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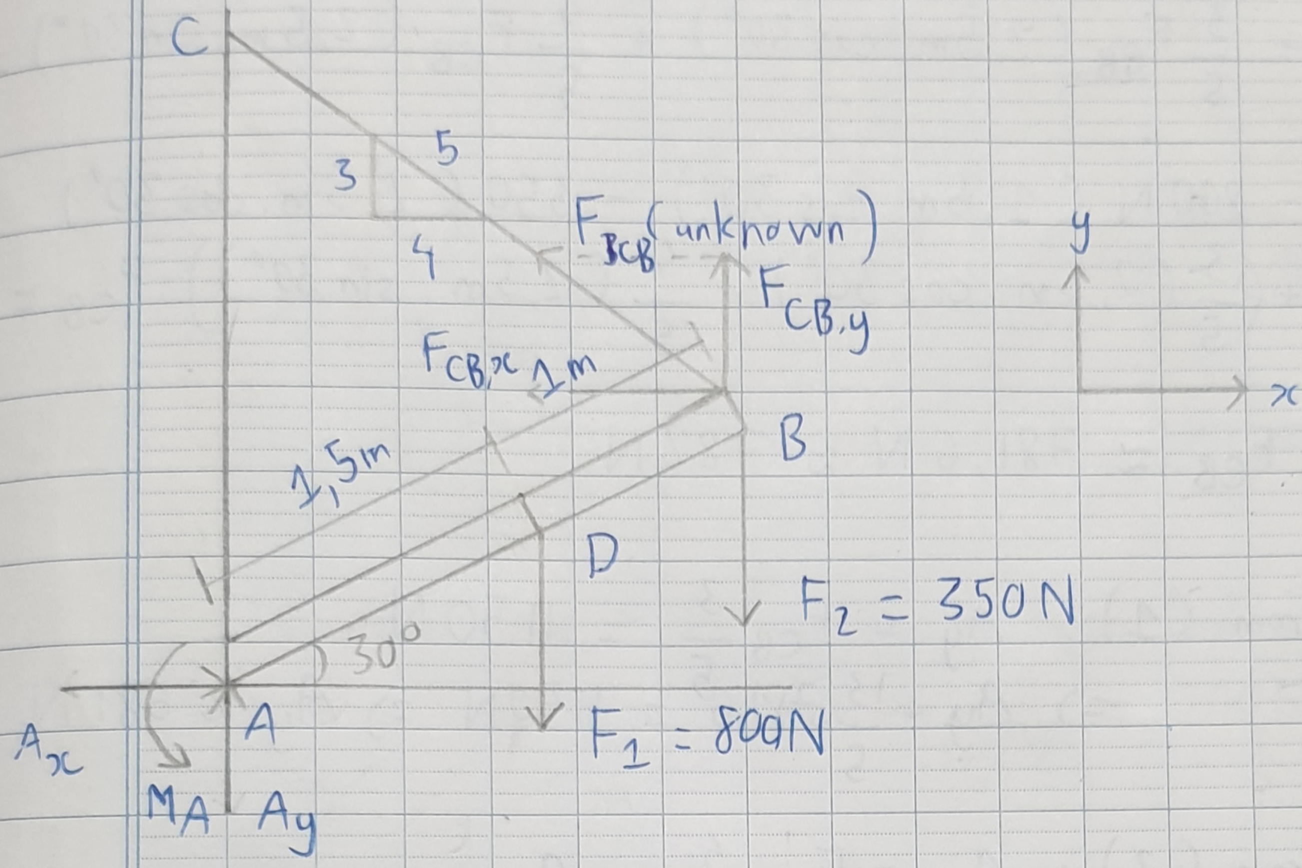
Statics & Dynamics (Assignment 2)

Exercise 1



For the structure to be in equilibrium

- $+\uparrow \Sigma F_y = 0$

$\Rightarrow A_y - 800N - 350N + F_{BC}\frac{3}{5} = 0$

$\Rightarrow A_y + F_{BC}\frac{3}{5} = 1150N$ (1)

- $+\rightarrow \Sigma F_x = 0$

$\Rightarrow A_x - F_{BC}\cdot\frac{4}{5} = 0N$ (2)

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$\circlearrowleft + M_A = 0$

