

# CivE 310 Assignment 2

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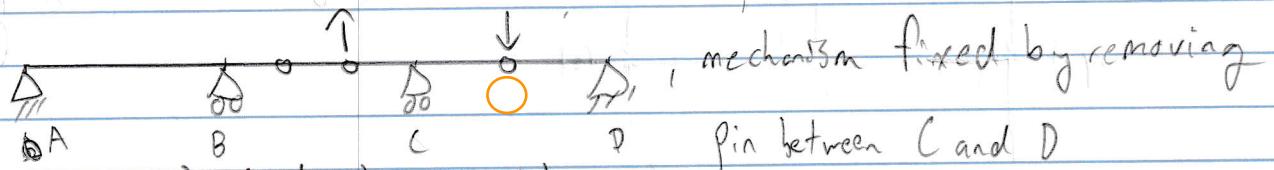
## **Assignment 2**

### **Questions 1-3**

See scanned pdfs below:

## 310 Assignment 2

1. a) Internally unstable (forms mechanism)



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

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

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

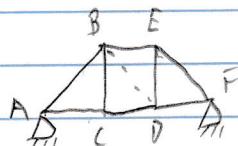
c) Internally unstable (rectangle forms mechanism)

$$b = 8$$

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

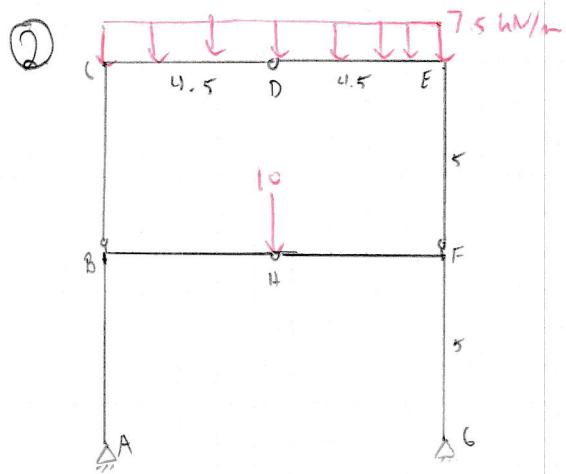
$$j = 6$$

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



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

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



Reactions

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

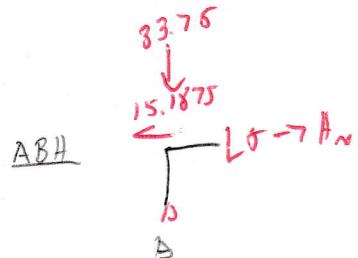
$$\sum F_y = 0, A_y = 38.75 \text{ [↑]} \\ \begin{array}{c} \uparrow \\ \text{ABH} \end{array} \quad \begin{array}{c} \nearrow 10/2 = 5 \\ \searrow \end{array}$$

