

CivE 310 Assignment 2

Benjamin Klassen

September 22, 2021

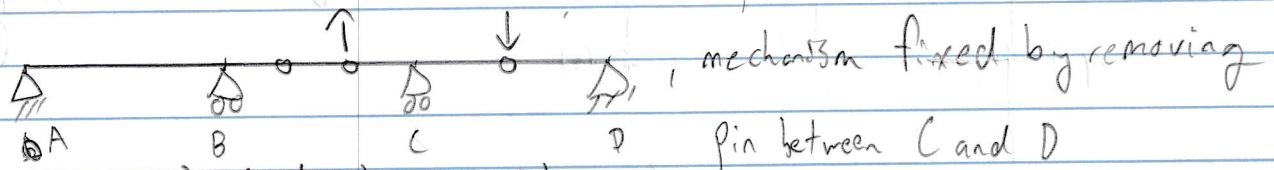
Assignment 2

Questions 1-3

See scanned pdfs below:

310 Assignment 2

1. a) Internally unstable (forms mechanism)



$$\text{Before: } R - (3 + C) = 6 - (3 + 3) = 0, \therefore \text{det}$$

$$\text{After: } R - (3 + C) = 6 - (3 + 2) = 1^\circ \text{ indeterminate}$$

$$b) R - (3 + C) = 6 - (3 + 2) = 1^\circ \text{ indeterminate, stable}$$

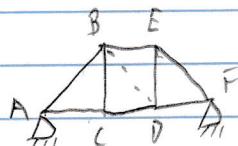
c) Internally unstable (rectangle forms mechanism)

$$b = 8$$

$$\text{Before: } r = 4 \quad b + r - 2j = 0, \therefore \text{determinate}$$

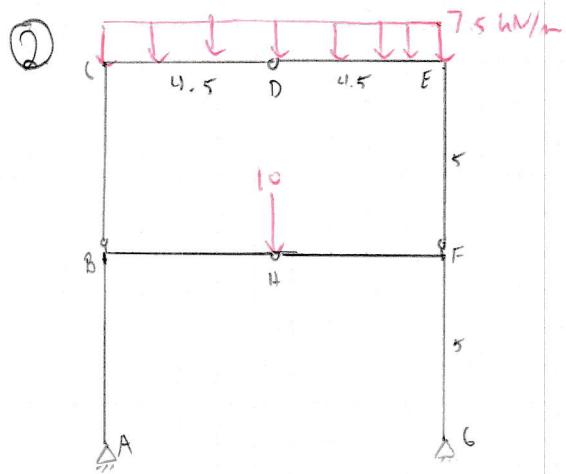
$$j = 6$$

Mechanism fixed by adding diagonal between B and D in below
(or B and C)



$$\text{After: } b + r - 2j = 9 + 4 - 2(6) = 1^\circ \text{ indeterminate}$$

$$d) b + r - 2j = 9 + 4 - 2(10) \\ = 3^\circ \text{ indeterminate, stable}$$



Reactions

$$\sum M_A = 0, -7.5(4.5)(4.5) - 10(4.5) + G_y(9) \\ G_y = 38.75 \text{ [↑]}$$

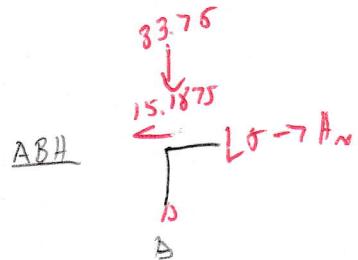
$$\sum F_y = 0, A_y = 38.75 \text{ [↑]} \\ \begin{array}{c} \uparrow \\ \text{ABH} \end{array} \quad \begin{array}{c} \nearrow 10/2 = 5 \\ \searrow \end{array}$$

$$\sum F_y = 0, 38.75 - 5 + F_{BCy} \\ F_{BCy} = 33.75 \text{ [C]}$$

$$\begin{array}{c} \text{BID} \\ \sum F_y = 0, \begin{array}{c} \uparrow 33.75 \\ \rightarrow \end{array} \\ 33.75 - 7.5(4.5) = V_D \\ V_D = 0 \end{array}$$

$$\sum M_B = 0, -7.5(4.5)(2.25) - D_x(5) \\ D_x = -15.1875 \text{ kN} = 15.1875 \text{ kN [←]}$$

$$\sum F_x = 0, B_x = 15.1875 \text{ kN [→]}$$



$$\sum M_A = 0, -15.1875(5) + 5(4.5) + H_x(5) \\ H_x = 10.6875 \text{ [→]}$$

$$\sum F_x = 0, -15.1875 + 10.6875 + A_x = 0 \\ A_x = 4.5 \text{ [→]} \text{ kN}$$

