SOLUTIONS TO ASSIGNMENT

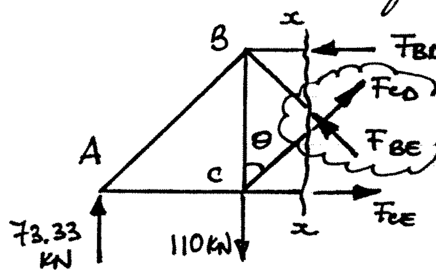
1. • Calculate the reaction forces on the FBD of the whole truss:

$\sum M_A = 0 \quad F_y(12) - 110(4) = 0 \quad \therefore \underline{F_y = 36.67\ \text{kN}\uparrow}$

$\sum F_x = 0 \quad \therefore A_x = 0$

$\sum F_y = 0 \quad A_y + 36.67 - 110 = 0 \quad \therefore \underline{A_y = 73.33\ \text{kN}\uparrow}$

• Cut the truss through members BD, BE, CD and CD and use the LHS of the resulting FBD.



One of these members must be in tension while the other must "go into compression" and hence go slack with zero force. For vertical equilibrium, the one in tension must have an upward vertical component of 110−73.33 = 36.67 kN, and that member can only be member CD. Therefore, $\underline{F_{BE} = 0\ \text{kN}}$. Then,

$\sum M_C = 0 \quad (-73.33)(4) + F_{BD}(3) = 0 \quad \therefore \underline{\underline{F_{BD} = 97.8\ \text{kN}\ (C)}}$

$\sum M_D = 0 \quad (-73.33)(8) + (110)(4) + F_{CE}(3) = 0 \quad \therefore \underline{\underline{F_{CE} = 48.9\ \text{kN}\ (T)}}$

$\sum F_y = 0 \quad 73.33 + F_{CD}\overbrace{\cos\theta}^{3/5} - 110 = 0 \quad \therefore \underline{\underline{F_{CD} = 61.1\ \text{kN}\ (T)}}$

• Design of member CE (Tension): Factored load: $F_f = (1.8)(48.9) = 88.02\ \text{kN}$

$A^{req'd} = \frac{F_f}{\sigma_y} = \frac{88.02\times10^3}{300} = 293.4\ \text{mm}^2$; Select $\underline{\underline{L\ 55\times55\times3}}$ with $A = 321\ \text{mm}^2$

• Design of member BD (Compression): Factored load: $F_f = (2.0)(97.8) = 195.6\ \text{kN}$

− Yielding: $A^{req'd} = \frac{F_f}{\sigma_y} = \frac{195.6\times10^3}{300} = 652\ \text{mm}^2$

− Buckling: $I^{req'd} = \frac{F_f L^2}{\pi^2 E} = \frac{(195.6\times10^3)(4000)^2}{\pi^2(200{,}000)} = 1.585\times10^6\ \text{mm}^4$

Select a section with both $A \geq A^{req'd}$ and $I \geq I$

Sections which can be selected: $\begin{cases} L\ 90\times90\times13, & A = 2{,}170\ \text{mm}^2,\ I = 1.60\times10^6\ \text{mm}^4 \\ L\ 100\times100\times10, & A = 1{,}900\ \text{mm}^2,\ I = 1.80\times10^6\ \text{mm}^4 \end{cases}$

Of these, select $\underline{\underline{L\ 100\times100\times10}}$ since it has a lower mass (14.9 kg/m) and, hence, is cheaper.

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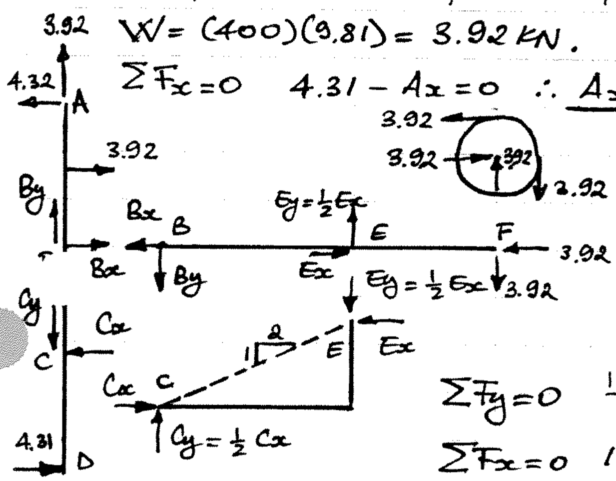
2. The frame is RIGID if removed from its supports, so calculate the reactions at A and D first

