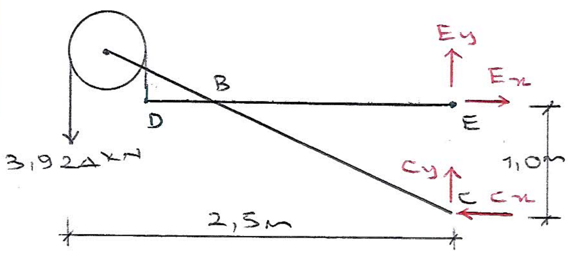
Problem set 7 (PS7)
Solution

1.



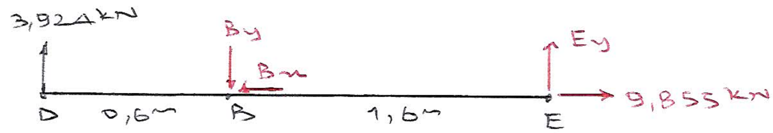
- First, look at the global system.

$\Sigma M_E = 0 \Rightarrow 3{,}924^{kN} \cdot 2{,}5^m - Cx \cdot 1{,}0^m = 0$

$\Rightarrow Cx = 9{,}855\ kN$

$\Sigma F_x = 0 \Rightarrow Ex = Cx = 9{,}855\ kN$

- Now, look at member DBE



- $\Sigma M_E = 0 \Rightarrow By \cdot 1{,}6^m - 3{,}924 \cdot (0{,}6 + 1{,}6) = 0 \Rightarrow By = 5{,}396\ kN$

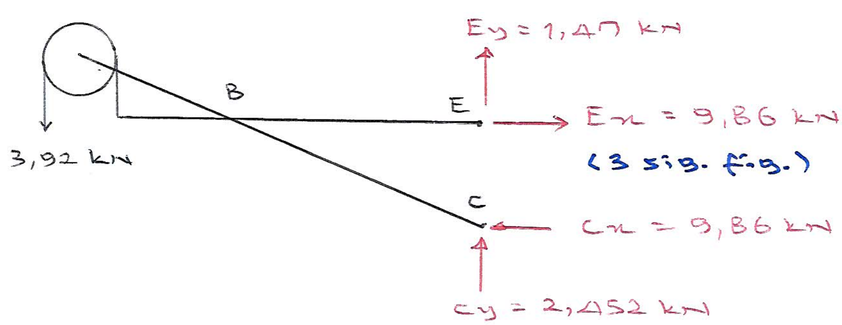
$\Sigma F_y = 0 \Rightarrow Ey + 3{,}924 - By = 0 \Rightarrow Ey = 1{,}472\ kN$

$\Sigma F_x = 0 \Rightarrow Bx = 9{,}855\ kN$

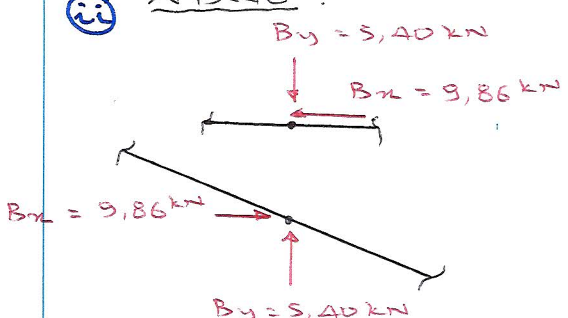
- Finally, look back at the global system:

$\Sigma F_y = 0 \Rightarrow Ey + Cy = 3{,}924\ kN \Rightarrow Cy = 2{,}452\ kN$

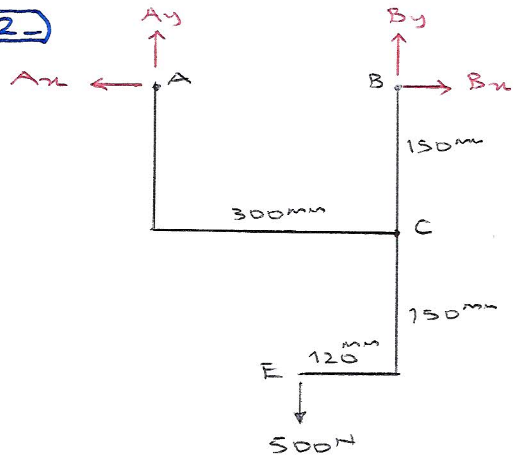
(i) Answer:



(ii) Answer:



2.