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

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

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

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



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

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

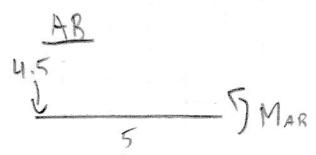
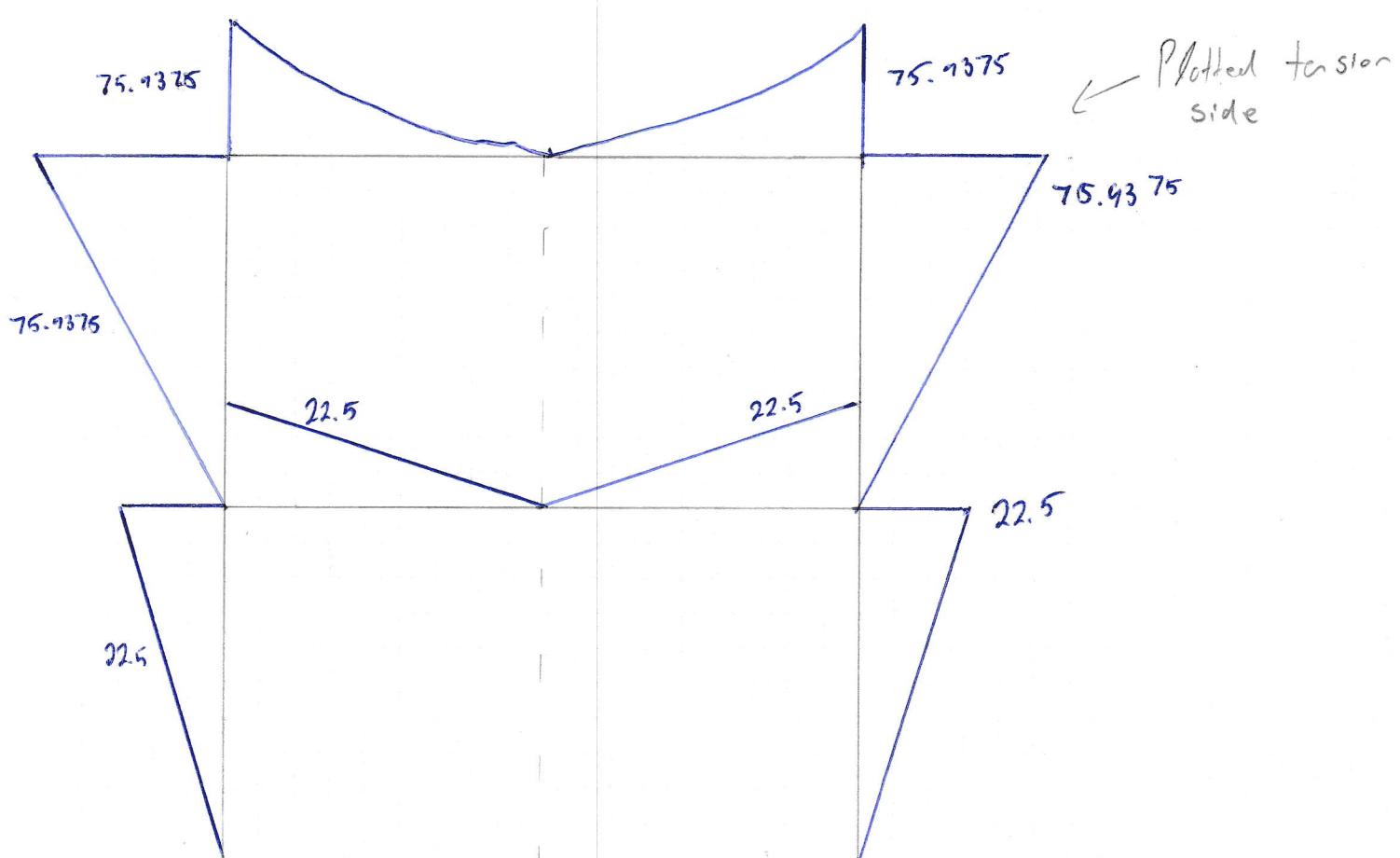
Since symmetrical,

$$G_x = 4.5 \text{ kN [←]}$$

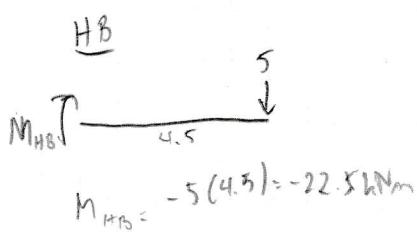
$$F_{ax} = 15.1875 \text{ kN [←]}$$

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

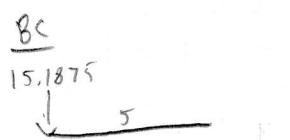
$$D_{ax} = 15.1875 \text{ kN [←]}$$



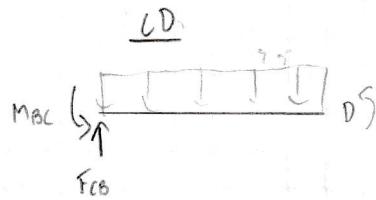
$$M_{AB} = -4.5(5) = -22.5 \text{ kNm}$$



