Approximate analysis for **Horizontal Loads**

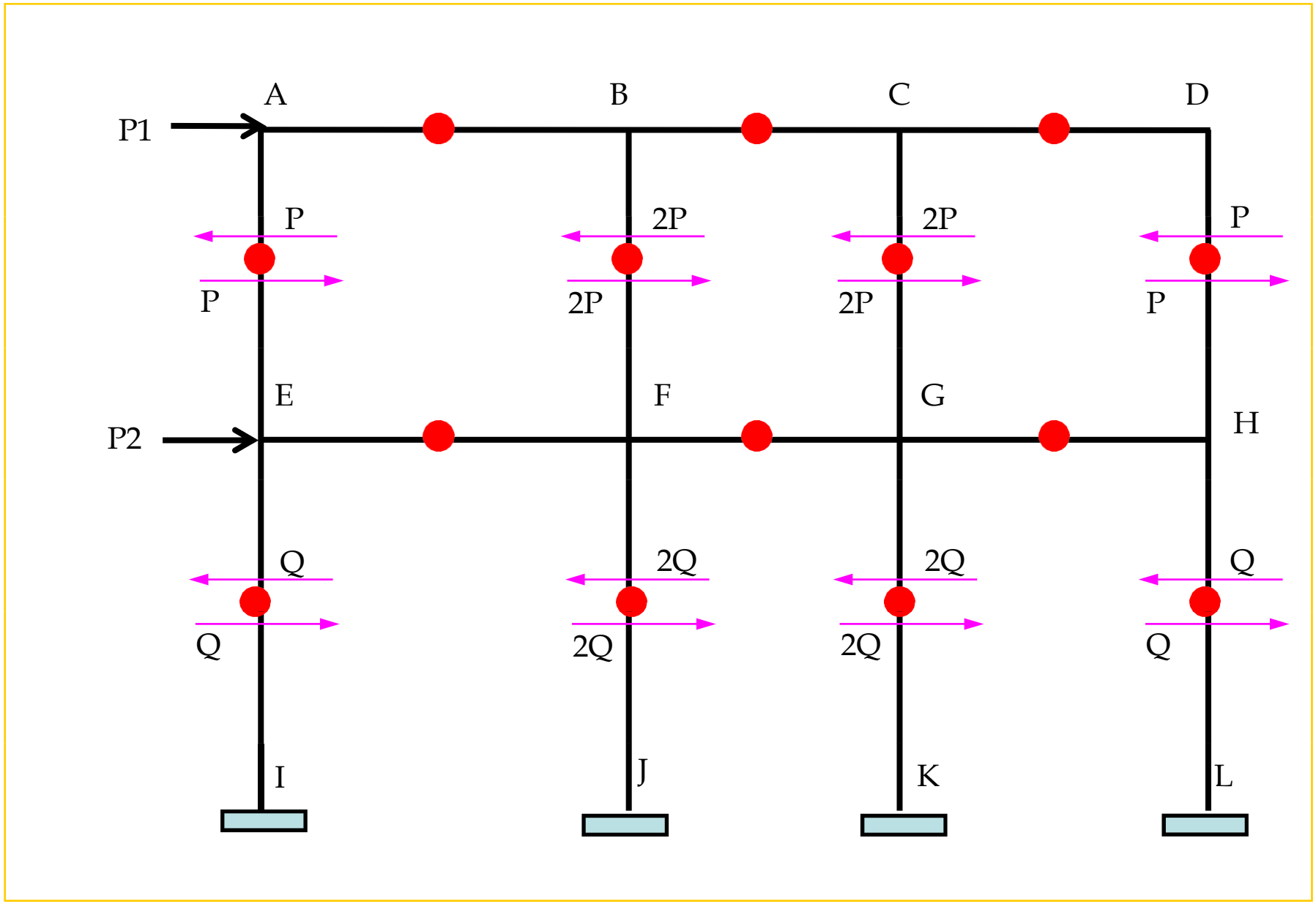
1. **Portal method**
2. **Cantilever method**
3. **Factor method**

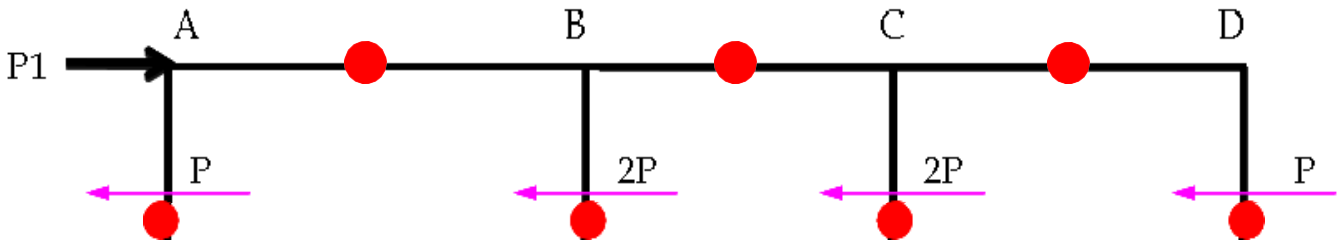
PORTAL METHOD

Assumptions

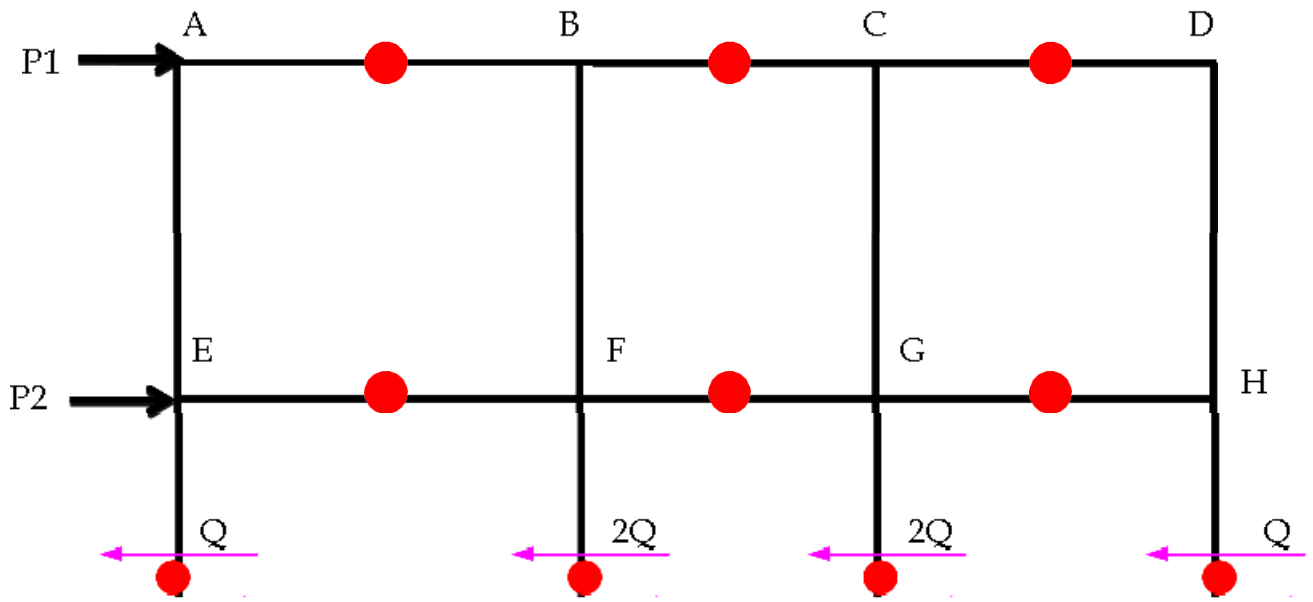
1. The points of contraflexure in all the members lie at their midpoints.
2. Horizontal shear taken by each interior column is double that taken by each exterior column.