- First, look at the global system.

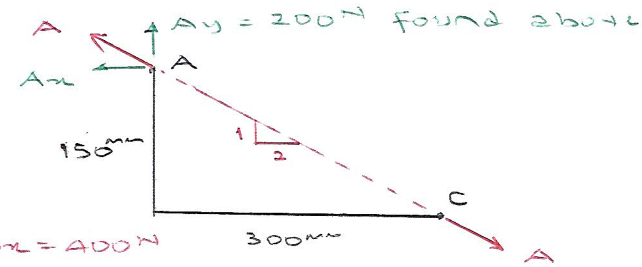
$\Sigma M_A = 0 \Rightarrow B_y \cdot 300 - 500 \cdot 180 = 0$

$\Rightarrow B_y = 300\ N$

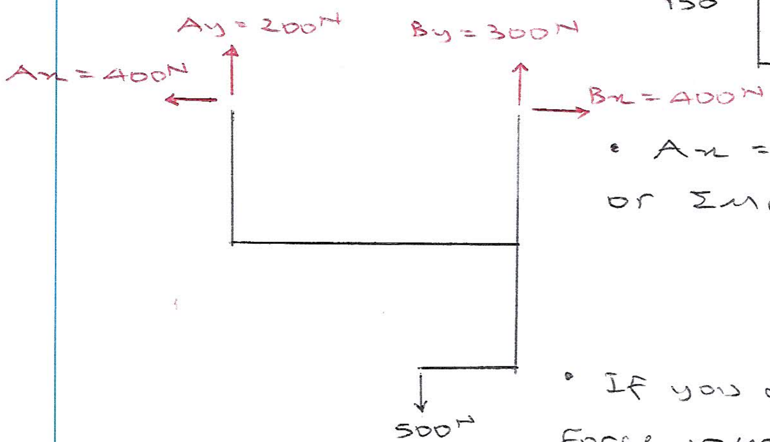
$\Sigma F_y = 0 \Rightarrow A_y + B_y = 500\ N \Rightarrow A_y = 200^N$

$\Sigma F_x = 0 \Rightarrow A_x = B_x$

- Then look at member AC. Realize that AC is a two-force member.



i. Answer :



- $A_x = 2 \cdot A_y = 400\ N$

or $\Sigma M_C = 0 \Rightarrow A_x \cdot 150 - A_y \cdot 300 = 0$

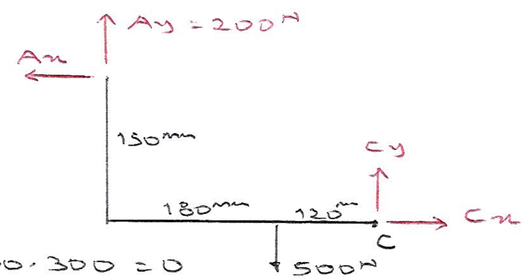
$\Rightarrow A_x = 400\ N$

$\Rightarrow B_x = 400\ N$ from above

- If you don't realize AC is a two-force member, the problem can still be solved. It will require looking at BCE as well. Try this approach to confirm you get the same results.

ii. Same as (i) : $B_y = 300\ N \uparrow$

$A_y = 200\ N \downarrow$



- Re-analyze member AC :

$\Sigma M_C = 0 \Rightarrow A_x \cdot 150 + 500 \cdot 120 - 200 \cdot 300 = 0$

$\Rightarrow A_x = 0\ N$

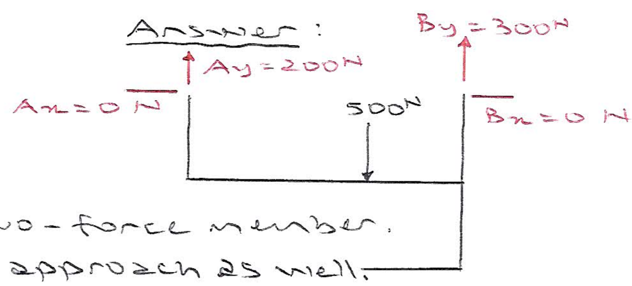
$\Sigma F_y = 0 \Rightarrow A_y + C_y = 500\ N \Rightarrow C_y = 300\ N$