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

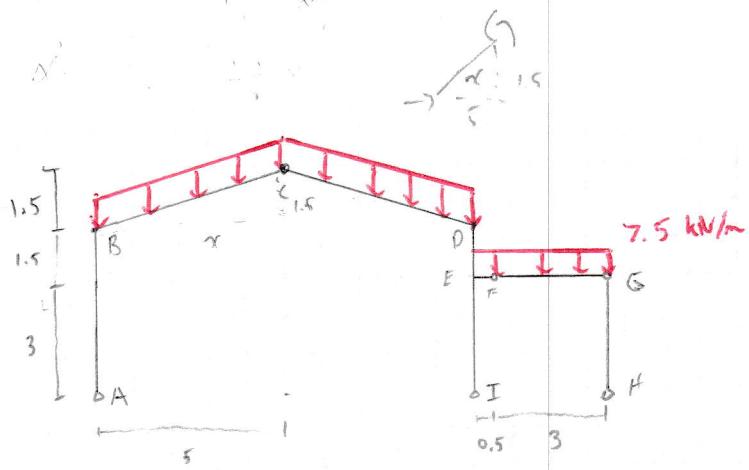


$$M_{BC} = -15.1875(5) \\ = -75.9375 \text{ kNm}$$



$$M_D = -75.9375 + 33.75(4.5) - 7.5(4.5)(2.25) \\ = 0$$

Plotted tension side



Reactions

$$\frac{G}{H} \quad \frac{O}{A}$$

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

$$\textcircled{1} \quad F_G$$

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

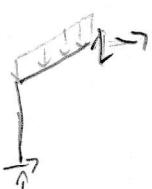
$$G_y = 11.25 \text{ kN} \quad [\uparrow]$$

$\therefore G_H$  is in compression.  $H_y = 11.25 \text{ [↑]}$

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

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

ABC



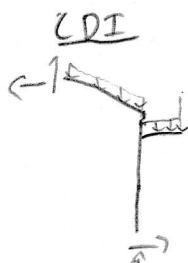
$$\sum M_A = 0, -7.5(5)(2.5) + C_y(5) - C_x(6)$$