Horizontal forces are assumed to act only at the joints.


A
B
C
D
P1
P
2P
2P
P
P
2P
2P
P
E
F
G
H
P2
Q
2Q
2Q
Q
Q
2Q
2Q
Q
I
J
K
L

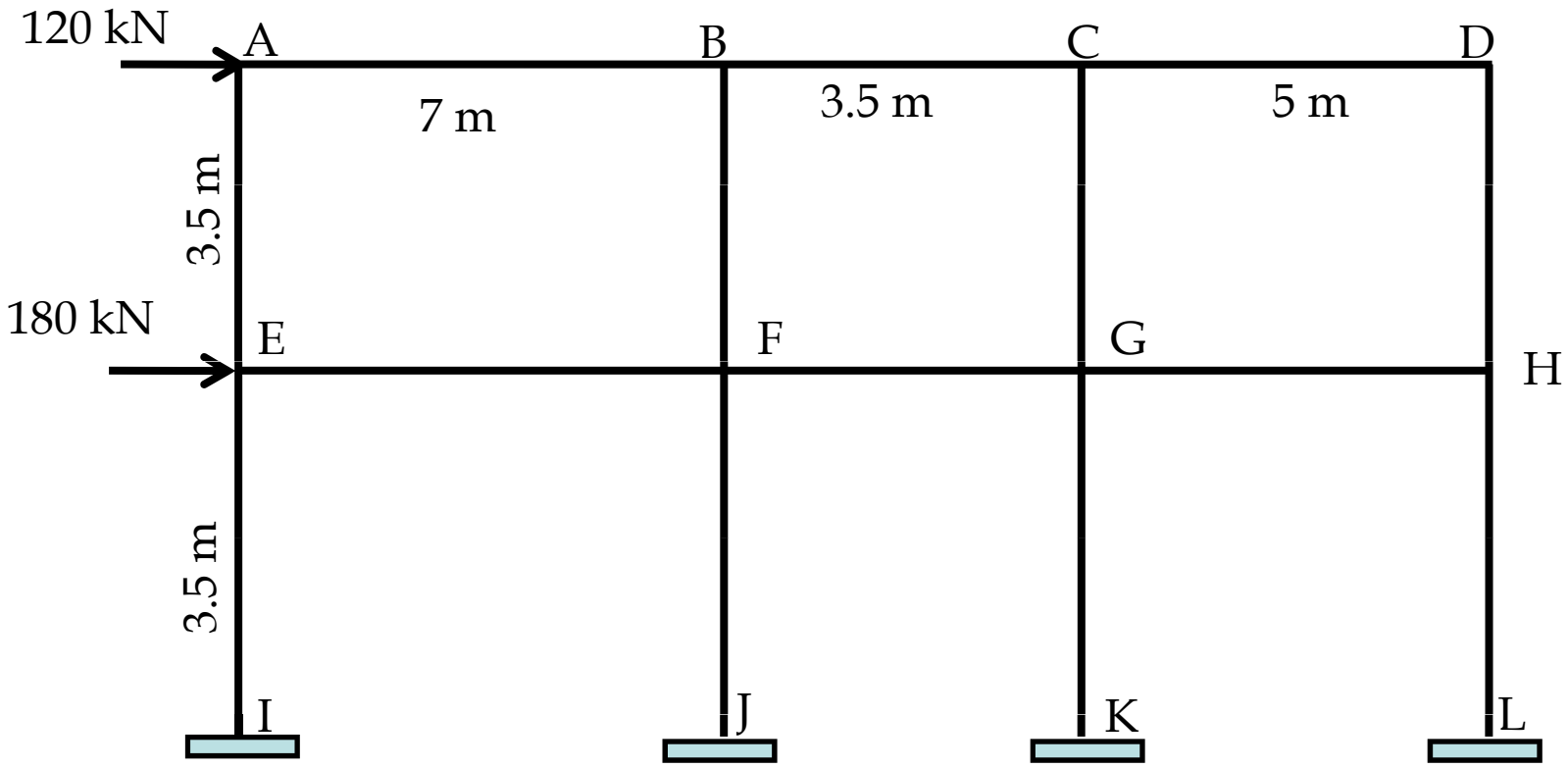


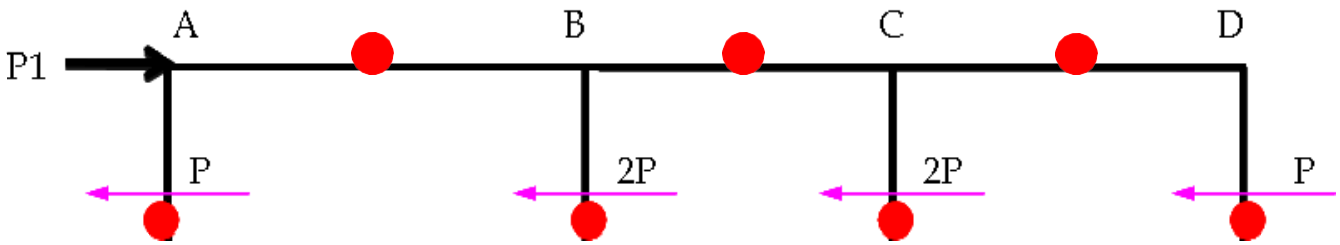
$$P_1 = P + 2P + 2P + P \qquad \Rightarrow P = \frac{P_1}{6}$$



$$P_1 + P_2 = Q + 2Q + 2Q + Q \qquad \Rightarrow Q = \frac{P_1 + P_2}{6}$$

Problem 3: Analyse the frame using portal method.



