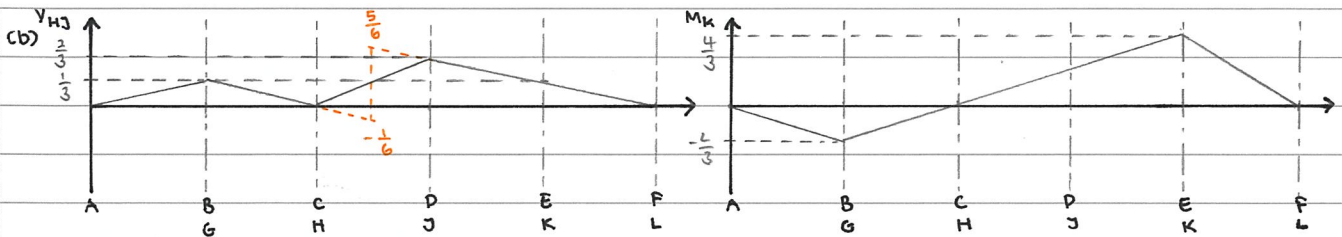
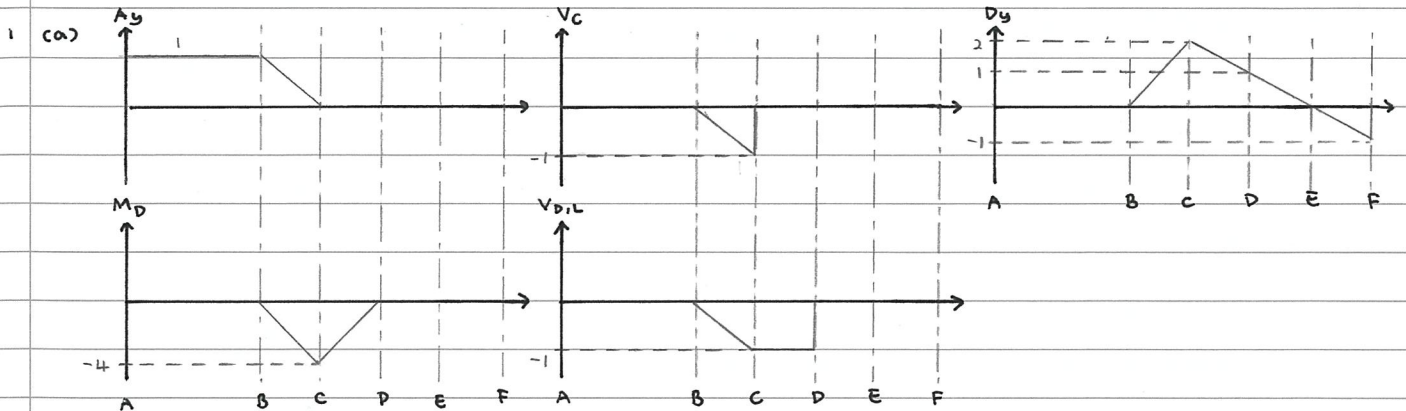


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$$M_{K, \max(+ve)} = \max\left(21 \times 1 + 15 \times \frac{4}{3}, 21 \times \frac{4}{3} + 15 \times \frac{2}{3}\right) = \max(41, 38) = 41 \text{ kNm.}$$

2 (a) select F_{DE} as redundant force.

$$M_1 = 0, M_2 = -9x_2 \left(\frac{x_2}{2}\right) = -4.5x_2^2, M_3 = -4.5x_3^2, N = 0$$

$$m_1 = x_1, m_2 = -x_2, m_3 = -x_3, n = 1$$

$$A_{DE} = \int \frac{mM}{EI} dx = 0.036, f_{DE, DE} = \int \frac{m^2}{EI} dx + \frac{n^2 L}{EA} = 0.0096$$

$$A_{DE} + F_{DE} f_{DE, DE} = 0 \rightarrow F_{DE} = -3.75 \text{ kN} = 3.75 \text{ kN (CC)}$$