$$\textcircled{1} \quad 5C_y + 6C_x = -93.75$$

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

$$\sum F_y = 0, -7.5(5) + A_y + C_y = 0$$

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



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

$$\textcircled{2} \quad 5C_y - 6C_x = 87.1875$$

Using  $\textcircled{1}$  &  $\textcircled{2}$

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

$$C_y = -0.65625 \text{ kN}$$

$$C_x = -15.078125 \text{ kN}$$

From  $\textcircled{3}$

$$A_y = -0.65625 + 37.5 \quad A_x = 15.078125 \text{ kN} \quad [-]$$

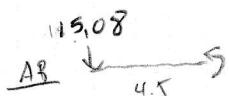
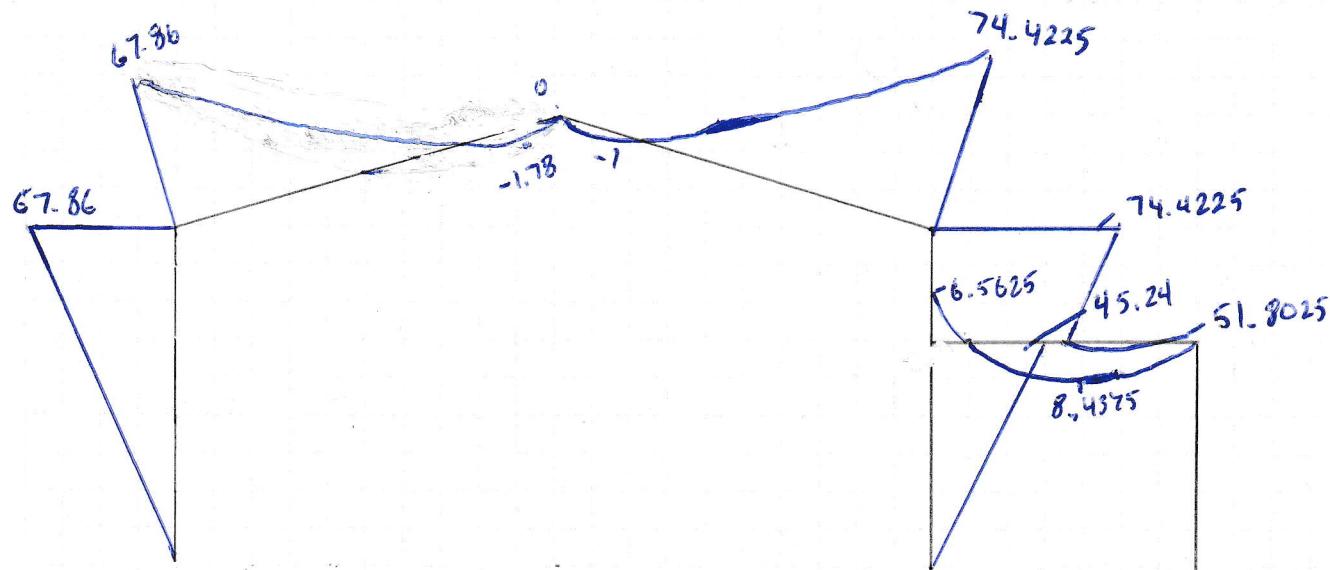
$$\frac{61.881}{\sum F_y} = 0, -7.5(13.5) + 11.25 + 36.84375 + I_y$$

$$I_y = 53.15625 \text{ [↑]}$$

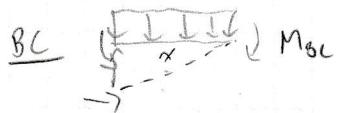
$$\sum F_x = 0, 15.078125 + J_x = 0$$

$$J_x = 15.078125 \text{ kN} \quad [-]$$

Plotted tension side



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



$$\theta = 4.5234^\circ$$

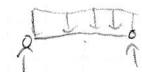
$$M_C = 67.86 + 15.08 \left( \frac{1.5}{3}x \right) - 36.84375x + 3.75x^2$$

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

$$x = 4.28$$

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

F6



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

EE

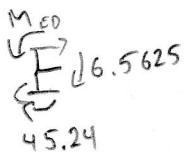


$$M_{EE} = 11.25(0.5) + 7.5(0.5)(0.25) \\ \approx 6.5625 \text{ kN.m}$$



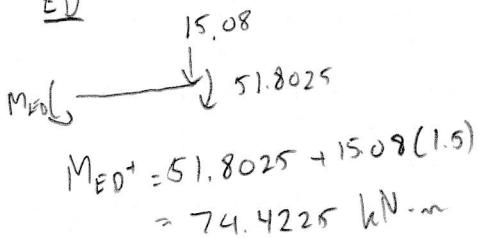
$$M_{EI} = 15.08(3) = 45.24 \text{ kN.m}$$

### Joint E



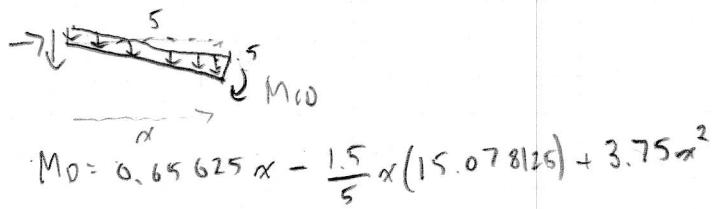
$$M_{ED} = 45.24 + 6.5625 \\ = 51.8025 \text{ kN}\cdot\text{m}$$