$W = (400)(9.81) = 3.92\ \text{kN}$. $\sum M_A = 0 \quad (-3.92)(5.5) + D_x(5) = 0 \quad \therefore \underline{D_x = 4.31\ \text{kN}\rightarrow}$

$\sum F_x = 0 \quad 4.31 - A_x = 0 \quad \therefore \underline{A_x = 4.31\ \text{kN}\leftarrow}$; $\sum F_y = 0 \quad A_y - 3.92 = 0 \quad \therefore \underline{A_y = 3.92\ \text{kN}\uparrow}$



Then, separate the component parts and draw FBDs as shown. Note that member CE is a two force member being acted upon by two forces along line CE, or by the equivalent forces shown.

• On FBD of member BF: $\sum M_B = 0 \quad (-3.92)(5) + \frac{1}{2}E_x(3) = 0$

$\therefore \underline{E_x = 13.07\ \text{kN}\rightarrow}$ and $\underline{E_y = \frac{1}{2}E_x = 6.54\ \text{kN}\uparrow}$ (on BF)

$\sum F_y = 0 \quad \frac{13.07}{2} - B_y - 3.92 = 0 \quad \therefore \underline{\underline{B_y = 2.62\ \text{kN}\downarrow}}$

$\sum F_x = 0 \quad 13.07 - B_x - 3.92 = 0 \quad \therefore \underline{\underline{B_x = 9.15\ \text{kN}\leftarrow}}$

on BF

- On FBD of member CE: $\Sigma F_x = 0 \quad C_x = E_x = \underline{\underline{13.07\,kN \rightarrow}}$
  $\Sigma F_y = 0 \quad C_y = E_y = \underline{\underline{6.54 \uparrow}}$ } on CE.

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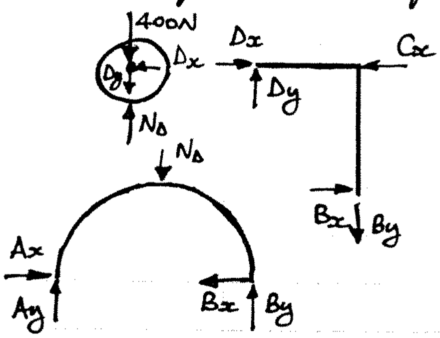
3. Since the frame is RIGID, start by calculating the external reactions on a FBD of the entire frame

$\Sigma M_A = 0 \quad (-400)(3) + C_x(3.5) = 0 \quad \therefore \underline{C_x = 342.9\,N \leftarrow}$

$\Sigma F_x = 0 \quad A_x - 342.9 = 0 \quad \therefore \underline{A_x = 342.9\,N \rightarrow}$

$\Sigma F_y = 0 \quad A_y - 400 = 0 \quad \therefore \underline{A_y = 400\,N \uparrow}$

Then, separate the component parts and draw FBDs as shown:



- On FBD of member AB: $\Sigma F_x = 0 \quad 342.9 - B_x = 0$
  $\therefore \underline{\underline{B_x = 342.9\,N \leftarrow}}$
  $\Sigma M_B = 0 \quad (-400)(6) + N_D(3) = 0 \quad \therefore \underline{\underline{N_D = 800\,N \downarrow}}$
  $\Sigma F_y = 0 \quad 400 - 800 + B_y = 0 \quad \therefore \underline{\underline{B_y = 400\,N \uparrow}}$ } (on AB)
- On FBD of the Disc: $\Sigma F_x = 0 \quad \therefore \underline{\underline{D_x = 0}}$
  $\Sigma F_y = 0 \quad 800 - 400 - D_y = 0 \quad \therefore \underline{\underline{D_y = 400\,N \downarrow}}$ (on Disc)

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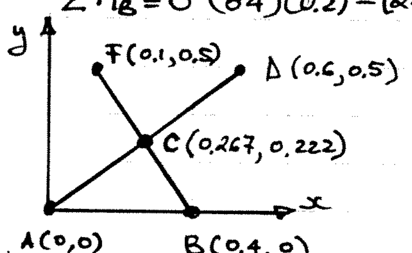
4. Again, this frame is RIGID, hence calculate the external reactions first:

$\Sigma F_x = 0 \quad 24 - 28\cos\theta = 0,$ where $\theta = \tan^{-1}(3/5) = 30.96°$. OK (satisfied identically)