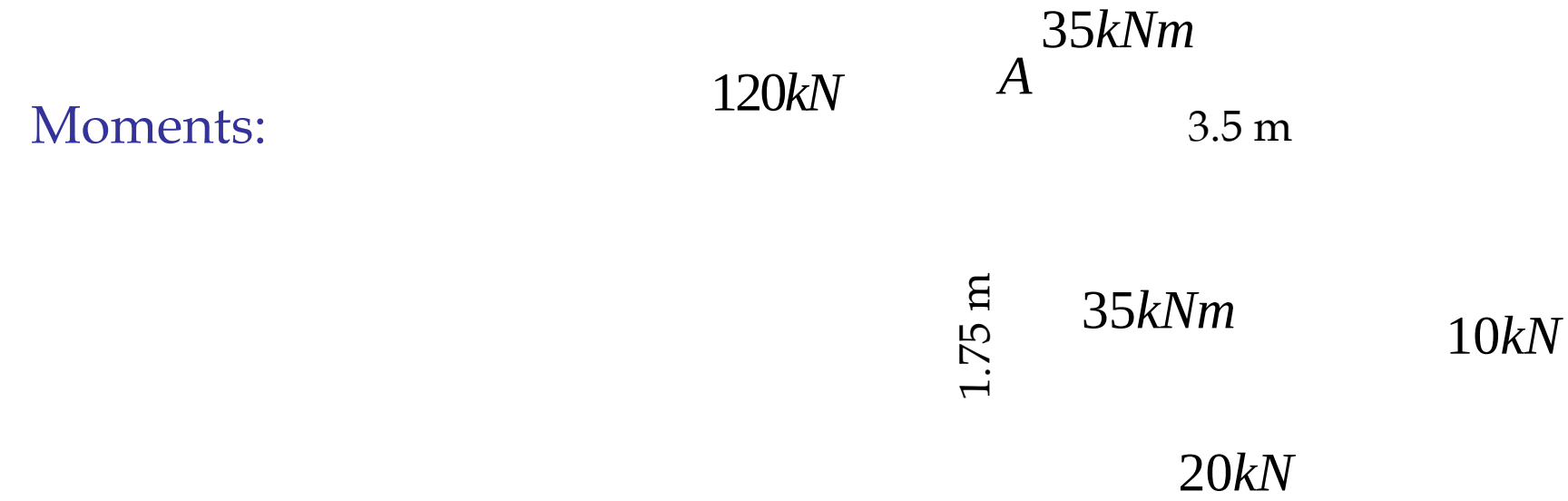


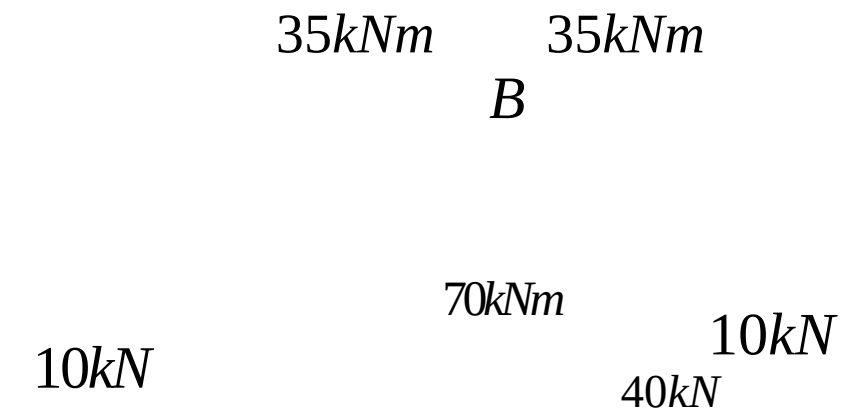
Horizontal shears:

$$\textit{For the top storey, } P_1 = P + 2P + 2P + P \quad \Rightarrow P = \frac{120}{6} = 20kN$$

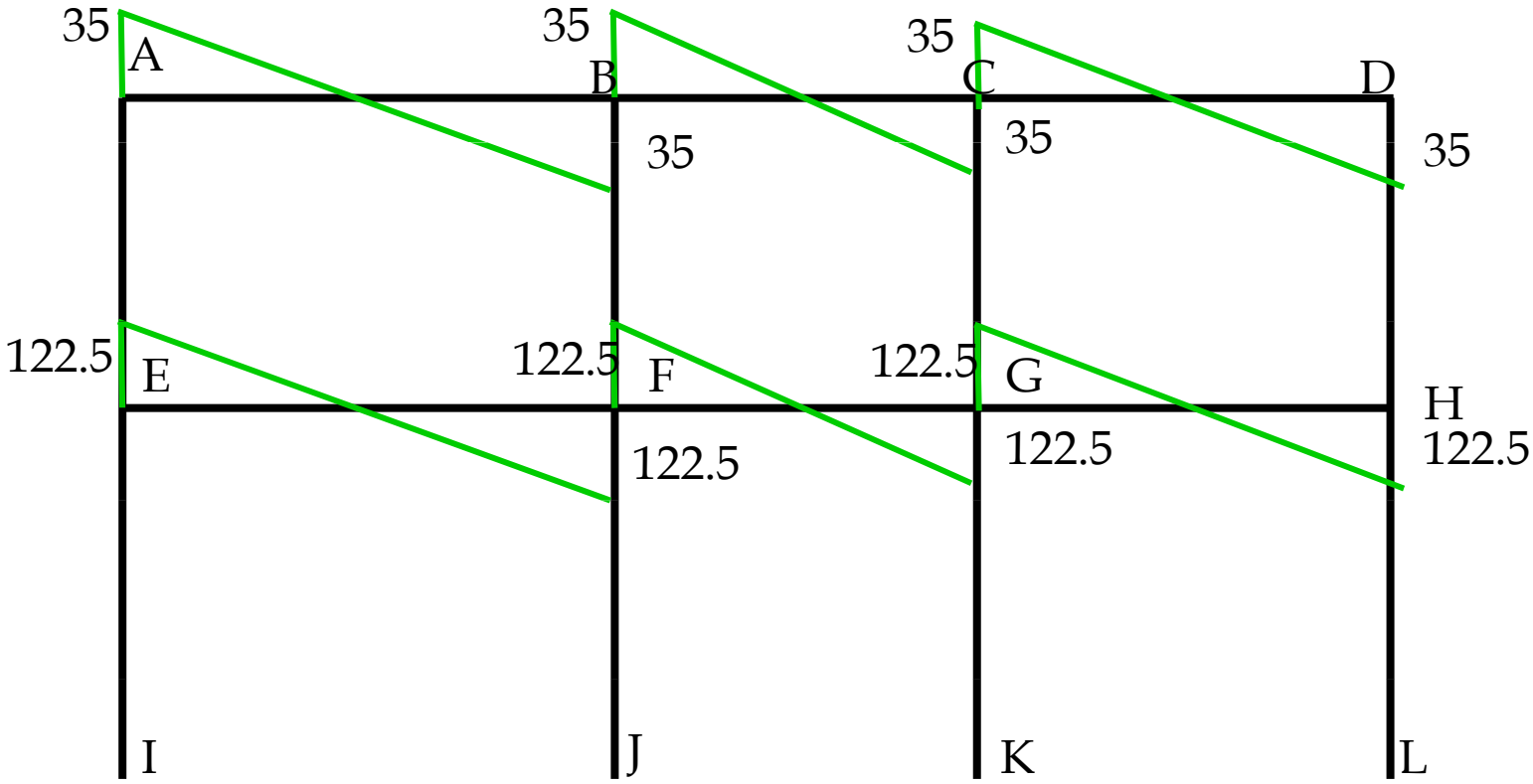
$$\textit{For the bottom storey, } Q = \frac{P_1 + P_2}{6} = \frac{120 + 180}{6} = 50kN$$