$\Rightarrow -F_1 . (1{,}5m . \cos 30°) - F_2 (2{,}5m . \cos 30°)$

$+ \frac{3}{5} F_{CB} (2{,}5m . \cos 30°) + \frac{4}{5} F_{CB} (2{,}5m . \sin 30°) = 0$

$\Rightarrow -800N (1{,}5m . \cos 30°) - 350 (2{,}5m . \cos 30°)$

$+ \left(\frac{3}{5}(2{,}5m . \cos 30°) + \frac{4}{5}(2{,}5m . \sin 30°)\right) . F_{CB} = 0$

$\Rightarrow F_{CB} \approx 781{,}6 N \approx 782 N$

From (1) : $A_y + F_{CB} \frac{3}{5} = 1150 N$

$\Rightarrow A_y + \frac{3}{5} . 781{,}6 = 1150 N \Rightarrow A_y \approx 681 N$

From (2) : $A_x - F_{BC} \frac{4}{5} = 0$

$\Rightarrow A_x - \frac{4}{5} . 781{,}6 = 0 \Rightarrow A_x \approx 625 N$

Answer: $A_x = 625 N$

$A_y = 681 N$

$F_{CB} = 782 N$

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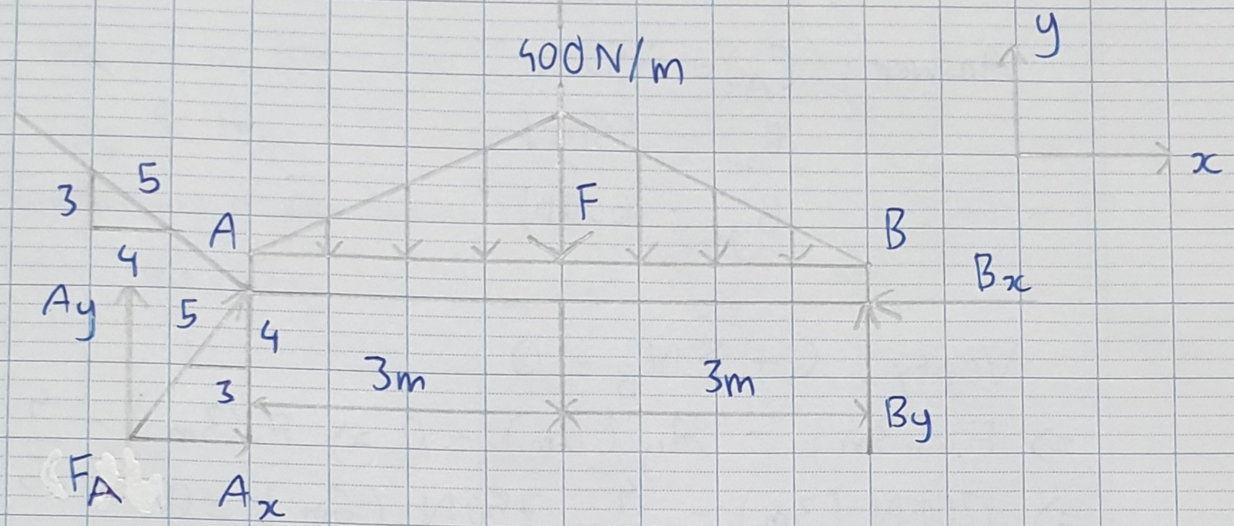
Exercise 2 : Determine reactions at the supports



The total force F acting from the beam from above

$$F = 400\ N/m \cdot (3m + 3m) \cdot \frac{1}{2} = 1200N$$

The reactions at support A: F_A

The reactions at support B: B_x and B_y

- Equilibrium

$+\uparrow \Sigma F_y = 0$

$$\Rightarrow \frac{4}{5} F_A + B_y - F \overset{=0}{} \Rightarrow \frac{4}{5} F_A + B_y = 1200N \ (1)$$

$+\rightarrow \Sigma F_x = 0$

$$\Rightarrow \frac{3}{5} F_A - B_x = 0 \ (2)$$

$$\circlearrowleft + \Sigma M_A = 0 \Rightarrow -F \cdot 3m + B_y \cdot 6m = 0$$

$$\Rightarrow -1200N \cdot 3m + B_y \cdot 6m = 0$$

$$\Rightarrow B_y = 600N$$

From (1) : $\frac{4}{5} F_A + 600N = 1200N \Rightarrow F_A = 750N$

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From (2): $\frac{3}{5} \cdot 750N - B_x = 0 \Rightarrow B_x = 450N$