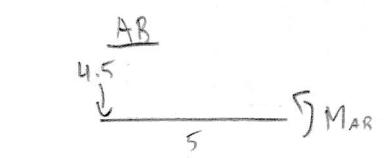
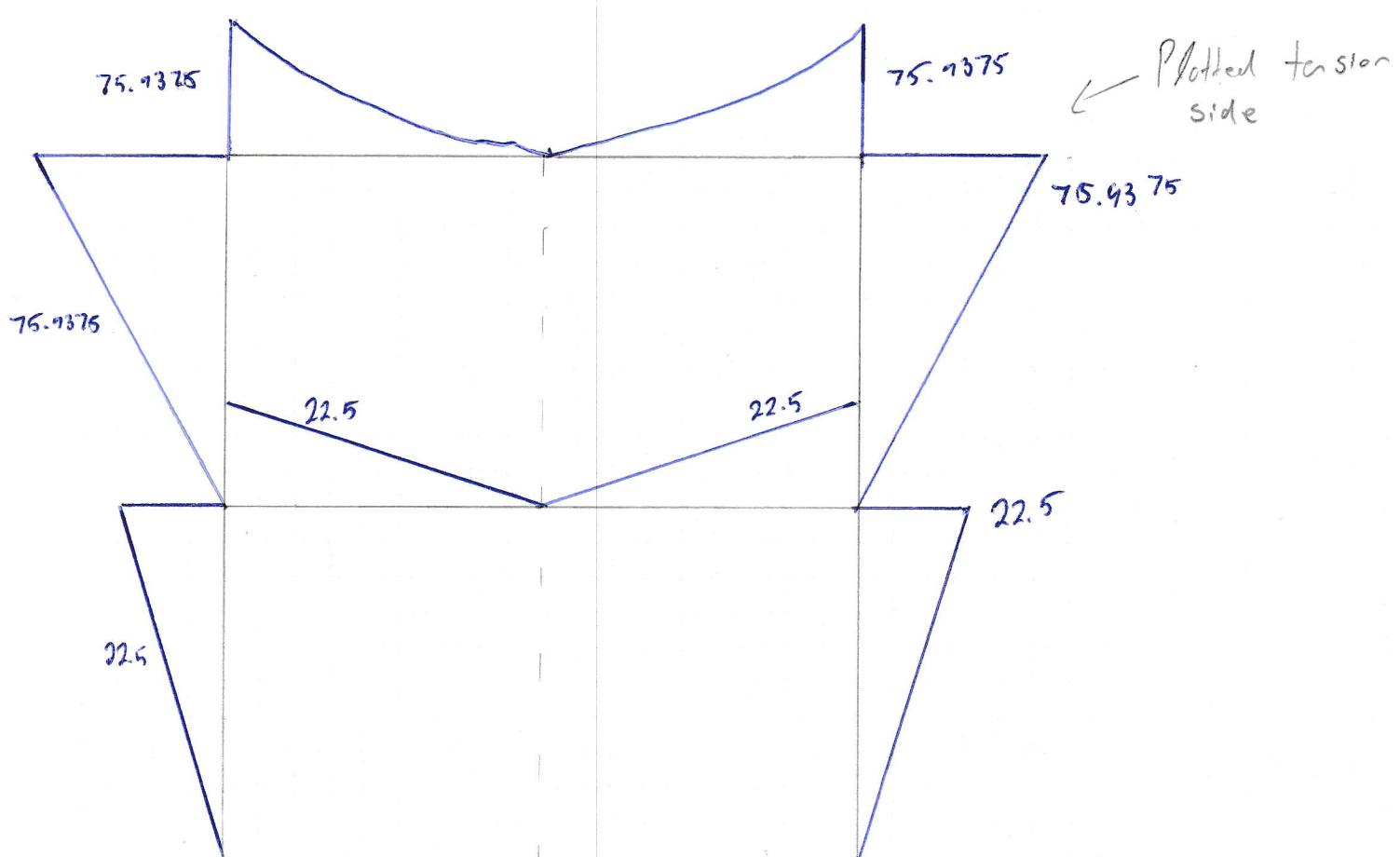
Since symmetrical,

$$G_x = 4.5 \text{ kN [←]}$$

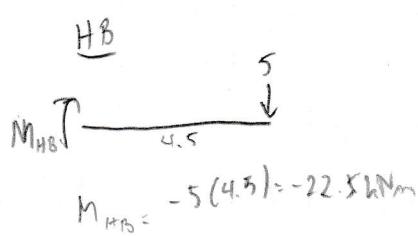
$$F_{ax} = 15.1875 \text{ kN [←]}$$

$$F_{FBx} = 33.75 \text{ kN [C]}$$

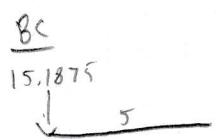
$$D_{ax} = 15.1875 \text{ kN [←]}$$



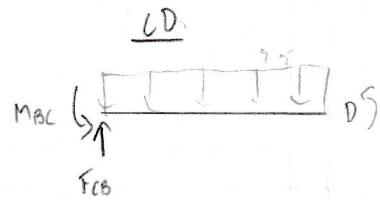
$$M_{AB} = -4.5(5) = -22.5 \text{ kNm}$$