Moments:

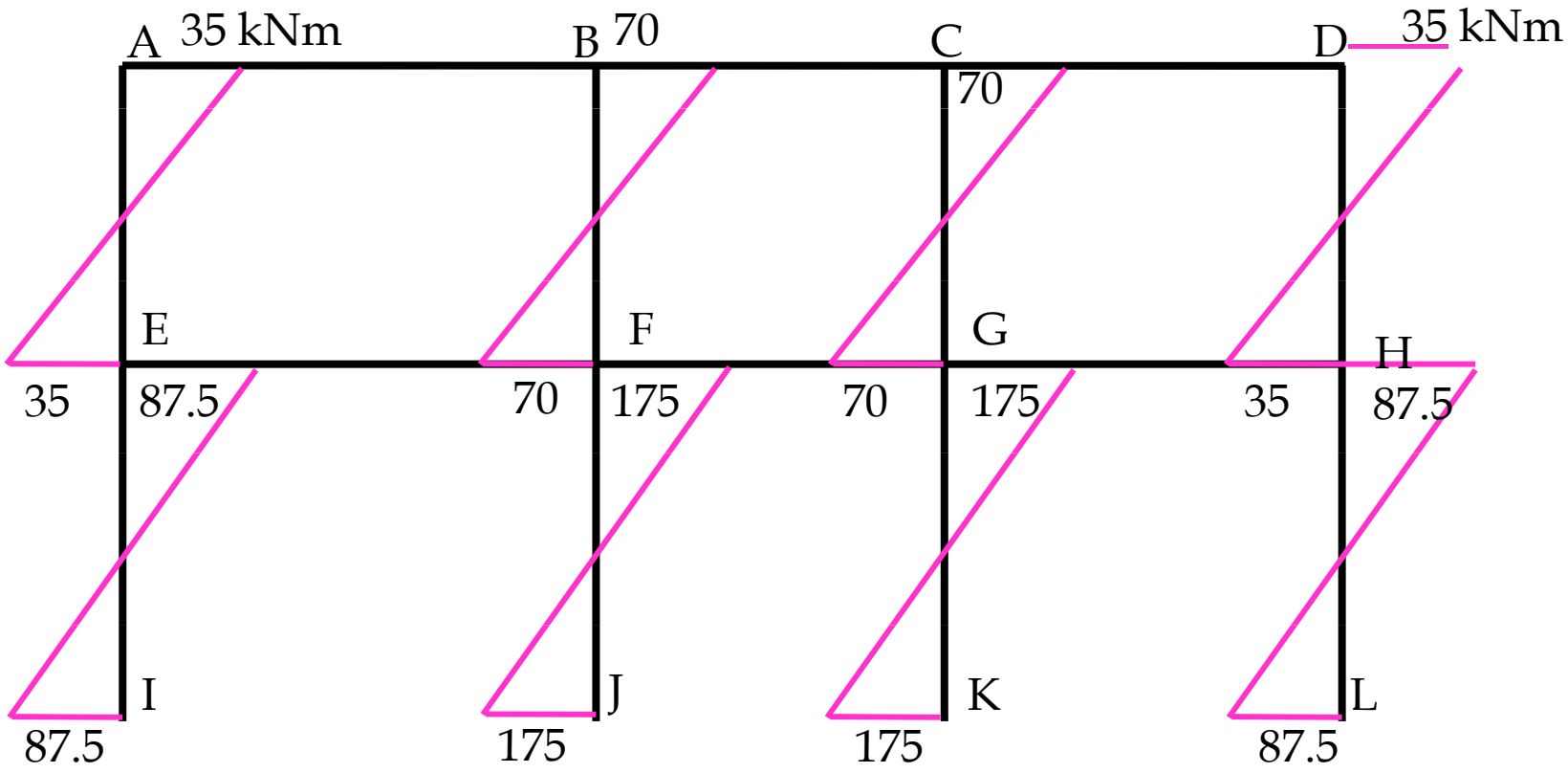

35kNm
120kN
A
3.5 m
1.75 m
35kNm
10kN
20kN


35kNm
35kNm
B
70kNm
10kN
10kN
40kN