### ED



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

### CD



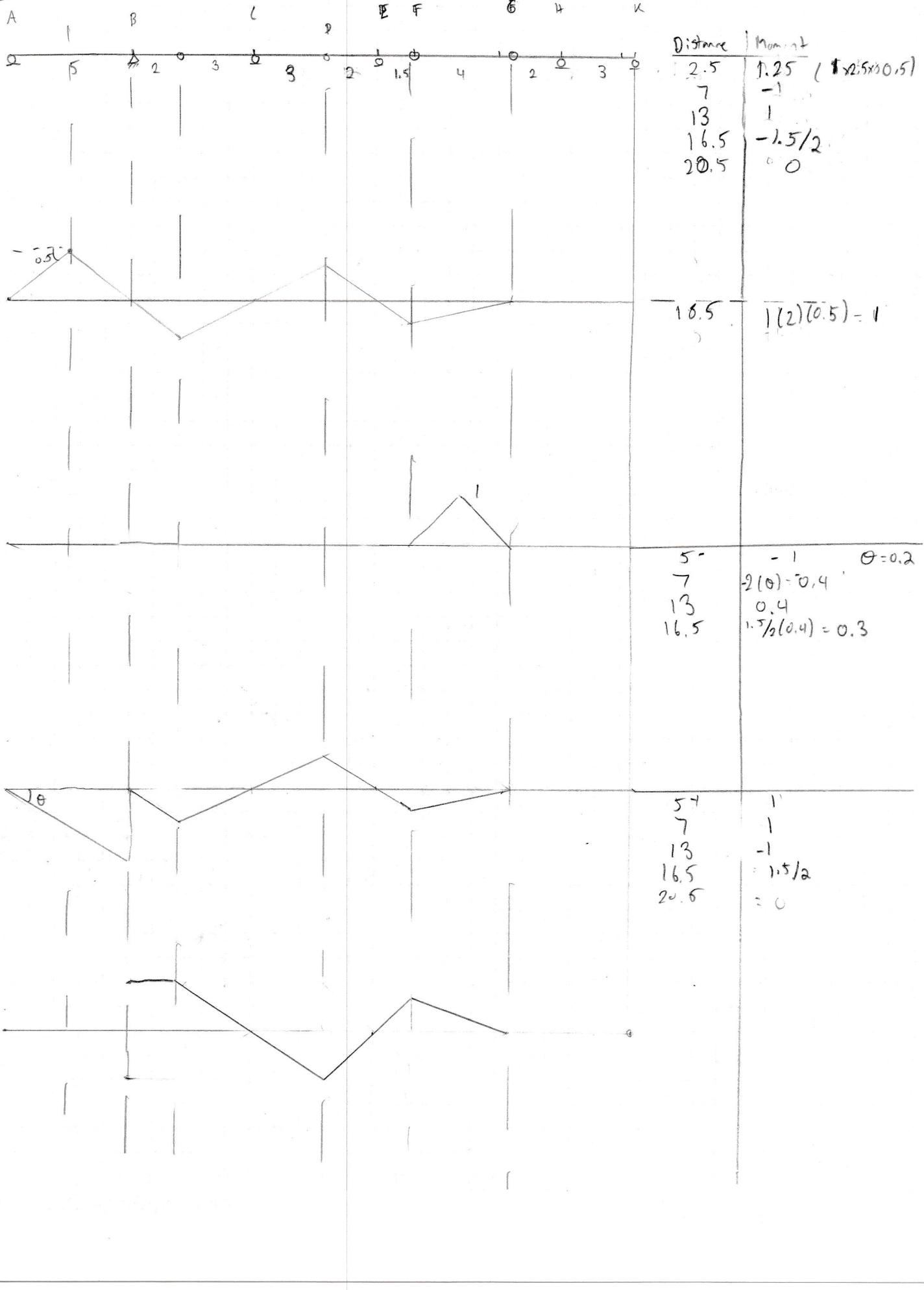
$$M_D = 0.65625x - \frac{1.5}{5}x(15.078125) + 3.75x^2$$