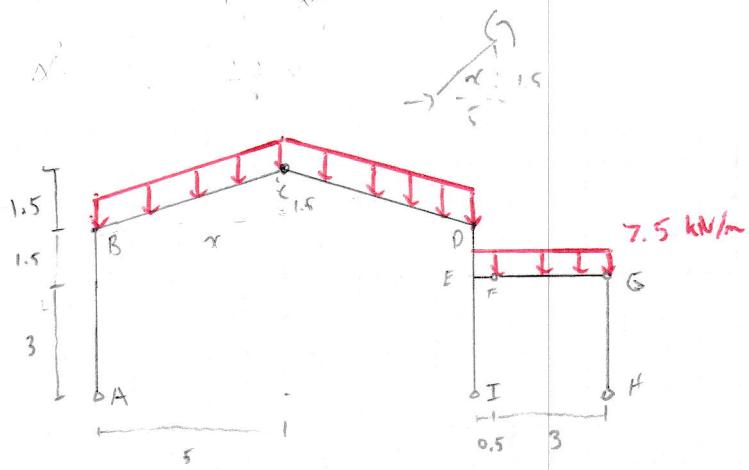
$$M_{HB} = -5(4.5) = -22.5 \text{ kNm}$$



$$M_{BC} = -15.1875(5) \\ = -75.9375 \text{ kNm}$$



$$M_{CD} = -75.9375 + 23.75(4.5) - 7.5(4.5)(2.25) \\ = 0$$



Reactions

$$\begin{array}{c} G_H \\ \text{---} \\ 0 \end{array} \quad \Delta'$$

$$\sum M_G = 0, H_x = 0$$

① F_G

$$\sum M_F = 0, -7.5(3)(1.5) + G_y(3) = 0$$

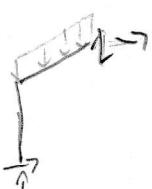
$$G_y = 11.25 \text{ kN} \quad [\uparrow]$$

∴ GH is in compression. H_y = 11.25 $\text{kN} \quad [\uparrow]$

$$\sum M_G = 0, -7.5(3)(1.5) + F_D(3)$$

$$F_D = 11.25 \text{ kN} \quad [\uparrow]$$

ABC



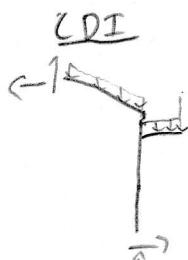
$$\sum M_A = 0, -7.5(3)(2.5) + G_y(5) - (x)(6)$$

$$\textcircled{1} \quad 5G_y + (6)x = -93.75$$

$$\textcircled{4} \quad \sum F_x = 0, A_x = -C_x$$

$$\sum F_y = 0, -7.5(3) + A_y + G_y = 0$$

$$\textcircled{3} \quad A_y = G_y + 37.5$$



$$\begin{aligned} \sum M_I = 0, & -F_y(0.5) - (0.5)(0.25)(7.5) \\ & + 7.5(5)(2.5) - C_y(5) + (x)(6) \end{aligned}$$

$$\textcircled{2} \quad 5G_y - 6(x) = 87.1875$$

Using ① & ②

$$\left| \begin{array}{cc|c} -6 & 5 & 87.1875 \\ 6 & 5 & -93.75 \end{array} \right| \xrightarrow{\text{R1}} \left| \begin{array}{cc|c} -6 & 5 & 87.1875 \\ 0 & 10 & -6.5625 \end{array} \right|$$

$$\begin{aligned} C_y &= -0.65625 \text{ kN} \\ C_x &= -15.078125 \text{ kN} \end{aligned}$$

