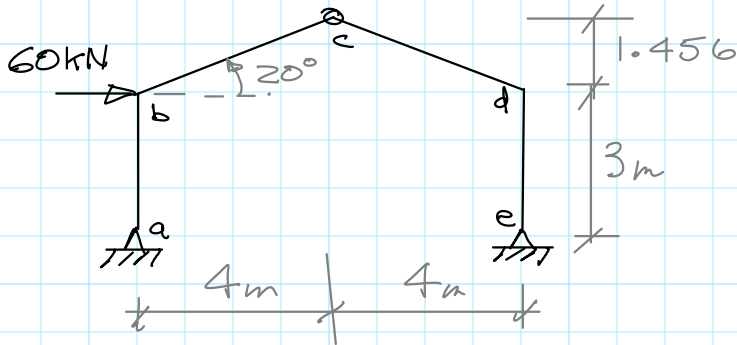
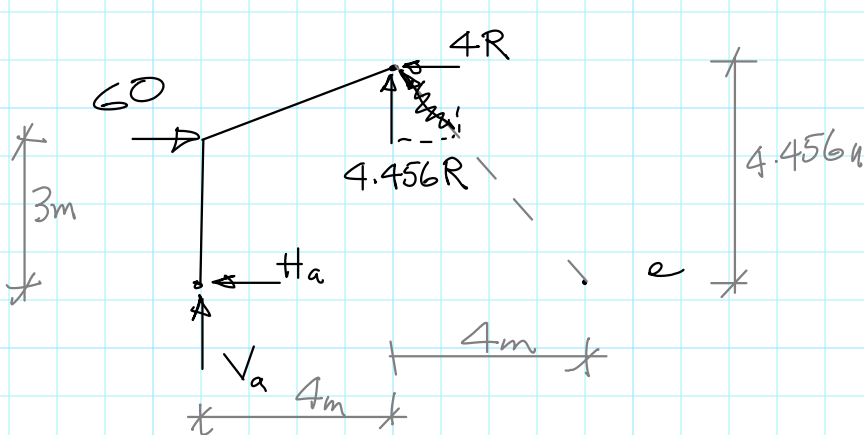


Example F2: Frames - Member End Forces & Joint Equilibrium



Recognizing c-d-e as a 2 force member:



∴ resultant of force @ c lies along c-e & thus components are in same ratio as distances
 $4 : 4.456$

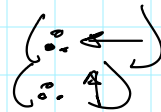
$$\sum M_a = 0 \quad (\curvearrowright)$$

