = \frac{425}{75} \rightarrow \alpha = 80°$$

$$\sum F_x = 0; \quad F_{CE}\cos 66.37° + F_{EF}\cos 80° - 12.332\cos 45° = 0 \quad (1)$$

$$\sum F_y = 0; \quad F_{CE}\sin 66.37° - F_{EF}\sin 80° - 12.332\sin 45° = 0 \quad (2)$$

Solving (1) & (2) to get:

$$F_{CE} = 18.240\ kN$$