From ③

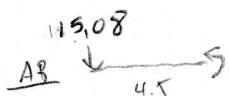
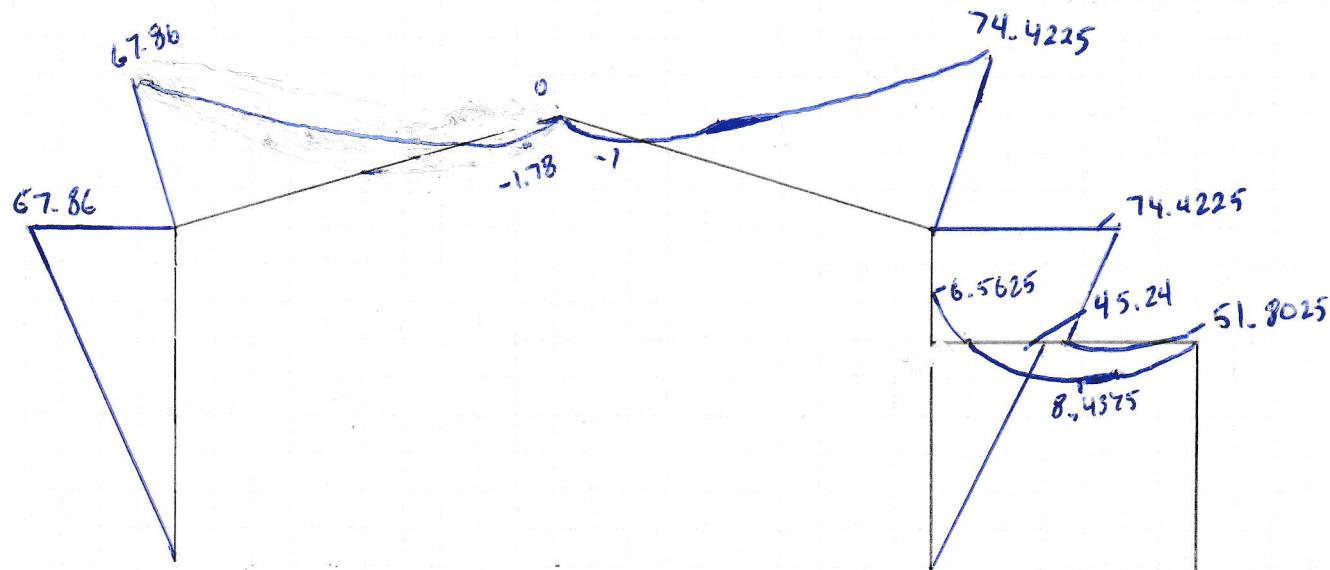
$$\begin{aligned} A_y &= -0.65625 + 37.5 \\ &= 36.84375 \text{ kN} \quad [\uparrow] \end{aligned}$$

$$\frac{61.8875}{\sum F_y} = 0, -7.5(13.5) + 11.25 + 36.84375 + I_y$$

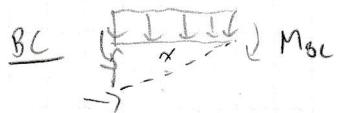
$$I_y = 53.15625 \quad [\uparrow]$$

$$\begin{aligned} \sum F_x &= 0, 15.078125 + J_x = 0 \\ J_x &= 15.078125 \text{ kN} \quad [\leftarrow] \end{aligned}$$

Plotted tension side



$$M_{AB} = 67.86 \text{ kN.m}$$



$$\theta = 4.5234^\circ$$

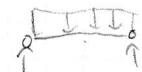
$$M_C = 67.86 + 15.08 \left(\frac{1.5}{3}x \right) - 36.84375x + 3.75x^2$$

$$\frac{dM}{dx} = 0, \quad 4.5234 - 36.8438 + 7.5x = 0$$

$$x = 4.28$$

$$M(4.28) = 67.86 + 4.5234(4.28) - 36.84375(4.28) + 3.75(4.28)^2 \\ \approx -1.78 \text{ kN.m}$$

F6



$$M = \frac{\Delta l^2}{8} = \frac{7.5(3)^2}{8} = 8.4375 \text{ kN.m}$$

EE

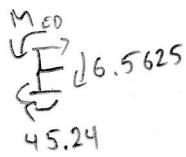


$$M_{EE} = 11.25(0.5) + 7.5(0.5)(0.25) \\ \approx 6.5625 \text{ kN.m}$$



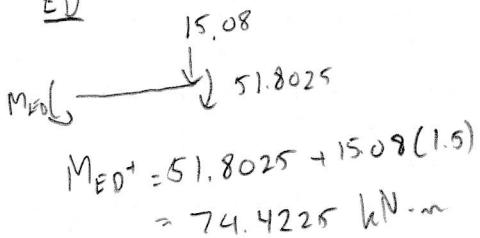
$$M_{EI} = 15.08(3) = 45.24 \text{ kN.m}$$

Joint E



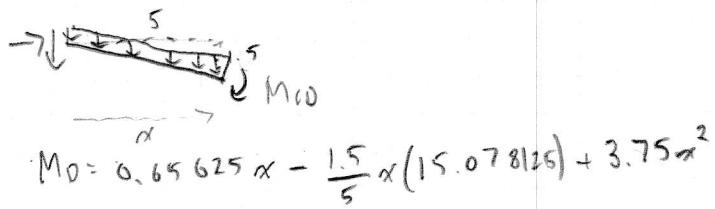
$$M_{ED} = 45.24 + 6.5625 \\ = 51.8025 \text{ kN}\cdot\text{m}$$