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

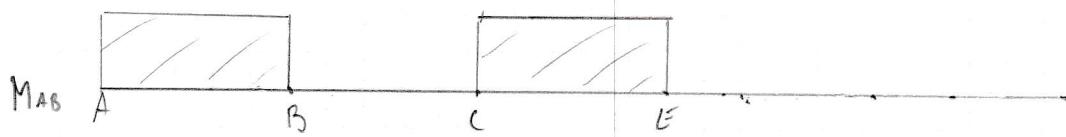
$$x = 0.516$$

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

(3)



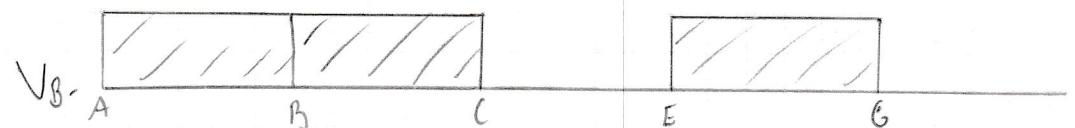
### Live Load Pattern:



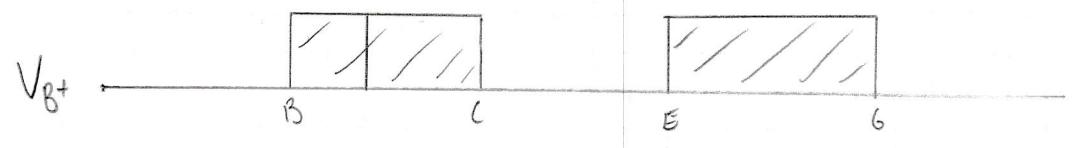
$$M_{A-7B} = 20(1.25)(5)(\frac{1}{2}) + 20(1)(5)(\frac{1}{2}) \approx 112.5 \text{ kN.m}$$