$\Sigma F_y = 0 \quad A_y + B_y - 84 - 28\sin\theta = 0$

$\Sigma M_B = 0 \quad (84)(0.2) - (24)(0.5) - 0.4(A_y) + (28)\left(0.3 + \frac{0.5}{\cos 30.96°}\right) = 0 \quad \therefore \quad \underline{\underline{A_y = 73.82\,N \uparrow}} \quad \underline{\underline{B_y = 24.58\,N \uparrow}}$

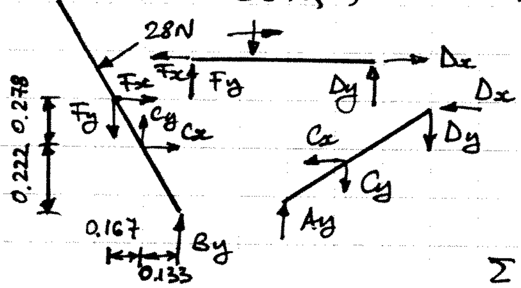


- To calculate the point of intersection of AD and BF (point C) write the equations of AD and BF and solve for x and y:

$AD: \; y = \frac{0.5}{0.6}x = 0.833x \; ; \; BF: \; y = -\frac{0.5}{0.3}x + 0.667 = -1.667x + 0.667$

Hence, $x = 0.267$ and $y = 0.222$ and $C(0.267, 0.222)$

Then, separate the component parts as shown:



- On FBD of DF:
  $\Sigma M_D = 0 \quad (84)(0.4) - (0.5)F_y = 0$
  $\Sigma F_y = 0 \quad F_y + D_y - 84 = 0$
  $\Sigma F_x = 0 \quad D_x - F_x + 24 = 0$
  $\therefore \quad F_y = 67.2\,N \uparrow, \quad D_y = 16.8\,N \uparrow, \quad D_x = F_x - 24$ } ON DF
- On FBD of BH: $\Sigma F_x = 0 \quad F_x + C_x - (28)\cos 30.96° = 0$
  $\Sigma F_y = 0 \quad 24.58 + C_y - 67.2 - 28\sin 30.96° = 0 \quad \therefore \underline{\underline{C_y = 57.0\,N \uparrow}}$

$\Sigma M_c = 0 \quad (28)(0.3 + (0.167)/\sin 30.96°) + (24.58)(0.133) + (67.2)(0.167) - F_x(0.278) = 0 \quad \therefore \underline{\underline{C_x = 91.0\,N \leftarrow}} \quad \underline{\underline{F_x = 115.1\,N \rightarrow}} \quad \underline{\underline{F_y = 67.2\,N \downarrow}}$ } on BH

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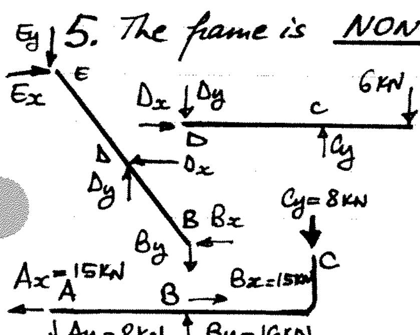
5. The frame is NON-RIGID, so analyse the component parts first:



- On FBD of CD: $\Sigma F_x = 0 \quad D_x = 0$
  $\Sigma M_D = 0 \quad C_y(3) - (6)(4) = 0 \quad \therefore \underline{\underline{C_y = 8\,kN \uparrow}}$
  $\Sigma F_y = 0 \quad 8 - 6 - D_y = 0 \quad \therefore \underline{\underline{D_y = 2\,kN \downarrow}}$ } ON CD
- On FBD of AC: $\Sigma M_A = 0 \quad (-8)(4) + B_y(2) = 0 \quad \therefore \underline{B_y = 16\,kN \uparrow}$ on AC
- On FBD of BE: $\Sigma M_E = 0 \quad (2)(1) - 0(1) - 16(2) - B_x(2) = 0 \quad \therefore \underline{B_x = 15\,kN \leftarrow}$ on B
- On FBD of AC: $\Sigma F_y = 0 \quad -8 + 16 - A_y = 0 \quad \therefore \underline{\underline{A_y = 8\,kN \downarrow}}$
  $\Sigma F_x = 0 \quad 15 - A_x = 0 \quad \therefore \underline{\underline{A_x = 15\,kN \leftarrow}}$ } on AC