$$-60 \times 3 + 4R \times 4.456 + 4.456R \times 4 = 0$$

$$R = 5.049$$

$$4R = 20.20 \text{ kN}$$

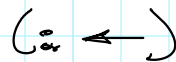
$$4.456R = 22.50 \text{ kN}$$



$$\sum F_x = 0 \quad \rightarrow$$

$$60 - 4R - H_a = 0$$

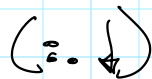
$$H_a = 39.80 \text{ kN}$$



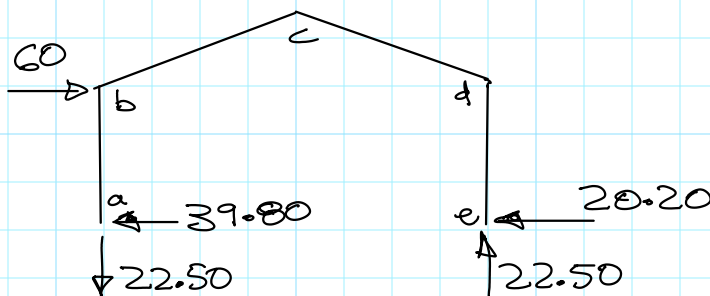
$$\sum F_y = 0 \quad \uparrow$$

$$V_a + 4.456R = 0$$

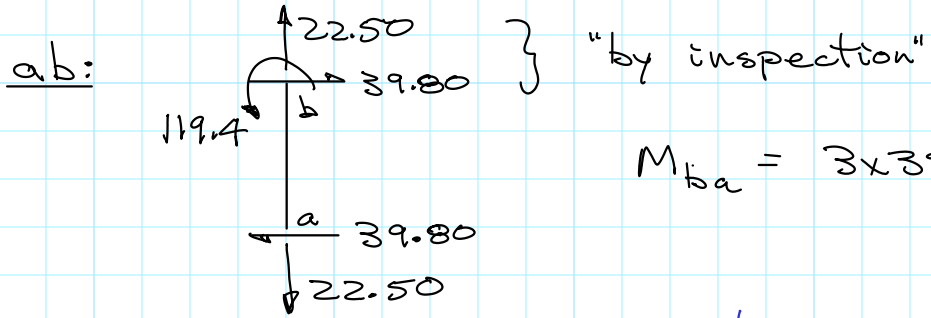
$$V_a = -22.50 \text{ kN}$$



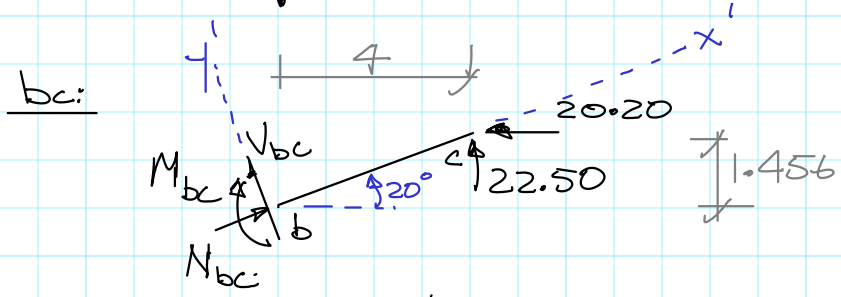
Summary



Member End Forces



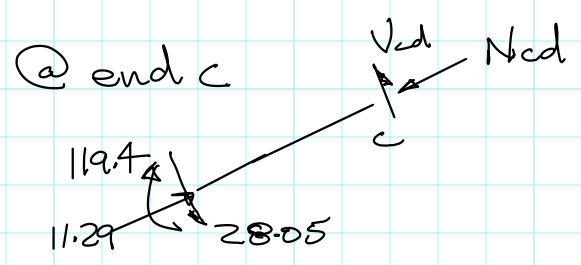
$$M_{ba} = 3 \times 39.80 = 119.4$$



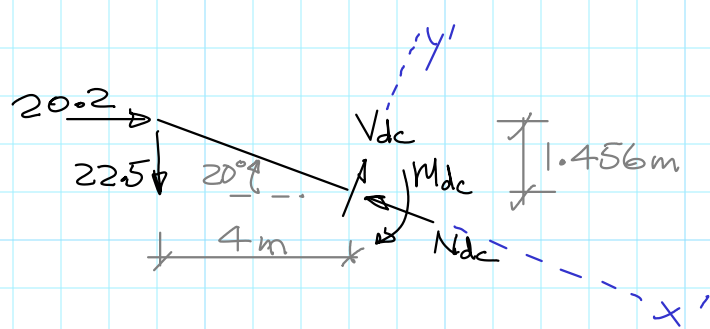
$$\sum F_{x'} = 0 \rightarrow$$
$$-20.20 \cos 20^\circ + 22.50 \sin 20^\circ + N_{bc} = 0$$
$$N_{bc} = 11.29 \text{ kN} \quad (\rightarrow)$$

$$\sum F_{y'} = 0 \uparrow$$
$$22.50 \cos 20^\circ + 20.20 \sin 20^\circ + V_{bc} = 0$$
$$V_{bc} = -28.05 \quad (\downarrow)$$

$$\sum M_b = 0 \quad (+)$$
$$-M_{bc} + 22.50 \times 4 + 20.20 \times 1.456 = 0$$
$$M_{bc} = 119.4 \text{ kNm} \quad (\curvearrowleft)$$



$$\underline{V_{cd} = 28.05 \text{ kN}}$$
$$\underline{N_{cd} = 11.29 \text{ kN}}$$

cd:

$$\sum F_{x'} = 0 \quad \rightarrow$$

$$20.2 \cos 20^\circ + 22.5 \sin 20^\circ - N_{dc} = 0$$

$$N_{dc} = 26.68 \text{ kN} \quad (\leftarrow)$$

$$\sum F_{y'} = 0 \quad \uparrow$$

$$20.2 \sin 20^\circ - 22.5 \cos 20^\circ + V_{dc} = 0$$

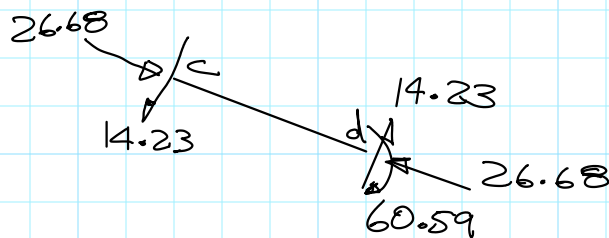
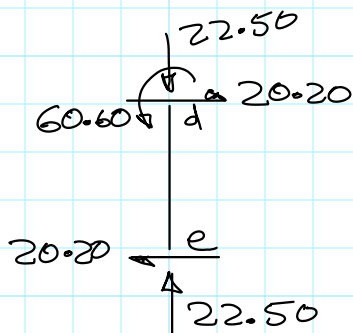
$$V_{dc} = 14.23 \text{ kN} \quad (\uparrow)$$

$$\sum M_d = 0 \quad (\curvearrowright)$$

$$22.5 \times 4 - 20.2 \times 1.456 - M_{dc} = 0$$

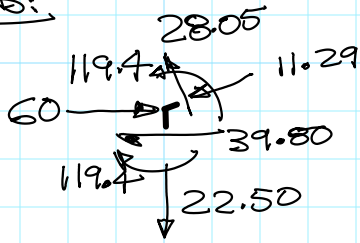
$$M_{dc} = 60.59 \text{ kN}\cdot\text{m} \quad (\curvearrowright)$$

end c, by inspection

de:

Joint Equilibrium

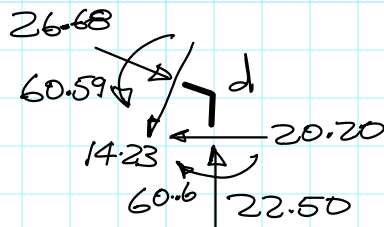
Joint b:



$$\begin{aligned}\sum M &= 119.4 - 119.4 = 0 && \text{OK} \\ \sum F_x &= -39.80 + 60 - 11.29 \cos 20 - 28.05 \sin 20 \\ &= -0.003 && \text{OK} \\ \sum F_y &= -22.50 + 28.05 \cos 20 - 11.29 \sin 20 \\ &= -0.003 && \text{OK}\end{aligned}$$

∴ Joint b OK

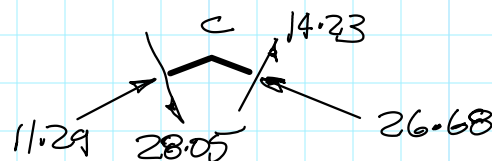
Joint d:



$$\begin{aligned}\sum M &= 60.59 - 60.60 = 0.01 && \text{OK} \\ \sum F_x &= -20.20 + 26.68 \cos 20 - 14.23 \sin 20 \\ &= 0.004 && \text{OK} \\ \sum F_y &= 22.50 - 14.23 \cos 20 - 26.68 \sin 20 \\ &= 0.003 && \text{OK}\end{aligned}$$

∴ Joint d OK

Joint c



$$\begin{aligned}\sum F_x &= 11.29 \cos 20 - 26.68 \cos 20 + 28.05 \sin 20 + 14.23 \sin 20 = -0.001 \text{ OK} \\ \sum F_y &= 11.29 \sin 20 + 26.68 \sin 20 - 28.05 \cos 20 + 14.23 \cos 20 = -0.005 \text{ OK} \\ &\therefore \underline{\underline{\text{Joint c OK}}}\end{aligned}$$

NVM Diagrams