$\Sigma F_x = 0 \Rightarrow A_x = C_x \Rightarrow C_x = 0\ N$

- From the global system :

$\Sigma F_x = 0 \Rightarrow A_x = B_x \Rightarrow B_x = 0\ N$

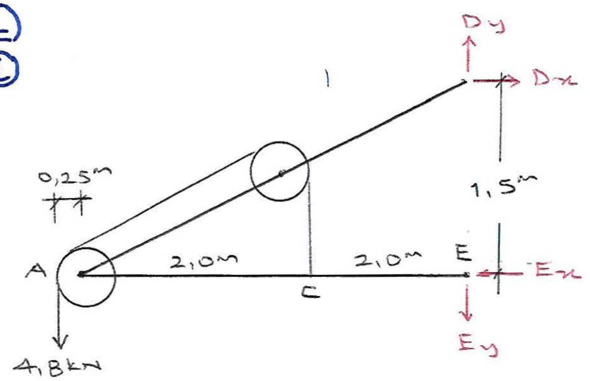
Answer :



- Note : now member BC is a two-force member. We could have use this. Try this approach as well.

3.)

(i)



• First, look at the global (i.e, whole) system.

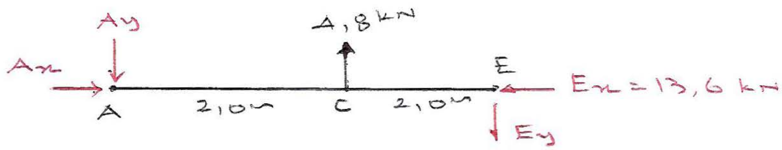
$\Sigma M_E = 0 \Rightarrow 4{,}8^{kN} \cdot 4{,}25^m - Dx \cdot 1{,}5^m = 0$

$\Rightarrow Dx = 13{,}6\ kN$

$\Sigma Fx = 0 \Rightarrow Ex = Dx \Rightarrow Ex = 13{,}6\ kN$

$\Sigma Fy = 0 \Rightarrow Dy - Ey = 4{,}8\ kN$

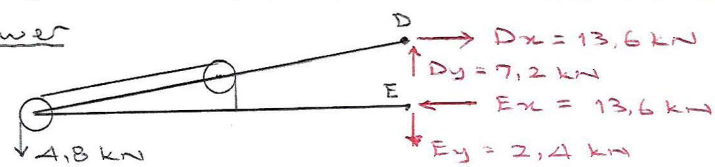
• Then, look at the easier part. Member ACE



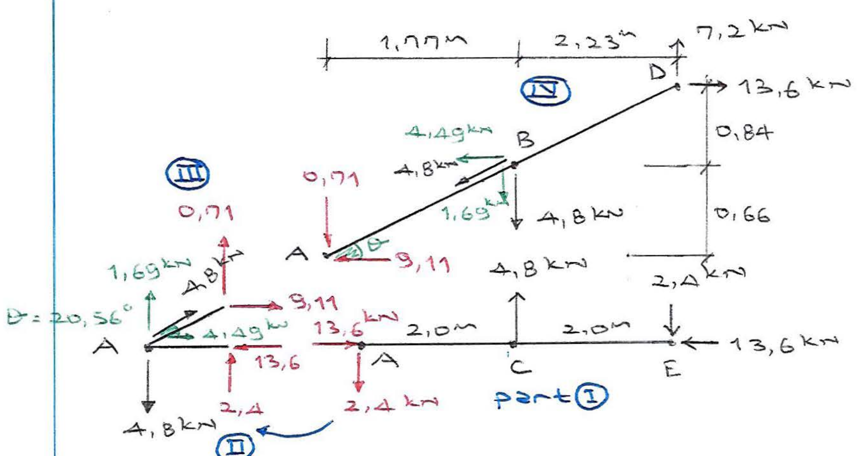
$\Sigma M_A = 0 \Rightarrow 4{,}8^{kN} \cdot 2{,}0^m - Ey \cdot 4{,}0^m = 0 \Rightarrow Ey = 2{,}4\ kN$

From the global system : $Dy = 4{,}8 + 2{,}4 = 7{,}2\ kN$

Answer



(ii) Loads are applied at the pin at A ; need to consider point A separately while disintegrating the system.