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



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



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

## 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.

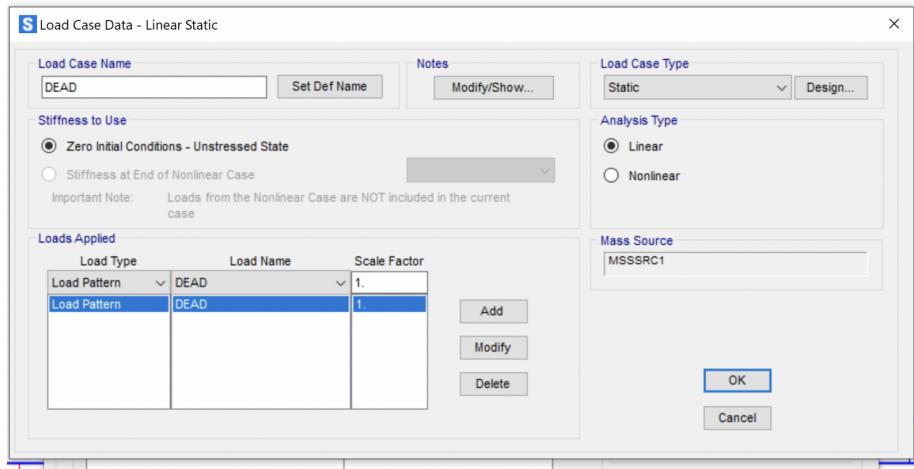


Figure 1: Load Case

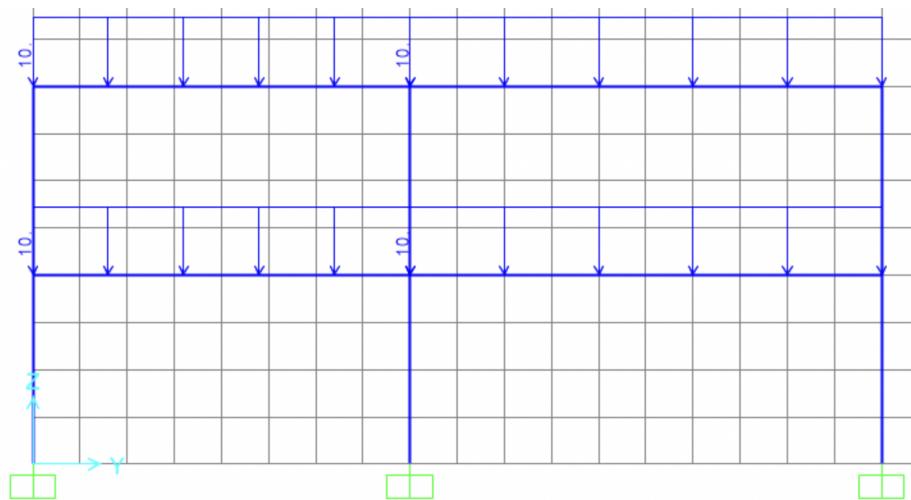


Figure 2: Loaded Structure

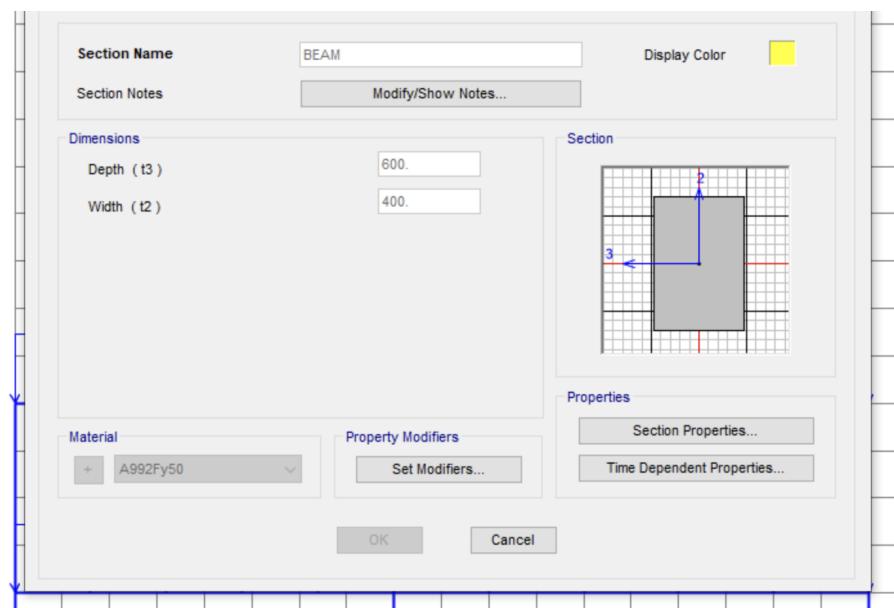