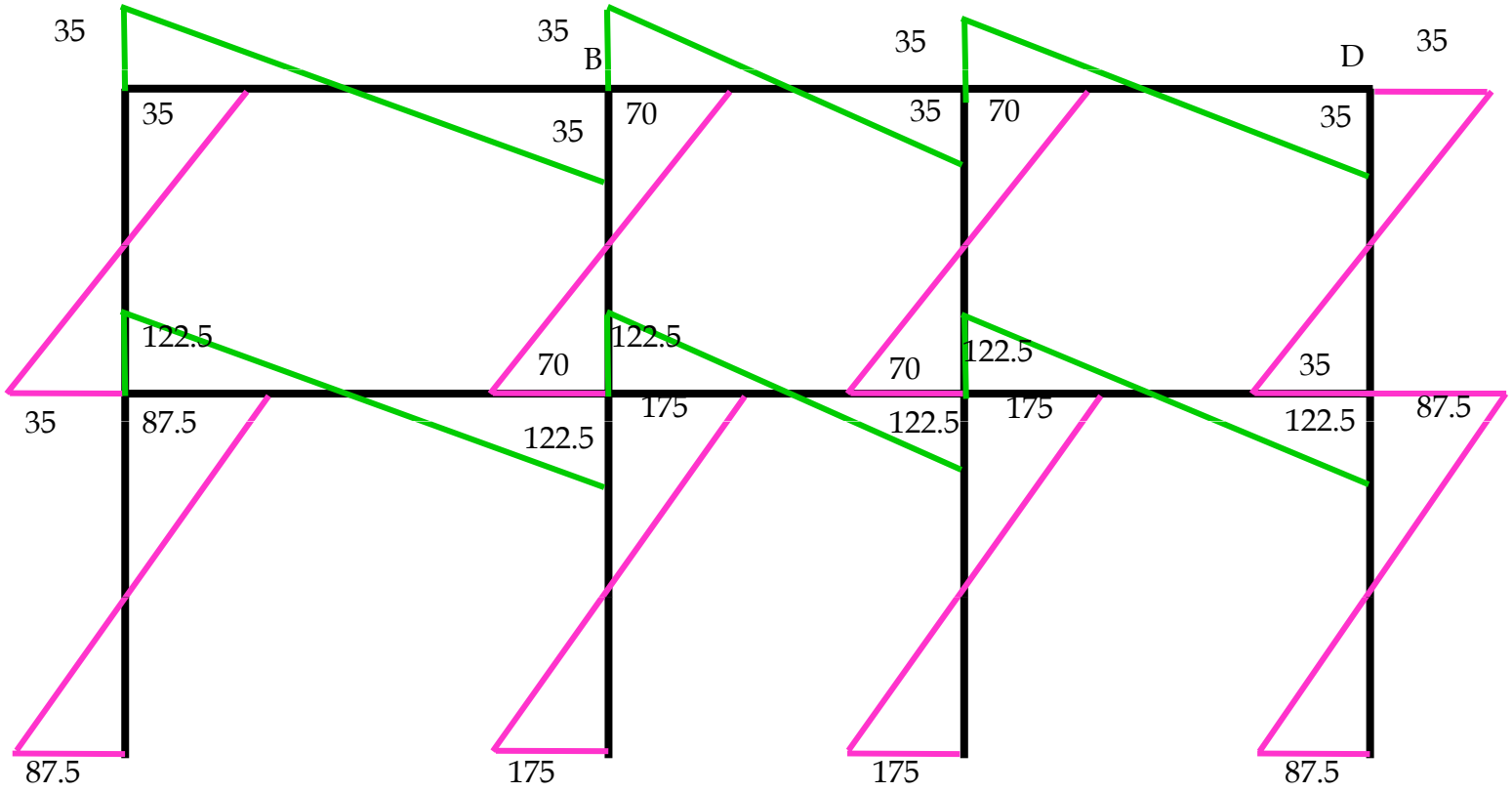
Beam moments:



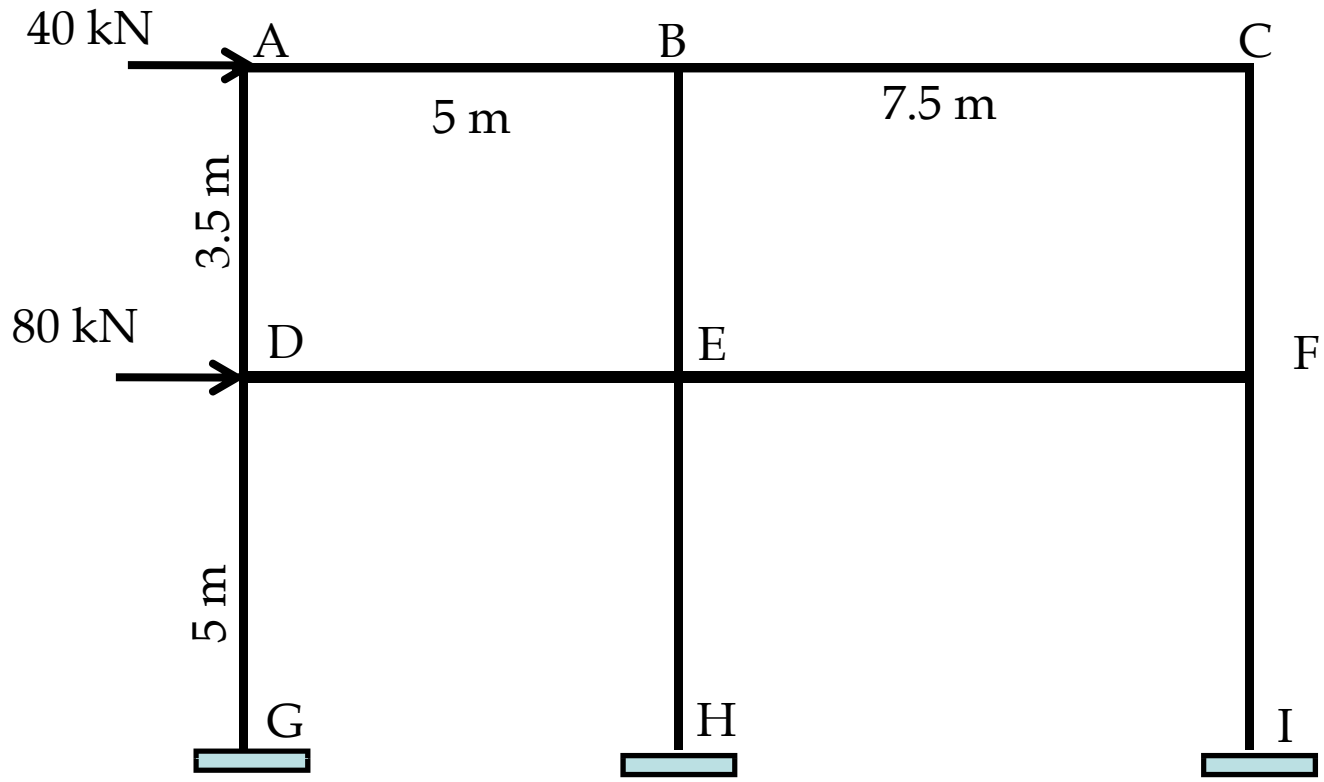
Column moments:



Beam and Column moments:



Home work

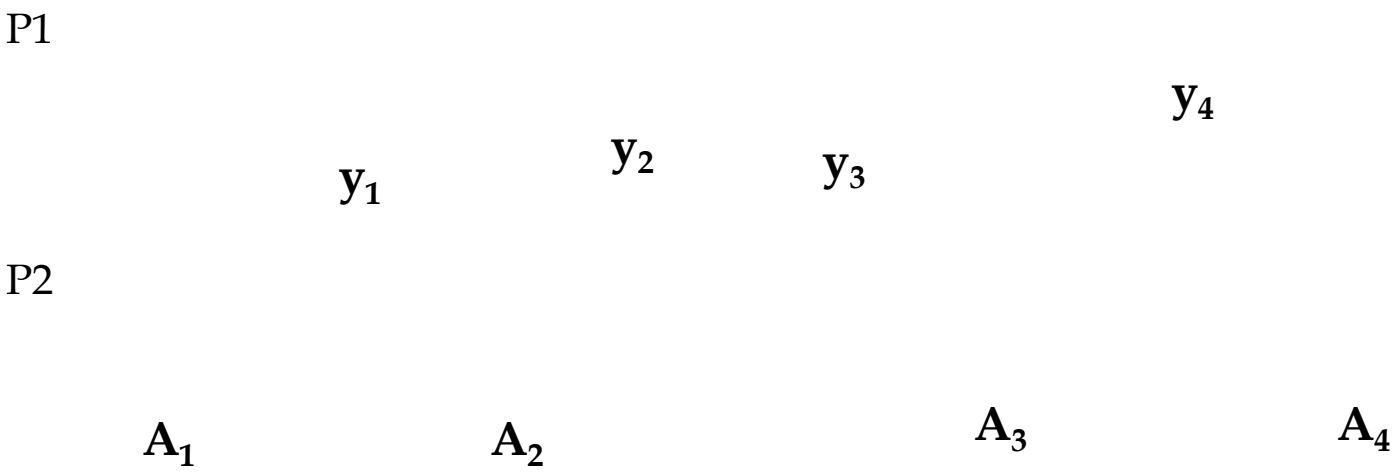


CANTILEVER METHOD

- Frame considered as a vertical cantilever

Assumptions

1. The points of contraflexure in all the members lie at their midpoints.
2. The direct stresses (axial stresses) in the columns are directly proportional to their distance from the centroidal vertical axis of the frame.



Area of cross section

Centroidal vertical axis of the frame

To locate centroidal vertical axis of the frame,

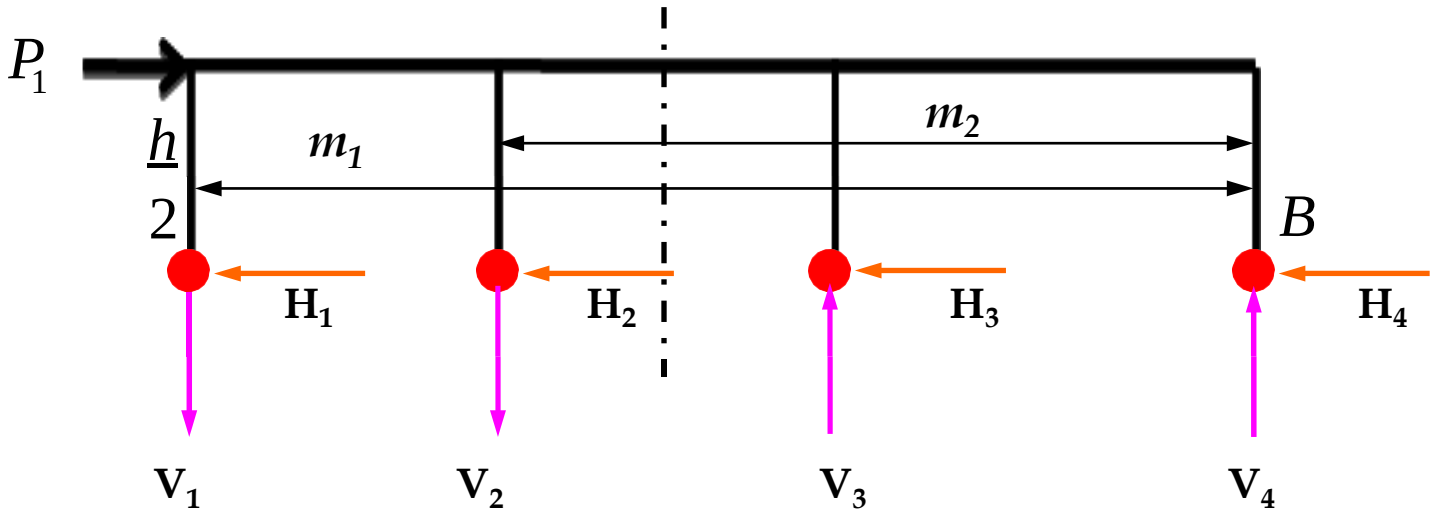
$$y = \frac{A_1 d_1 + A_2 d_2 + A_3 d_3 + A_4 d_4}{A_1 + A_2 + A_3 + A_4}$$

$\mathbf{V_1}$ $\mathbf{V_2}$ $\mathbf{V_3}$ $\mathbf{V_4}$

$$\sigma_x = \frac{My}{I}$$

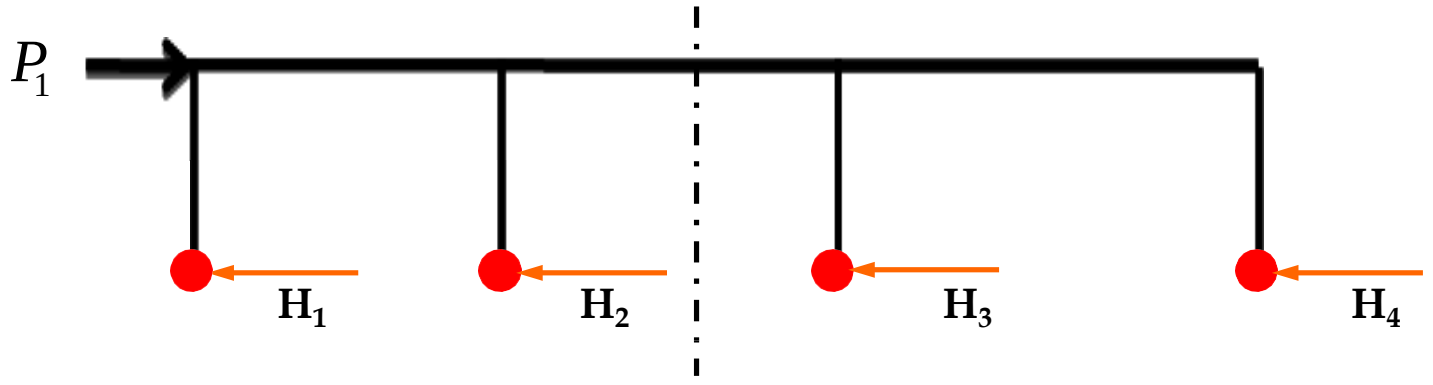
$\frac{M}{I}$ is constant at a given height (of the 'vertical cantilever').