• Part I : Find two unknown forces at A using Equilibr.

• Joint A : transfer 13,6 and 2,4 kN. Do $\Sigma Fx = 0$; $\Sigma Fy = 0$ to find 0,71 and 9,11 kN.

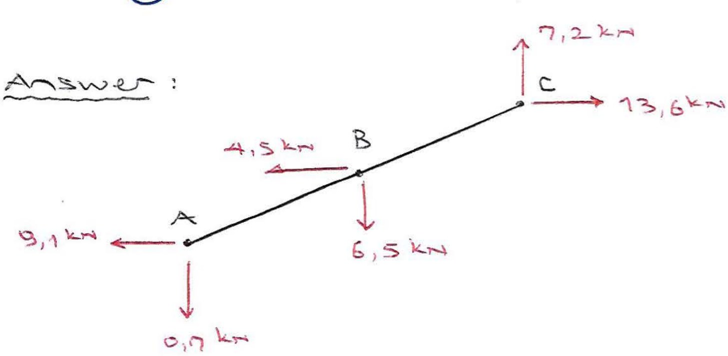
• Part IV : no unknowns. Check equilibrium to make sure solution is ok.

$\Sigma M_A = 0 \Rightarrow -(4{,}8 + 1{,}69) \cdot 1{,}77$

$-13{,}6 \cdot 1{,}5 + 7{,}2 \cdot 4{,}0 + 4{,}49 \cdot 0{,}66$

$= 0{,}12 \approx 0$ $\boxed{\text{ok}}$ ✓

Answer :



4-

(i) Given: $L_{AE} = 3200\,mm$; $F_{AE} = +105\,kN$ (T)

- Factored Load: $F_{AEf} = 1{,}9 \cdot 105 = 199{,}5\,kN$
- Required Sectional Area: $A = P / \sigma_{yield} = 199{,}5 \cdot 10^3 N / 350^{MPa}$
  $= 570\,mm^2$
- Provide Square section: $a \times a = 570\,mm^2 \Rightarrow a = 23{,}9\,mm$
  Select a section $\overline{\underline{25mm + 25mm}}$
  Answer
- Actual Axial stress: $\sigma = \dfrac{P}{A} = \dfrac{+105 \cdot 10^3 N}{25 \cdot 25\,mm^2} = \overline{\underline{168\,MPa \ (T)}}$
  Answer
- Axial Deformation: $\Delta L = \dfrac{P \cdot L}{A \cdot E} = \dfrac{+105 \cdot 10^{3\,N} \cdot 3200^{mm}}{25 \cdot 25^{mm^2} \cdot 200\,000^{MPa}} = +2{,}69\,mm$ (elongation)
  Answer
- Axial strain: $\varepsilon = \dfrac{\Delta L}{L} = \dfrac{2{,}69^{mm}}{3200^{mm}} = \overline{\underline{0{,}840 \cdot 10^{-3}\ mm/mm}}$
  Answer

(ii) Given: $L_{BF} = 3200\,mm$, $F_{BF} = -100\,kN$ (C)

- First, consider yielding.
  From table on P13 for L75×75×10
  $P_{yield} = \sigma_{yield} \cdot A = 350^{MPa} \cdot 1400^{mm^2} = 490 \cdot 10^3 N = \underline{490\,kN}$
- Then, consider buckling:
  From table on P13 for L75×75×10
  $P_{Euler} = \dfrac{\pi^2 \cdot E \cdot I}{L^2} = \dfrac{\pi^2 \cdot 200\,000^{MPa} \cdot 0{,}725 \cdot 10^6\,mm^4}{3200^2} = \underline{139{,}8\,kN} < 490^{kN}$
- Member will buckle before yielding.

$\therefore$ $P_{fail} = -139{,}8\,kN$ (C)

- Load Factor: $\dfrac{P_{Failure}}{P_{service}} = \dfrac{-139{,}8\,kN}{-100\,kN} = \overline{\underline{1{,}40}}$
  Answer
- Comment: Load Factor of 1,40 is less than 1,7.
  Answer
  Safety margin is less than desired.
  $\therefore$ A larger member section (with a larger cross-section area) must be used.
  → Section is not adequate.