Figure 3: Beam Properties

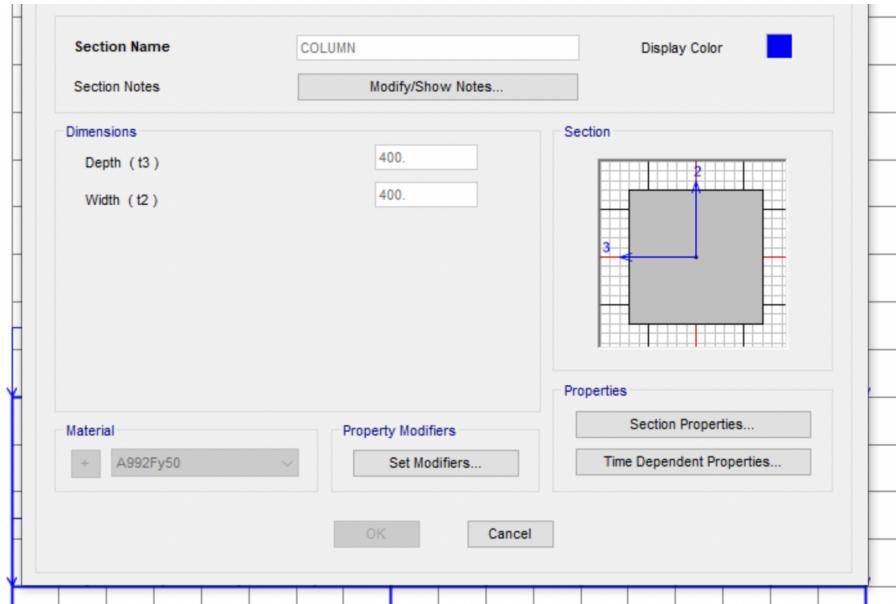


Figure 4: Column Properties

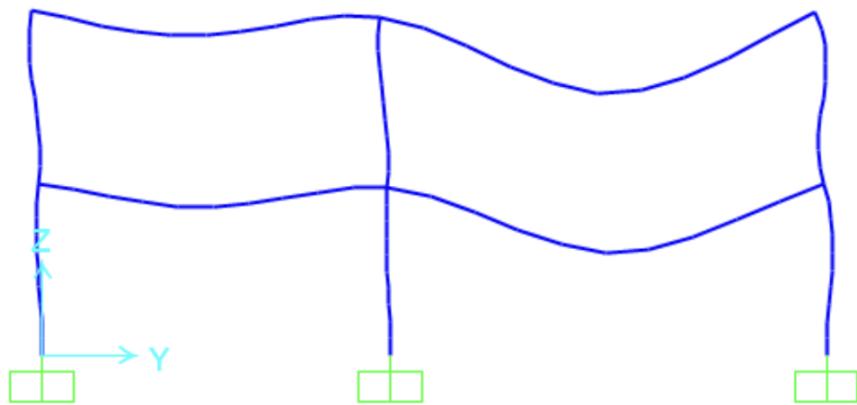


Figure 5: Deflected Shape

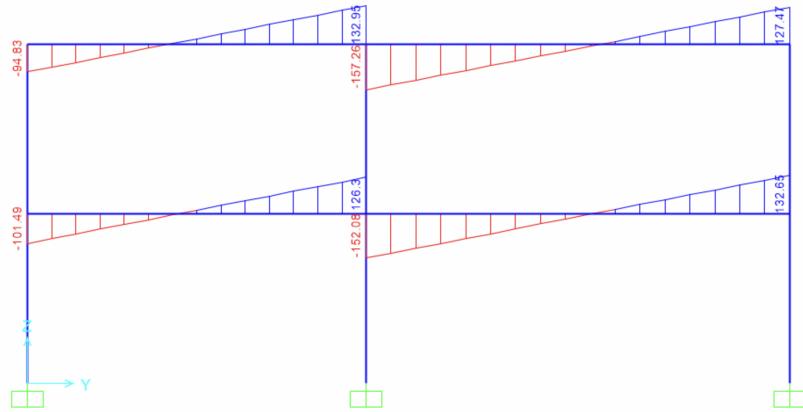


Figure 6: Shear Force Diagram

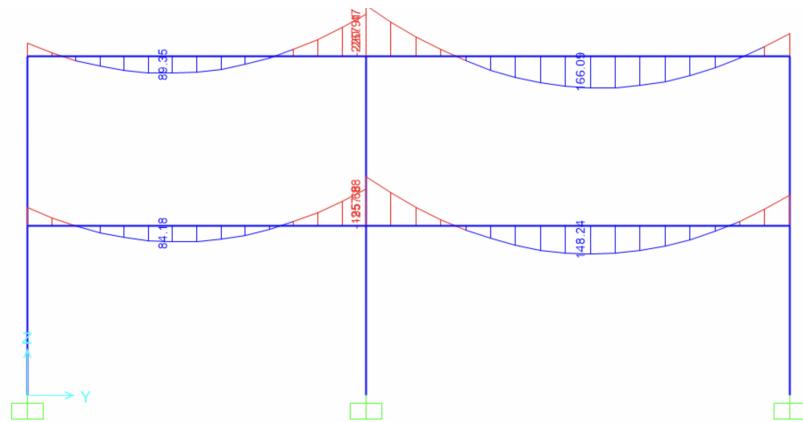


Figure 7: Moment Diagram



Figure 8: Floor 1 max values



Figure 9: Floor 2 max values