ED



$$M_{ED} = 51.8025 + 15.08(1.5) \\ = 74.4225 \text{ kN}\cdot\text{m}$$

CD



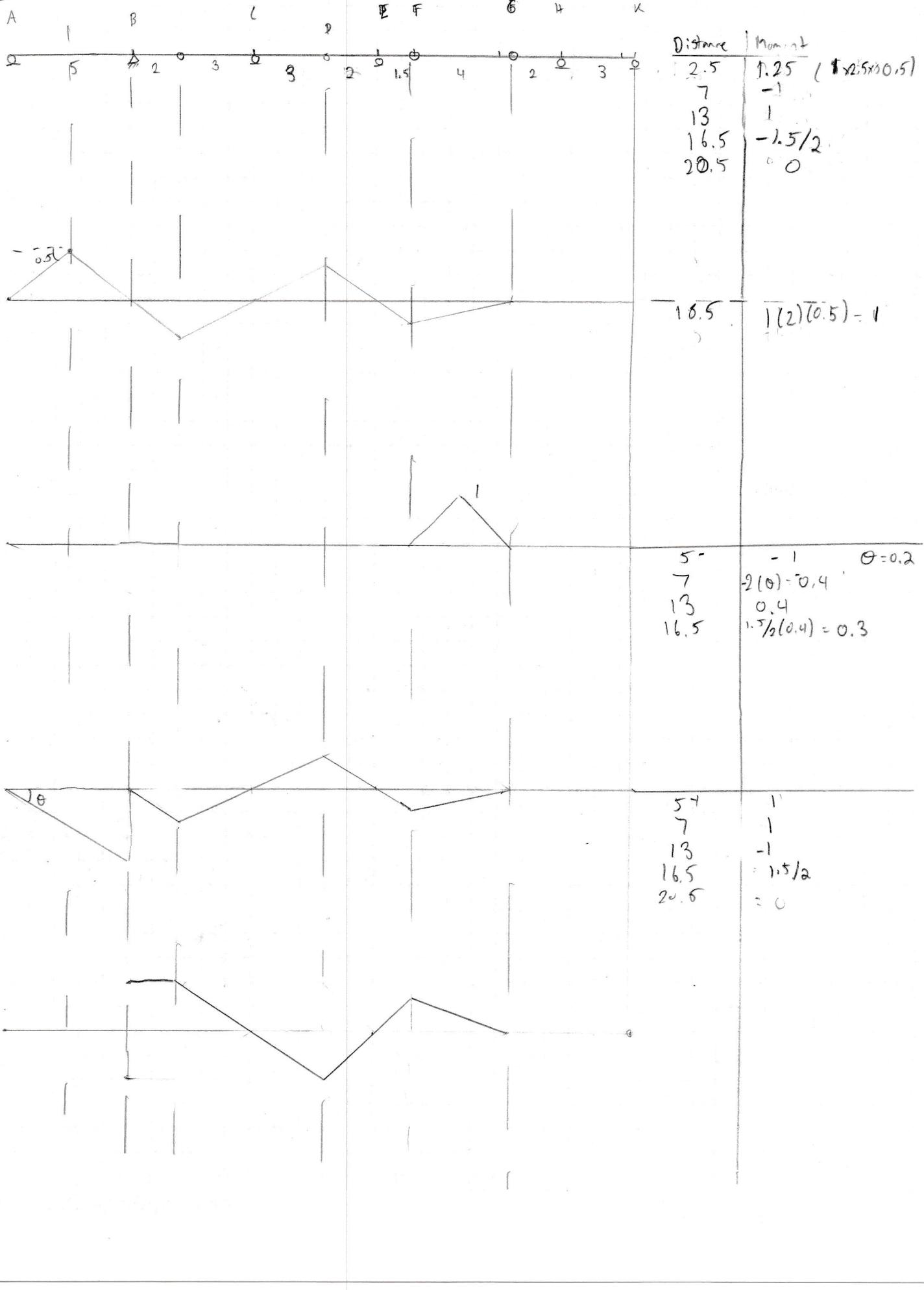
$$M_D = 0.65625x - \frac{1.5}{5}x(15.078125) + 3.75x^2$$

$$\frac{dM}{dx} = 0.65625 - 4.52344 + 7.5x$$

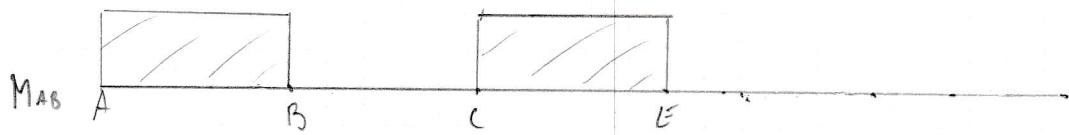
$$x = 0.516$$

$$M(0.516) = 0.65625(0.516) - \frac{1.5}{5}(0.516)(15.078125) + 3.75(0.516)^2 \\ = -1 \text{ kN}\cdot\text{m}$$

(3)