Answer: $F_A = 750N$,

$B_x = 450N$

$B_y = 600N$

Verify: $\circlearrowleft + \Sigma M_B = 0$

$\Rightarrow F.(3m) - A_y(6m) = 0 \Rightarrow F.(3m) - \frac{4}{5} F_A (6m) = 0$

$\Rightarrow 1200N(3m) - \frac{4}{5} \cdot 750N.(6m) = 0$

(Correct equation)

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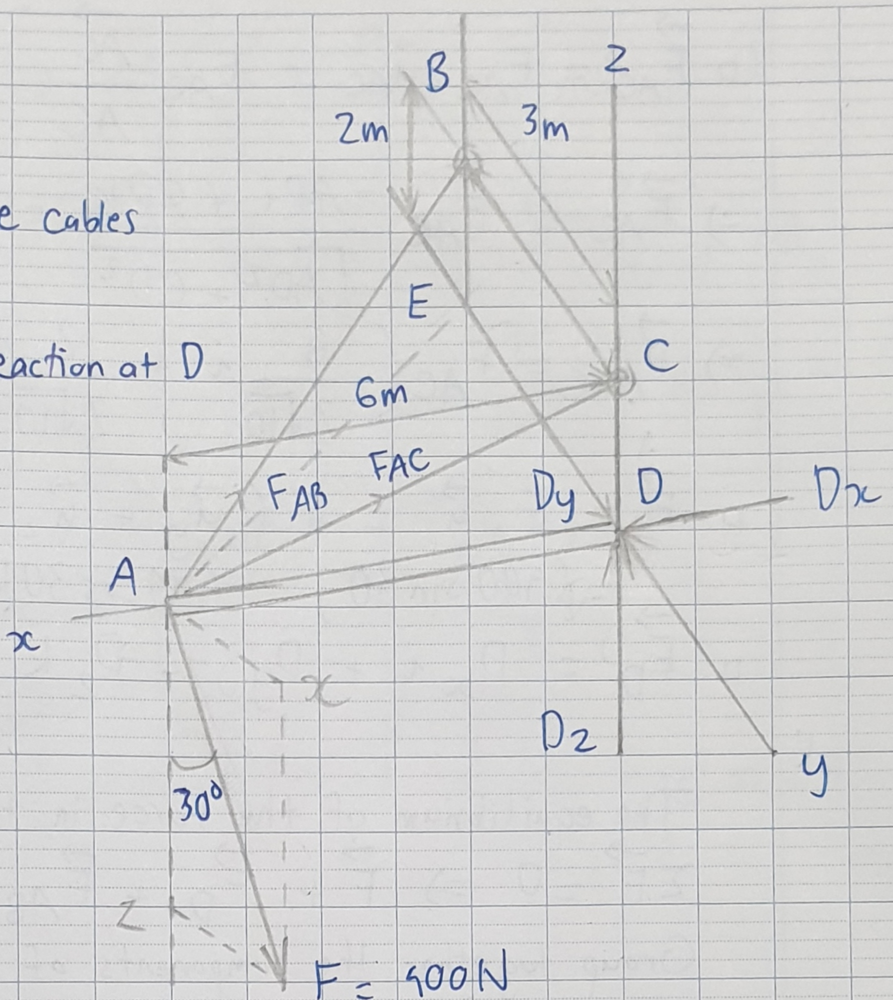
Exercise 3:



Tensions in the cables

F_{AB} & F_{AC}

Components of reaction at D

D_x, D_y, D_z

We have : $BC = ED = 3m$

$BE = CD = 2m$

$AD = 6m \quad AC = 2\sqrt{10}m$

$AE = 3\sqrt{5}m \quad AB = 7m$

Since we don't know the scalar length of components of $F = 400N$ => we use vectors. The coordinates are $A(6,0,0)$ $B(0,-3,2)$, $C(0,0,2)$, $D(0,0,0)$, $E(0,-3,0)$