$$\frac{\sigma_1}{y_1} = \frac{\sigma_2}{y_2} = \frac{\sigma_3}{y_3} = \frac{\sigma_4}{y_4} \Rightarrow \frac{V_1 A_1}{y_1} = \frac{V_2 A_2}{y_2} = \frac{V_3 A_3}{y_3} = \frac{V_4 A_4}{y_4} \quad \text{——————} (1)$$



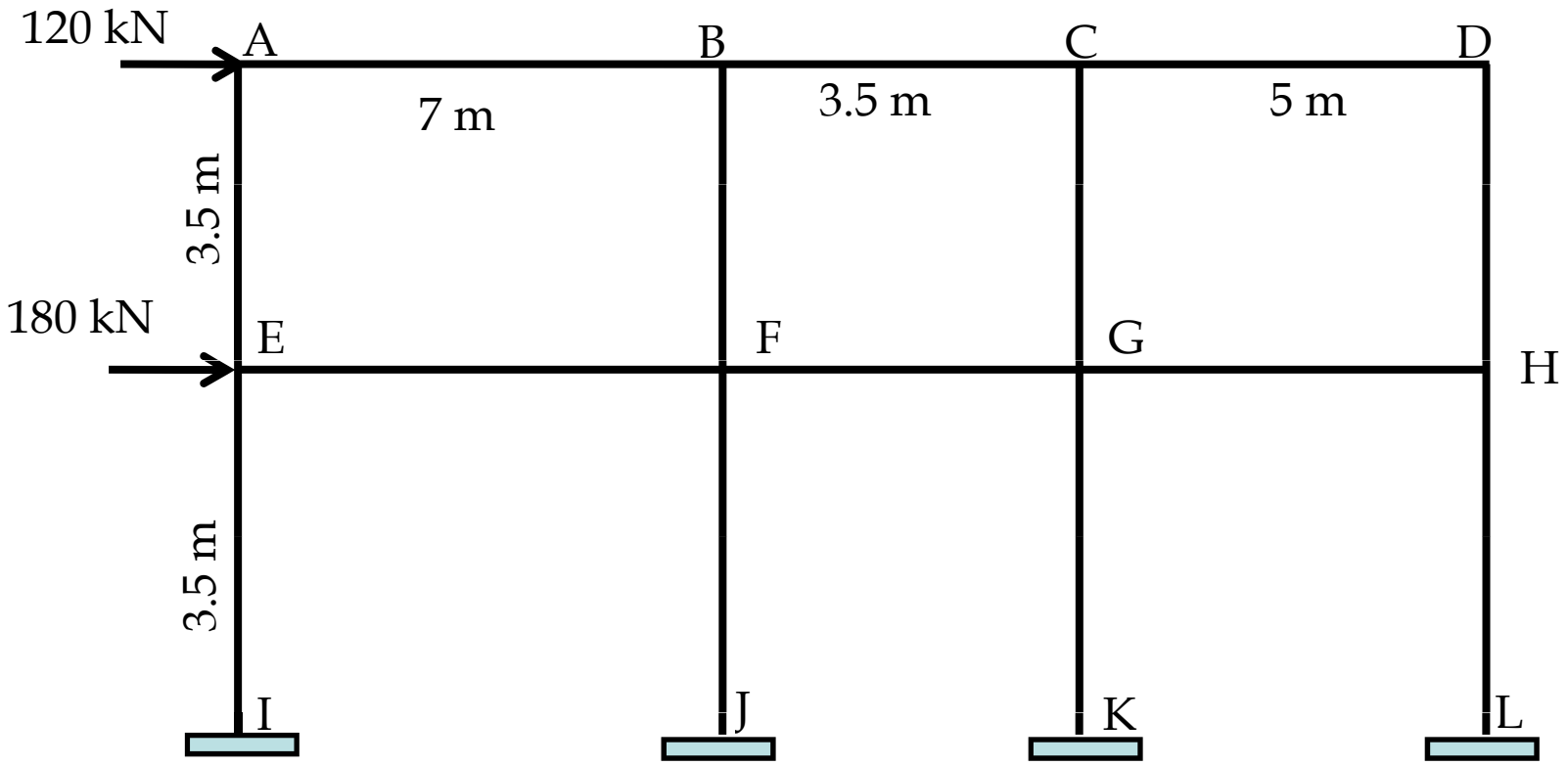
$$\sum M_B \Rightarrow P_1 \frac{h}{2} = Vm_{11} + Vm_{22} - Vm_{33} - Vm_{44} \qquad \text{(2)}$$

From (1) and (2), V_1, V_2, V_3, V_4 can be found.



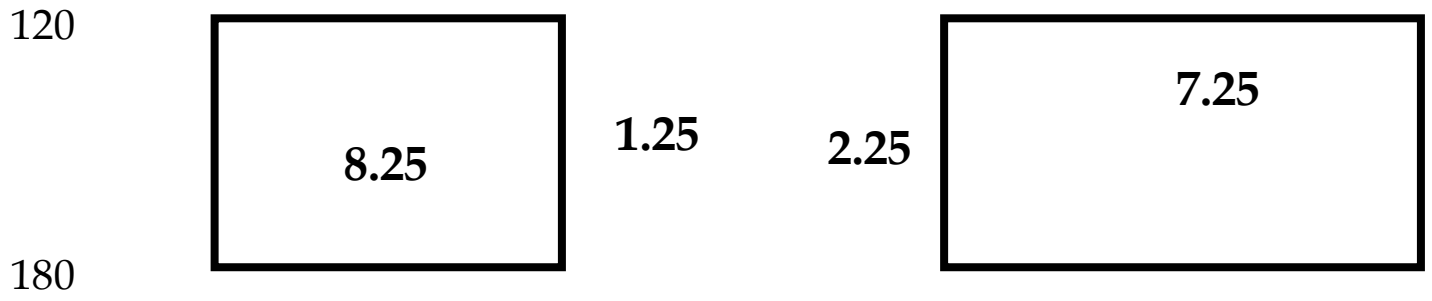
$$P_1 = H_1 + H_2 + H_3 + H_4$$

Problem 4: Analyse the frame using cantilever method, if all the columns have the same area of cross section.