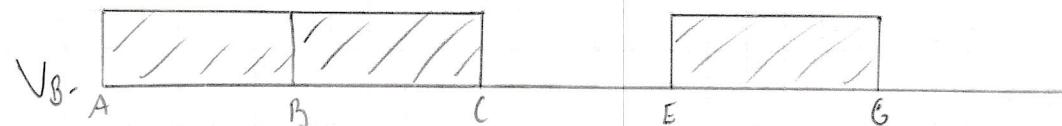
Live Load Pattern:



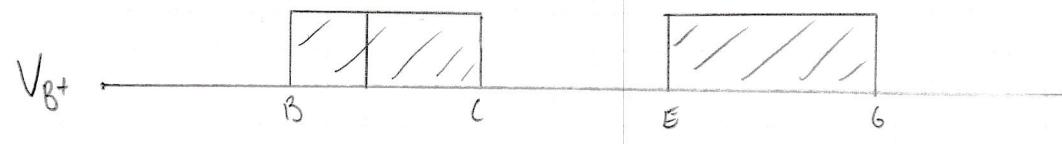
$$M_{A-7B} = 20(1.25)(5)(\frac{1}{2}) + 20(1)(5)(\frac{1}{2}) \approx 112.5 \text{ kN.m}$$



$$M_{F-7G} = 20(1)(4)(\frac{1}{2}) = 40 \text{ kN.m}$$



$$V_{B-} = 20(-1)(5)(\frac{1}{2}) + 20(-0.4)(5)(\frac{1}{2}) + 20(-0.3)(5.5)(\frac{1}{2}) = -86.5 \text{ kN}$$



$$V_{B+} = 20(1)(2) + 20(1)(3)(\frac{1}{2}) + 20(0.75)(5.5)(\frac{1}{2}) = 111.25 \text{ kN}$$

Question 4

Since this is a pure mechanics question, the load case used was 1.0D. Also, the joints and ends are all assumed to be fixed.

The maximum moment and shear on the first floor were found to be -152 kN and -257.88 kN-m, respectively. On the second floor, these were -157.27 kN and -267.47 kN-m, respectively.

See screenshots of SAP2000 model below, including the load case, loaded structure, material properties, bending moment and shear force diagram, and deflected shape.