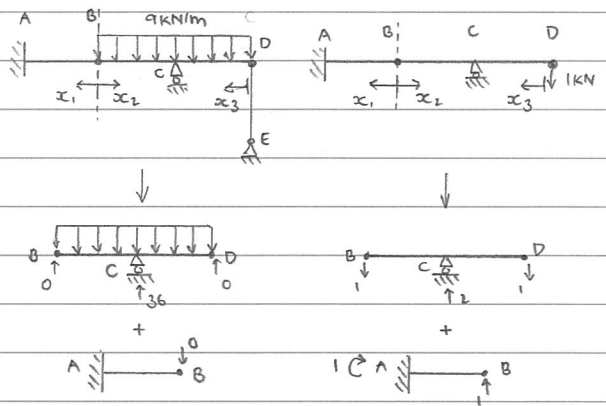
$$D_y = 3.75 \text{ kN } (\uparrow)$$

$$\sum M_B = 0, 9 \times 4 \times 2 = 3.75 \times 4 + C_y \times 2 \rightarrow C_y = 28.5 \text{ kN}$$

$$\sum B_y = 0, 9 \times 4 = 28.5 + 3.75 + B_y \rightarrow B_y = 3.75 \text{ kN } (\downarrow/\uparrow)$$

$$\sum A_y = 0, A_y = 3.75 \text{ kN } (\uparrow)$$

$$M_A = 3.75 \times 2 = 7.5 \text{ kNm (CCW)}$$



(b) $0.036 + 0.0096 F_{DE} = 0.12$

$$F_{DE} = 8.75 \text{ kN } (\uparrow)$$

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$$3 \text{ (a) } M_{NF} = 2E \left(\frac{I}{L} \right) [2\theta_N + \theta_F - 3\psi] + (FEM)_{NF}$$

$$M_{AB} = 2E \left(\frac{2I}{6} \right) [0 + \theta_B] - 36 = \frac{2EI}{3} \theta_B - 36$$

$$M_{BA} = 2E \left(\frac{2I}{6} \right) [2\theta_B] + 36 = \frac{4EI}{3} \theta_B + 36$$

$$M_{BD} = 2E \left(\frac{1.5I}{6} \right) [2\theta_B + \theta_D] - \frac{80}{3} = EI\theta_B + \frac{EI}{2}\theta_D - \frac{80}{3}$$

$$M_{DB} = 2E \left(\frac{1.5I}{6} \right) [2\theta_D + \theta_B] + \frac{40}{3} = EI\theta_D + \frac{EI}{2}\theta_B + \frac{40}{3}$$

$$M_{DF} = 3E \left(\frac{I}{4} \right) [\theta_D + 0] - 18 = \frac{3EI}{4} \theta_D - 18$$

$$\hookrightarrow M_D = 0, M_{DB} + M_{DF} = 0:$$

$$M_B = 0, M_{BA} + M_{BD} = 0:$$

$$\frac{4EI}{3} \theta_B + 36 + EI\theta_B + \frac{EI}{2}\theta_D - \frac{80}{3} = 0$$

$$\frac{7EI}{3} \theta_B + \frac{EI}{2}\theta_D + \frac{28}{3} = 0$$

$$\downarrow [\times \frac{3}{2}]$$

$$\frac{7EI}{4} \theta_D = -\frac{49EI}{6} \theta_B - \frac{98}{3} \quad (*)$$

$$EI\theta_D + \frac{EI}{2}\theta_B + \frac{40}{3} + \frac{3EI}{4}\theta_D - 18 = 0$$

$$\frac{7EI}{4} \theta_D + \frac{EI}{2}\theta_B - \frac{14}{3} = 0$$

\downarrow sub in (*)

$$-\frac{49EI}{6} \theta_B + \frac{EI}{2}\theta_B - \frac{98}{3} - \frac{14}{3} = 0$$

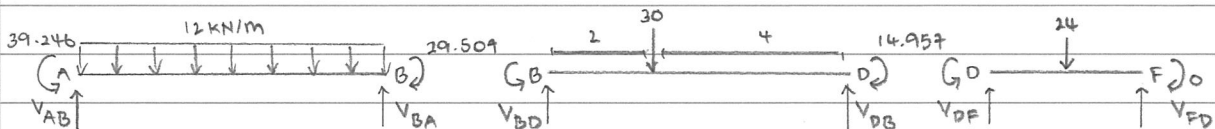
$$\frac{23EI}{3} \theta_B = -\frac{112}{3} \rightarrow \theta_B = -\frac{112}{23EI}$$

$$\theta_D = \frac{280}{69EI}$$

Sub θ_B and θ_D into end moments, $M_{AB} = -39.246 \text{ kNm}$, $M_{BA} = 29.507 \text{ kNm}$, $M_{BD} = -29.507 \text{ kNm}$.

$$M_{DB} = 14.957 \text{ kNm}, M_{DF} = -14.957 \text{ kNm}$$

FBDs:



By taking moment (and/or force equilibrium), $V_{AB} = 37.623 \text{ kN} (\uparrow)$, $V_{BA} = 34.377 \text{ kN} (\uparrow)$,

$$V_{BD} = 22.425 \text{ kN} (\uparrow), V_{DB} = 7.575 \text{ kN} (\uparrow), V_{DF} = 15.739 \text{ kN} (\uparrow), V_{FD} = 8.261 \text{ kN} (\uparrow).$$