We have

$\square$ $\vec{F}_{AB} = F_{AB} \cdot \vec{u}_{AB} = F_{AB} \dfrac{\overrightarrow{AB}}{AB}$

$\Rightarrow \vec{F}_{AB} = F_{AB} \dfrac{-AD\,i - ED\,j + EB\,k}{\sqrt{AD^2 + ED^2 + EB^2}} = F_{AB} \dfrac{-6i - 3j + 2k}{\sqrt{6^2 + 3^2 + 2^2}}$

$\Rightarrow \vec{F}_{AB} = F_{AB}\left(-\dfrac{6}{7} i - \dfrac{3}{7} j + \dfrac{2}{7} k\right) N$

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- $\vec{F}_{AC} = F_{AC} \cdot \vec{u}_{AC} = F_{AC} \dfrac{\vec{AC}}{AC}$

$\Rightarrow \vec{F}_{AC} = F_{AC} \dfrac{-AD i + CD k}{\sqrt{AD^2 + CD^2}} = F_{AC} \dfrac{-6i + 2k}{\sqrt{6^2 + 2^2}}$

$\Rightarrow \vec{F}_{A\cancel{B}C} = F_{AC} \left(-\dfrac{6}{2\sqrt{10}} i + \dfrac{2}{2\sqrt{10}} k \right) N$

- $\vec{F} = F . \vec{u} = F(\vec{u}_y + \vec{u}_z)$
$= (400 \sin 30 j - 400 \cos 30 k) N = (200 j - 200\sqrt{3} k) N$

- $\vec{F}_D = D_x i + D_y j + D_z k$

The equilibrium of the force in the system is

$\Sigma \vec{F} = 0 \Rightarrow \vec{F} + \vec{F}_D + \vec{F}_{AB} + \vec{F}_{AC} = \vec{0}$

Group together the components of each i, j, k, we have

$$\left(D_x - \frac{6}{7} F_{AB} - \frac{3\sqrt{10}}{10} F_{AC} \right) i + \left(D_y - \frac{3}{7} F_{AB} + 200 \right) j$$

$$+ \left(D_z + \frac{2}{7} F_{AB} + \frac{1}{\sqrt{10}} F_{AC} - 200\sqrt{3} \right) k = \vec{0}$$

For the components to equal 0

$$\Rightarrow \begin{cases} D_x - \frac{6}{7} F_{AB} - \frac{3\sqrt{10}}{10} F_{AC} = 0 \ (1) \\ D_y - \frac{3}{7} F_{AB} + 200 = 0 \ (2) \\ D_z + \frac{2}{7} F_{AB} + \frac{1}{\sqrt{10}} F_{AC} - 200\sqrt{3} = 0 \ (3) \end{cases}$$

Since $\vec{F}$, $\vec{F}_{AB}$ and $\vec{F}_{AC}$ starts at A and the moment equilibrium is at D $\Rightarrow$ The equilibrium of moments in the system is

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$$\Sigma \vec{M}_D = \vec{0} \Rightarrow \vec{DA}(\vec{F} + \vec{F}_{AB} + \vec{F}_{AC}) = \vec{0}$$

$$\Rightarrow 6i\left[(200j - 200\sqrt{3}k) + \left(\frac{-6}{7}i - \frac{3}{7}j + \frac{2}{7}k\right)F_{AB} + \left(-\frac{3\sqrt{10}}{10}i + \frac{1}{\sqrt{10}}k\right)F_{AC}\right] = \vec{0}$$

$$\Rightarrow 6\left(-\frac{2}{7}F_{AB} - \frac{1}{\sqrt{10}}F_{AC} + 200\sqrt{3}\right)j + 6\left(-\frac{3}{7}F_{AB} + 200\right)k = 0$$

$$\Rightarrow \begin{cases} -\frac{2}{7}F_{AB} - \frac{1}{\sqrt{10}}F_{AC} + 200\sqrt{3} = 0 \Rightarrow F_{AC} \approx 673,8N \\ -\frac{3}{7}F_{AB} + 200 = 0 \Rightarrow F_{AB} = \frac{1400}{3}N \end{cases}$$