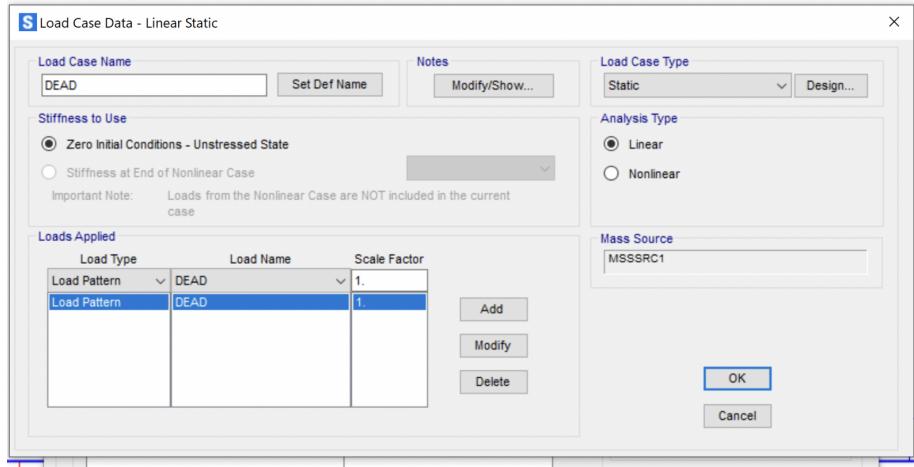


Figure 1: Load Case

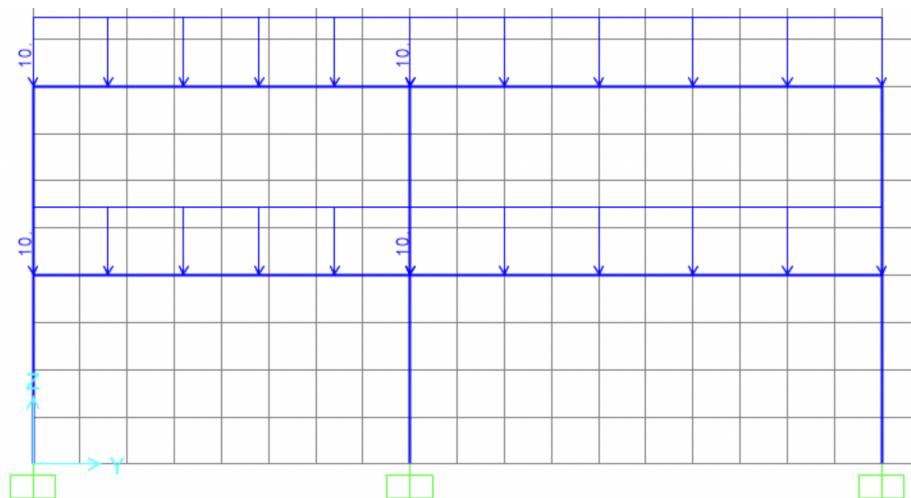


Figure 2: Loaded Structure

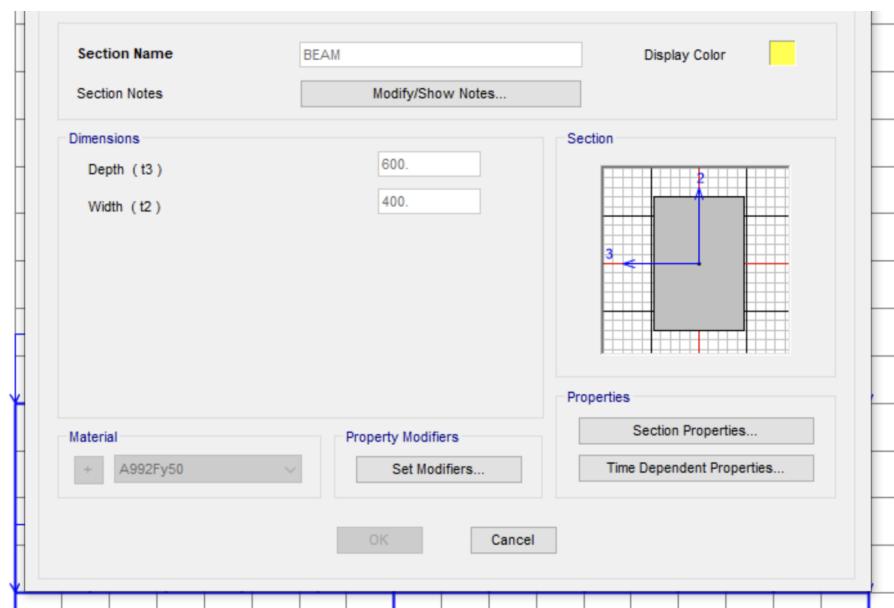


Figure 3: Beam Properties

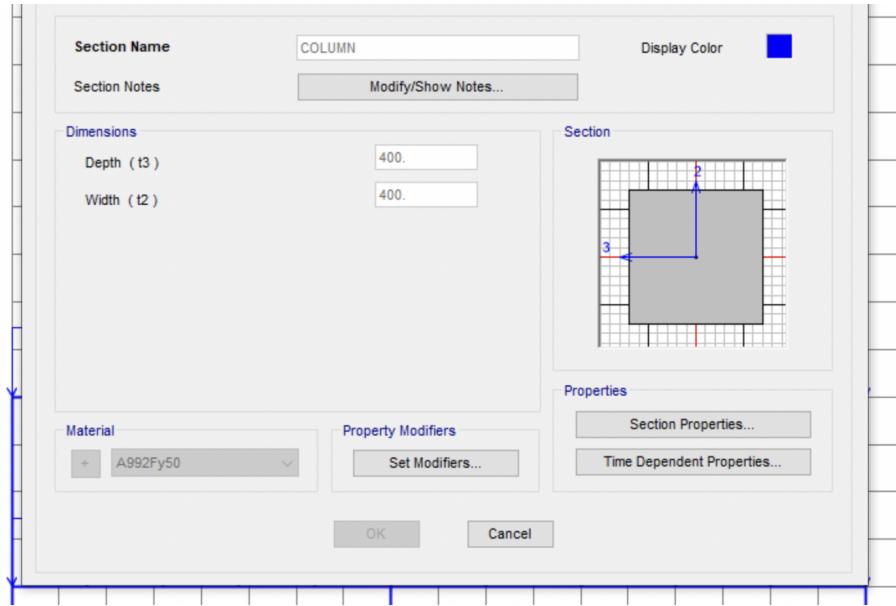


Figure 4: Column Properties