(b) Reusing equations from part (a), $M_{DF} = -48$

$$M_{DB} + M_{DF} = 0 \rightarrow EI\theta_D + \frac{EI}{2}\theta_B + \frac{40}{3} - 48 = 0 \rightarrow EI\theta_D + \frac{EI}{2}\theta_B - \frac{104}{3} = 0 \quad (1)$$

$$M_{BA} + M_{BD} = 0 \rightarrow \frac{7EI}{3}\theta_B + \frac{EI}{2}\theta_D + \frac{28}{3} = 0 \quad [\times 2] \rightarrow \frac{14EI}{3}\theta_B + EI\theta_D + \frac{56}{3} = 0 \quad (2)$$

Sub (1) into (2):

$$\frac{14EI}{3}\theta_B + \left(\frac{104}{3} - \frac{EI}{2}\theta_B \right) + \frac{56}{3} = 0 \rightarrow \frac{25EI}{6}\theta_B + \frac{160}{3} = 0 \rightarrow \theta_B = -\frac{64}{5EI}, \theta_D = \frac{616}{15EI}$$

Sub θ_B and θ_D into end moments, $M_{AB} = -44.533 \text{ kNm}$, $M_{BA} = 18.933 \text{ kNm}$, $M_{BD} = -18.933 \text{ kNm}$

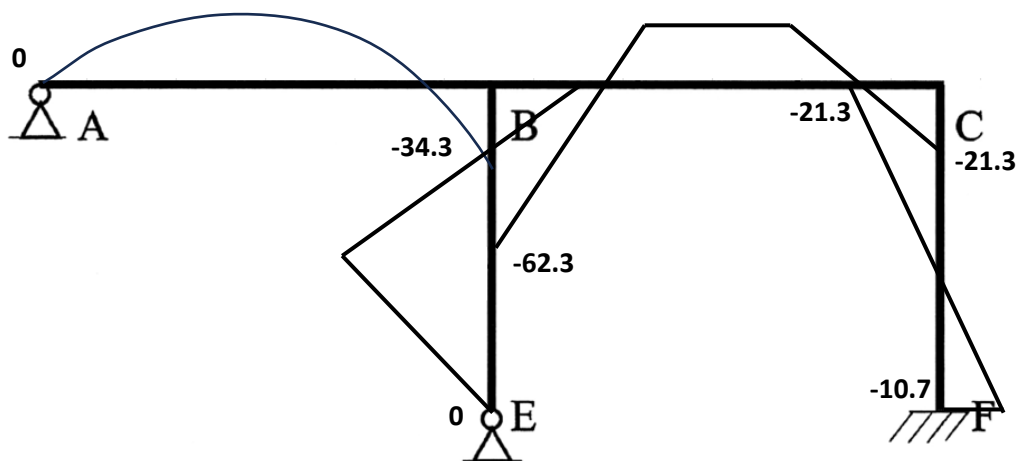
$$M_{DB} = 48 \text{ kNm}, M_{DF} = -48 \text{ kNm}.$$

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4(a)

| Joint | A | B | | | C | | E | F |
|------------|----|---------|---------|---------|--------|---------|----|---------|
| Member | AB | BA | BC | BE | CB | CF | EB | FC |
| DF | 1 | 0.1875 | 0.25 | 0.5625 | 0.25 | 0.75 | 1 | 0 |
| FEM | 0 | 45 | -44.444 | 60 | 35.556 | 0 | 0 | 0 |
| Distri. | - | -11.354 | -15.139 | -34.063 | -8.889 | -26.667 | - | - |
| CO | - | - | -4.445 | - | -7.569 | - | - | -13.334 |
| Distri. | - | 0.833 | 1.111 | 2.5 | 1.892 | 5.677 | - | - |
| CO | - | - | 0.946 | - | 0.556 | - | - | 2.839 |
| Distri. | - | -0.177 | -0.237 | -0.532 | -0.139 | -0.417 | - | - |
| CO | - | - | -0.07 | - | -0.119 | - | - | -0.209 |
| Distr. | - | 0.013 | 0.018 | 0.039 | 0.03 | 0.089 | - | - |
| ΣM | 0 | 34.315 | -62.26 | 27.944 | 21.318 | -21.318 | 0 | -10.704 |

(b)



---END---

NOTE:

Do reach out to me at KEAL0001@e.ntu.edu.sg if you have any queries regarding any of my submitted workings. Feel free to leave an email to ask any questions covered in the curriculum, will be glad to help!

DISCLAIMER:

You are advised to take my solutions as a **guide**, rather than an absolute answer to the questions.