Replace into (1): $D_x = \frac{6}{7}F_{AB} + \frac{3\sqrt{10}}{10}F_{AC}$

$$\Rightarrow D_x \approx 1039,2\ N$$

Replace into (2): $D_y = \frac{3}{7}F_{AB} - 200$

$$\Rightarrow D_y = 0$$

Replace into (3): $D_z = 200\sqrt{3} - \frac{2}{7}F_{AB} - \frac{1}{\sqrt{10}}F_{AC}$

$$\Rightarrow D_z \approx 0$$

Answers: $F_{AB} = \frac{1400}{3}N$ $\quad F_{AC} = 673,8N$

$D_x = 1039,2N \quad D_y = D_z = 0$

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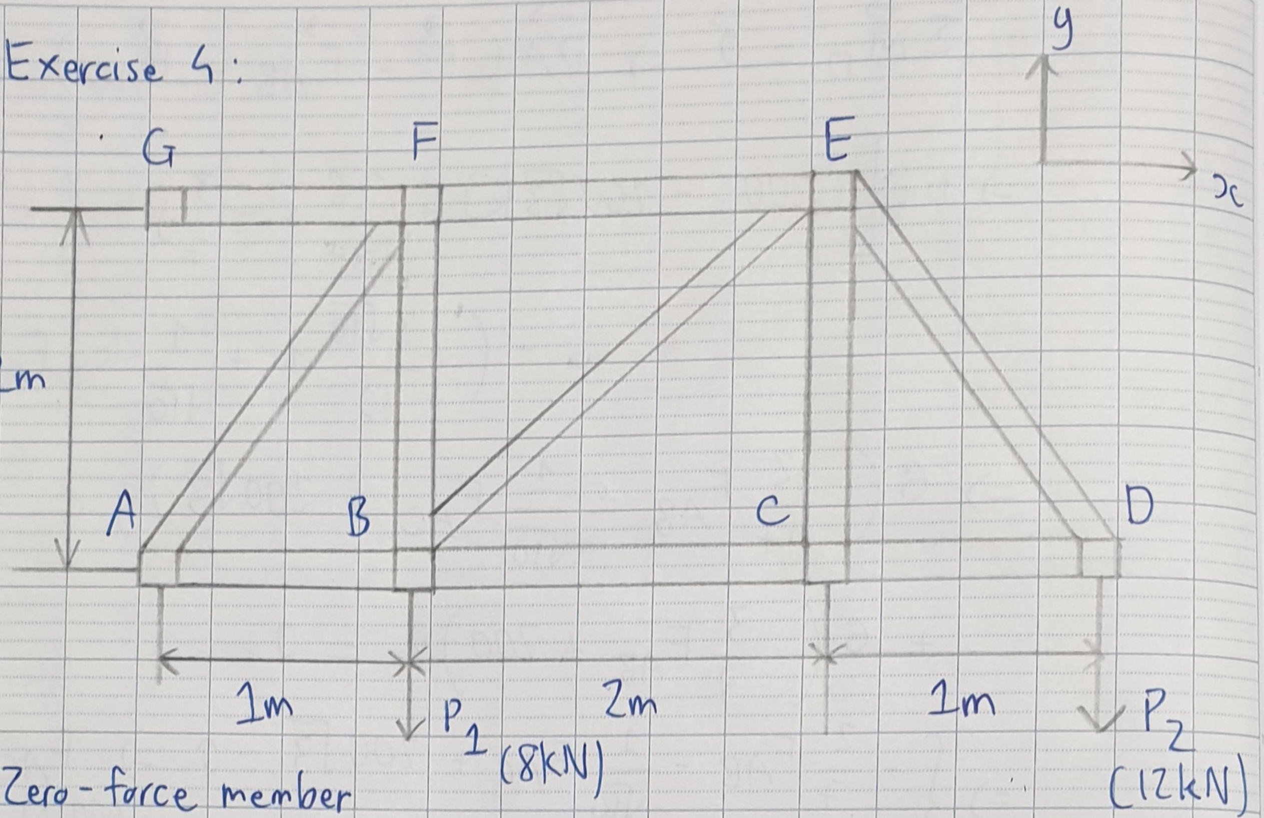
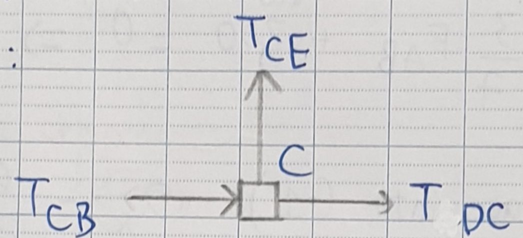
Exercise 4:



- Zero-force member

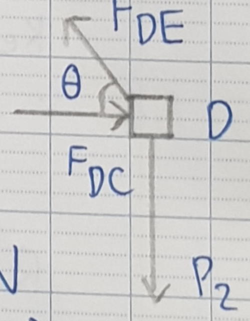
Equilibrium at C:



$+\uparrow \Sigma F_y = 0 \Rightarrow T_{CE} = 0 \Rightarrow$ CE is zero-force member

- Method of Joints

\- Equilibrium at D is



$+\uparrow \Sigma F_y = 0$

$\Rightarrow F_{DE} \sin\theta - P_2 = 0$

$\Rightarrow F_{DE}\left(\frac{2}{\sqrt{5}}\right) - 12 = 0 \Rightarrow F_{DE} = 6\sqrt{5}$ kN (Tension)

$+\rightarrow \Sigma F_x = 0$

$\Rightarrow F_{DC} - F_{DE}\cos\theta = 0$

$\Rightarrow F_{DC} = 6\sqrt{5} \cdot \frac{1}{\sqrt{5}} = 6$ kN

(Compression)

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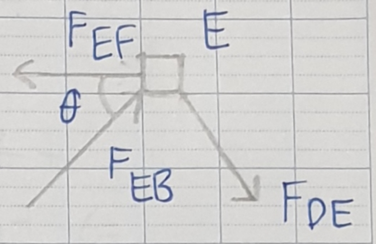
- Equilibrium at C

$+\rightarrow \Sigma F_x = 0 \Rightarrow F_{CB} - F_{DC} = 0 \Rightarrow F_{CB} = 6\,kN$ (Compression)

$+\uparrow \Sigma F_y = 0 \Rightarrow F_{CE} = 0$

- Equilibrium at E

$+\uparrow \Sigma F_y = 0$



$\Rightarrow F_{EB} \sin\theta - F_{DE}\left(\frac{2}{\sqrt{5}}\right) = 0$

$\Rightarrow F_{EB}\left(\frac{1}{\sqrt{2}}\right) - (6\sqrt{5})\left(\frac{2}{\sqrt{5}}\right) = 0 \Rightarrow F_{EB} = 12\sqrt{2}\,kN$ (Compression)

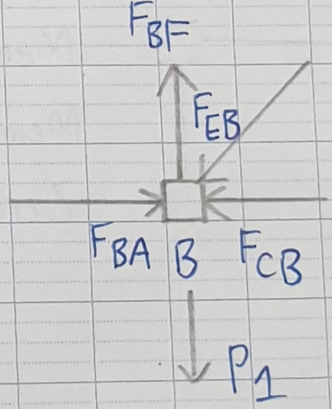
$+\rightarrow F_x = 0$

$\Rightarrow F_{DE}\left(\frac{1}{\sqrt{5}}\right) + F_{EB}\cos\theta - F_{EF} = 0$

$\Rightarrow 6\sqrt{5}\left(\frac{1}{\sqrt{5}}\right) + 12\sqrt{2}\left(\frac{1}{\sqrt{2}}\right) - F_{EF} = 0 \Rightarrow F_{EF} = 18\,kN$ (Tension)

- Equilibrium at B

$+\uparrow \Sigma F_y = 0$



$\Rightarrow F_{BF} - P_1 - F_{EB}\left(\frac{1}{\sqrt{2}}\right) = 0$

$\Rightarrow F_{BF} = 8 + 12\sqrt{2}\,\frac{1}{\sqrt{2}} = 20\,kN$ (Tension)

$+\rightarrow \Sigma F_x = 0$

$\Rightarrow F_{BA} - F_{CB} - F_{EB}\left(\frac{1}{\sqrt{2}}\right) = 0$

$\Rightarrow F_{BA} = 6 + (12\sqrt{2})\left(\frac{1}{\sqrt{2}}\right) = 18\,kN$ (Compression)