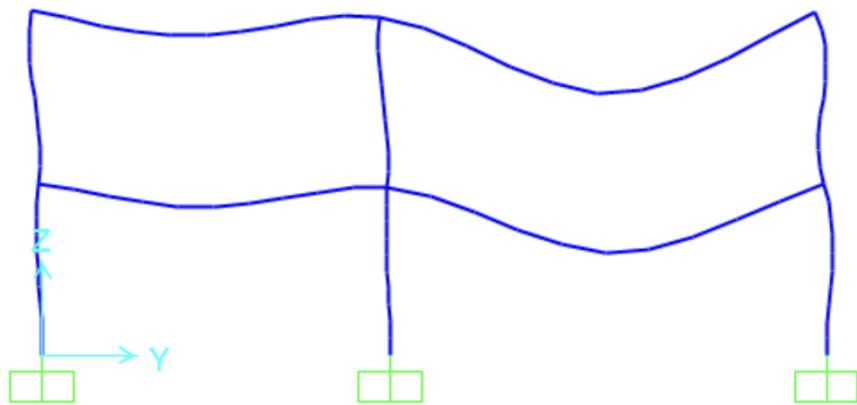


Figure 5: Deflected Shape

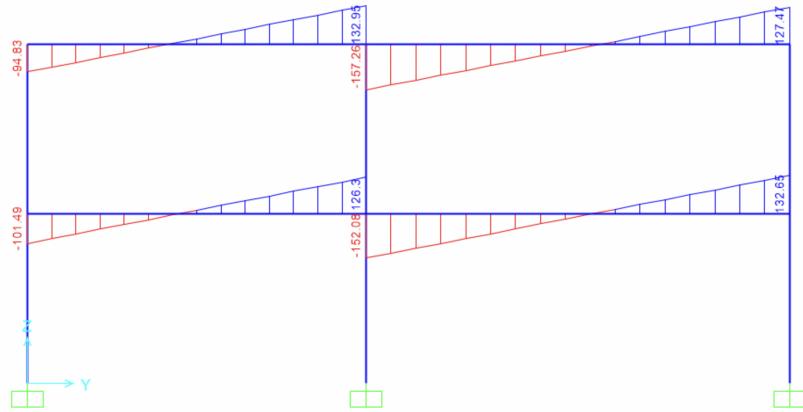


Figure 6: Shear Force Diagram

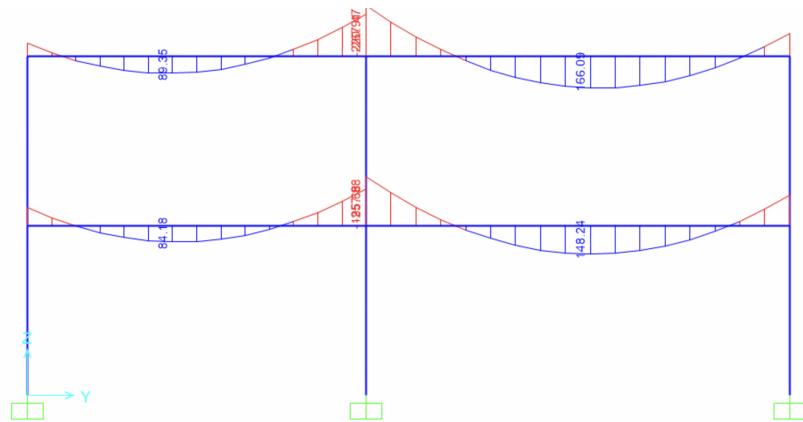


Figure 7: Moment Diagram

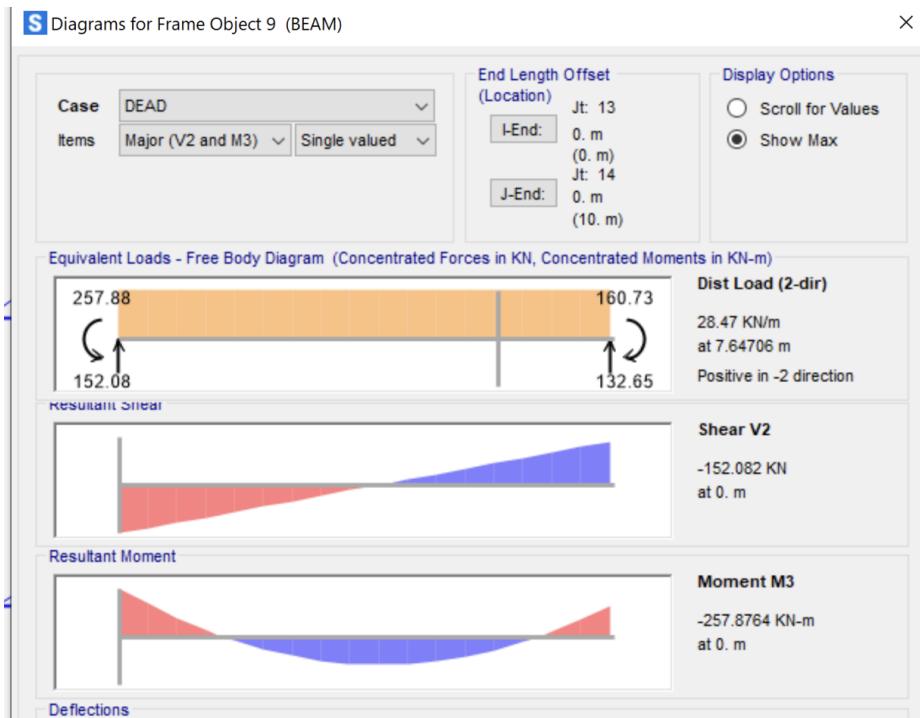


Figure 8: Floor 1 max values



Figure 9: Floor 2 max values