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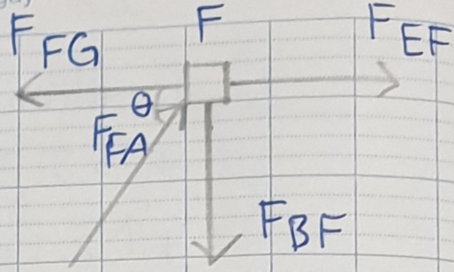

p Equilibrium at F

$+\uparrow \sum F_y = 0$

$\Rightarrow F_{FA} \sin\theta - F_{BF} = 0$

$\Rightarrow F_{FA} \dfrac{2}{\sqrt{5}} - 20 = 0 \Rightarrow F_{FA} = 10\sqrt{5}$ kN (Compression)

$+\rightarrow \sum F_x = 0$

$\Rightarrow F_{EF} - F_{FG} + F_{FA} \cos\theta = 0$

$\Rightarrow 18 - F_{FG} + 10\sqrt{5} \cdot \dfrac{1}{\sqrt{5}} \Rightarrow F_{FG} = 28$ kN (Tension)

Answer : $F_{DE} = 6\sqrt{5}$ kN

$F_{DC} = F_{CB} = 6$ kN $\quad F_{CE} = 0$

$F_{EB} = 17$ kN

$F_{EF} = F_{BA} = 18$ kN $\quad F_{BF} = 20$ kN

$F_{FA} = 10\sqrt{5}$ kN $\quad F_{FG} = 28$ kN

Members in tension: GF , FE, EB , ED

Members in compression: AF , AB , BC , CD

Zero force member: CE

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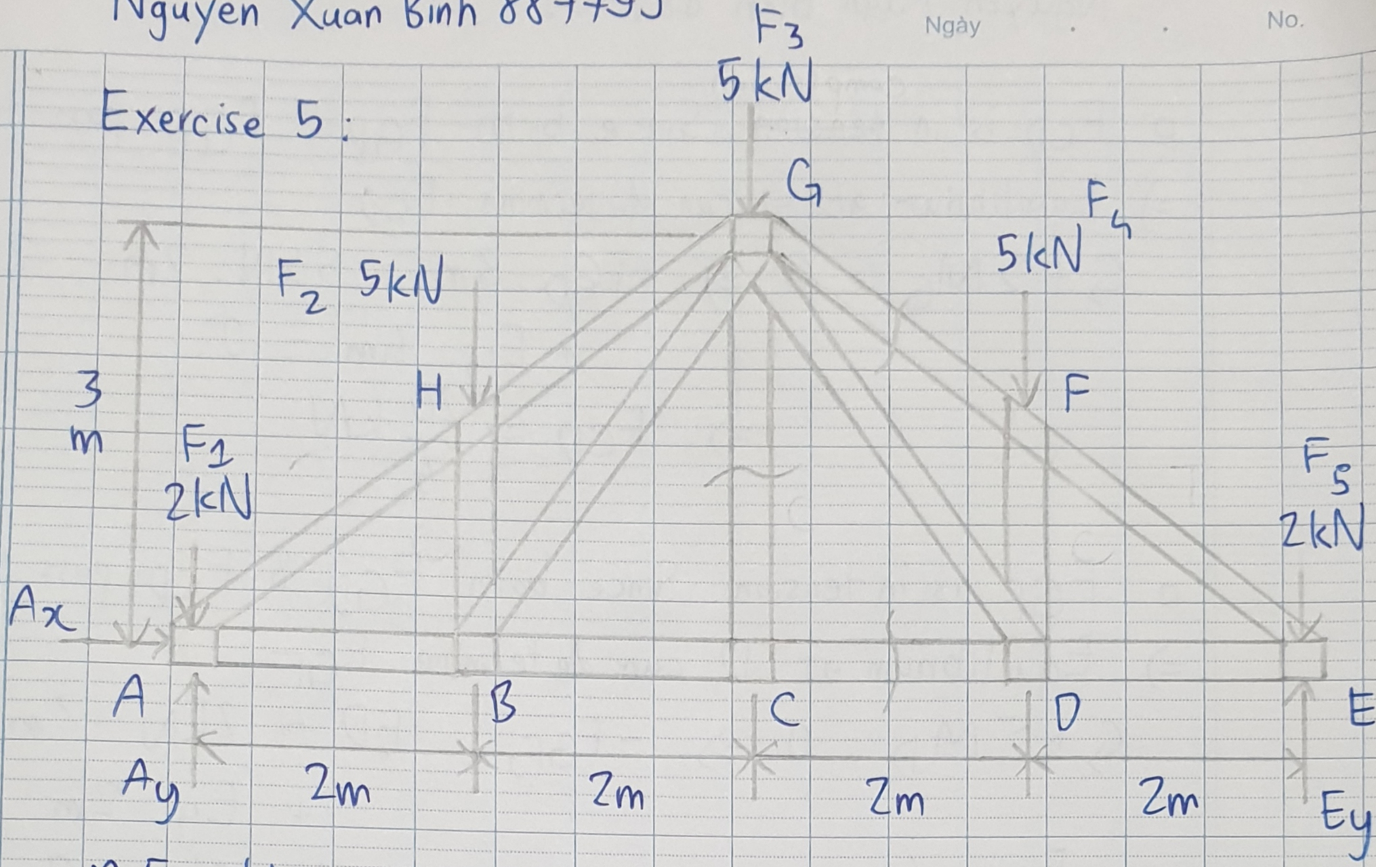
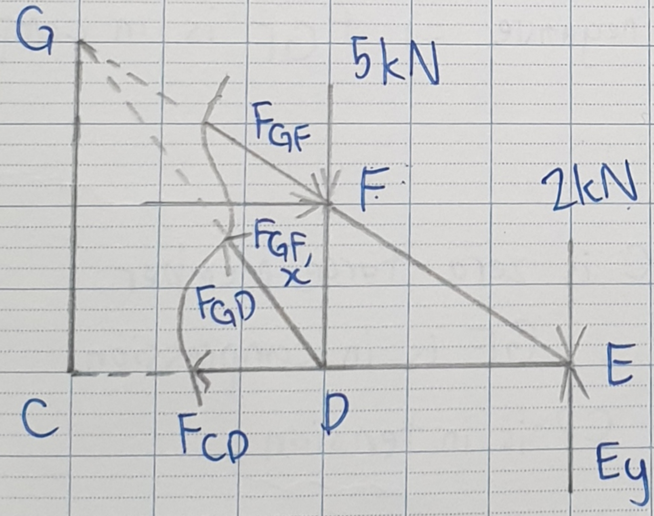
Exercise 5:



- A Equilibrium at point C

$\uparrow \Sigma F_y = 0 \Rightarrow F_{GC} = 0$

- Method of ~~sessions~~ sections



Speculation

Since $F_3 = 5kN$ act on G, CD and GD member will be in tension to support the force

Since $F_3 = 5kN$ and $F_4 = 5kN$ act on G and F, GF will be stretched

$\Rightarrow$ GF is in compression

Find Ey: A is in equilibrium

$\Rightarrow \circlearrowleft + \Sigma M_A = 0 \Rightarrow -5kN.2m - 5kN.4m - 5kN.6m + E_y.8m - 2kN.8m$

$\Rightarrow E_y = 9,5kN$

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- F_{CD} is in tension. Since both F_{GD} & F_{GF} pass through G

=) Equilibrium at G can determine F_{CD}

$$\circlearrowleft + \sum M_G = 0 \Rightarrow -F_{CD} \cdot 3m - 5kN \cdot 2m - 2kN \cdot 4m + E_y \cdot 4m = 0$$

$$\Rightarrow F_{CD} = \frac{20}{3} kN$$

- F_{GF} is in tension. Since both F_{GD} & F_{CD} pass through D

=) Equilibrium at D can determine F_{GF}

$$\circlearrowleft + \sum M_D = 0 \Rightarrow -F_{GF,x} \cdot FD - 2kN \cdot 2m + E_y \cdot 2m = 0$$

$$\Rightarrow -F_{GF} \cdot \frac{4}{5} \cdot 1,5m - 2kN \cdot 2m + 9,5kN \cdot 2m = 0$$

$$\Rightarrow F_{GF} = -12,5 kN$$

Since the result is negative =) F_{GF} is in compression

Answer

- $F_{GC} = 0$. GC is zero-force member
- $F_{GF} = 12,5 kN$. GF is in compression
- $F_{CD} = \frac{20}{3} kN$. CD is in tension