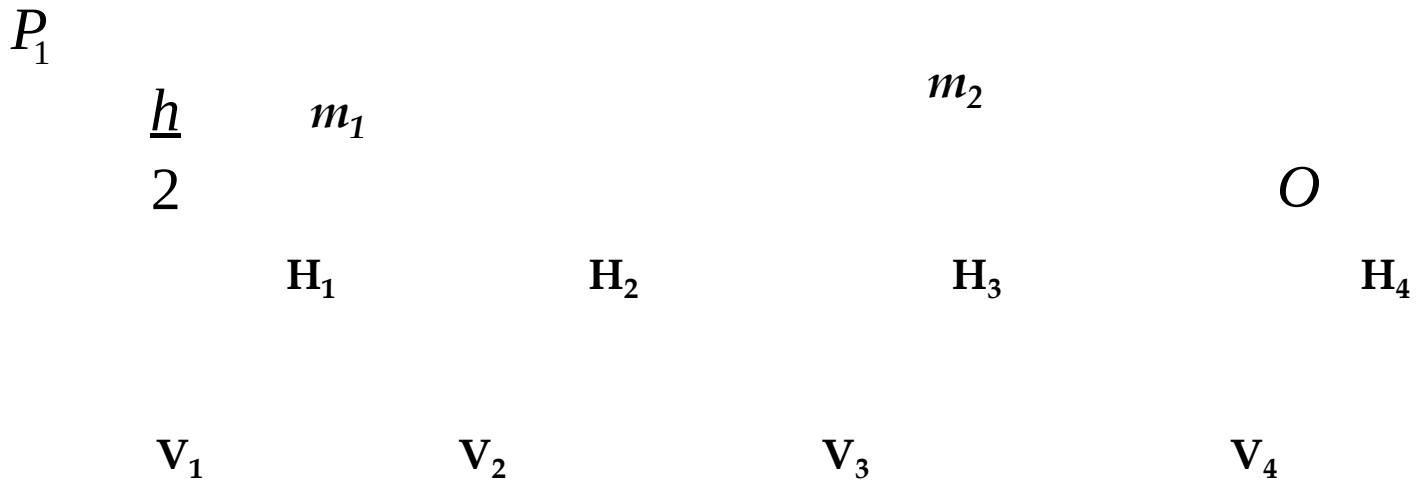
To locate centroidal vertical axis of the frame,

$$y = \frac{A_1 \times 0 + A_1 \times 7 + A_1 \times 10.5 + A_1 \times 15.5}{A_1 + A_1 + A_1 + A_1} = \frac{33}{4} = 8.25m$$



Also, $$\frac{V_1}{8.25} = \frac{A_1}{1.25} = \frac{V_2}{2.25} = \frac{A_2}{7.25} = \frac{V_3}{A_3} = \frac{V_4}{A_4} \Rightarrow \frac{V_1}{8.25} = \frac{V_2}{1.25} = \frac{V_3}{2.25} = \frac{V_4}{7.25}$$

$$V_2 = \frac{1.25V_1}{8.25},\ V_3 = \frac{2.25V_1}{8.25},\ V_4 = \frac{7.25V_1}{8.25}$$



For the top storey, $\sum M_O \Rightarrow P_1 \frac{h}{2} = Vm_{1\,1} + Vm_{2\,2} - Vm_{3\,3} - Vm_{4\,4}$

$$\Rightarrow 120 \times \frac{3.5}{2} = V_1 \times 15.5 + V_2 \times 8.5 - V_3 \times 5 - V_4 \times 0$$

$$\Rightarrow 120\times\frac{3.5}{2}=V_1\times 15.5+\left(\frac{1.25V_1}{8.25}\right)\times 8.5-\left(\frac{2.25V_1}{8.25}\right)\times 5$$

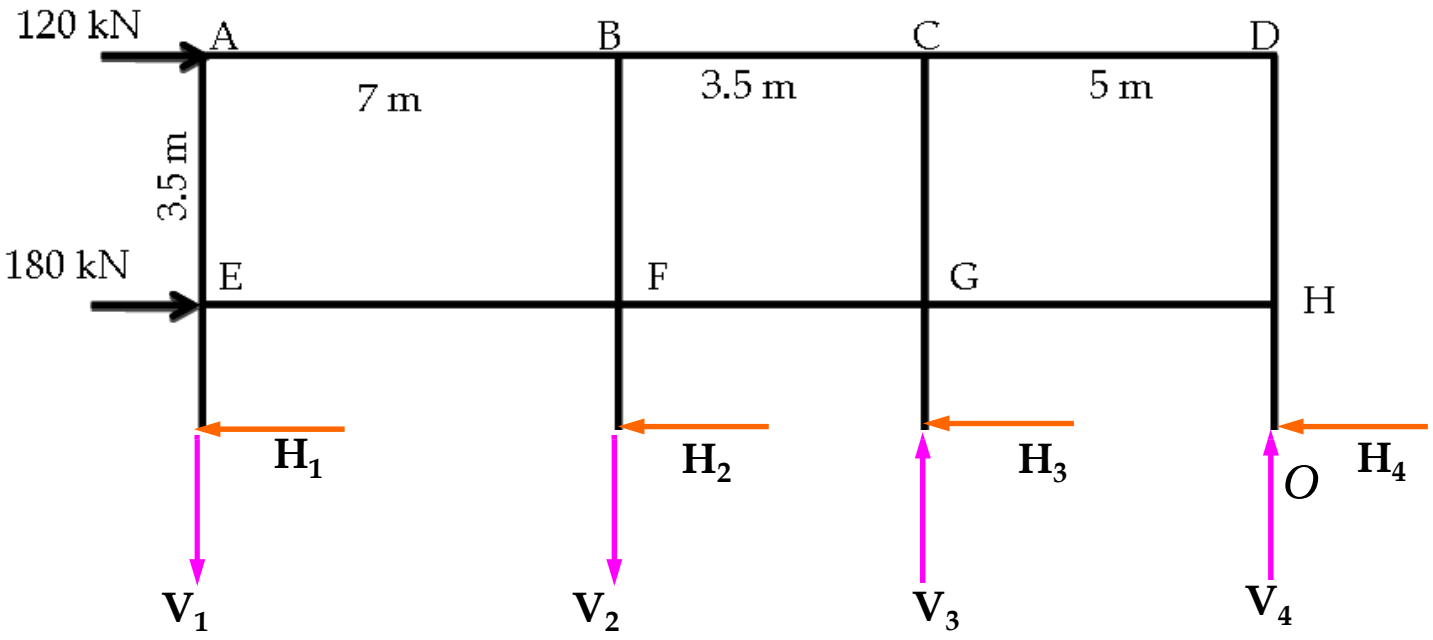
$$\Rightarrow V_1=13.615kN$$

$$V_2=\frac{1.25\times 13.615}{8.25}=2.063kN,$$

$$V_3=\frac{2.25\times 13.615}{8.25}=3.713kN,$$

$$V_4=\frac{7.25\times 13.615}{8.25}=11.965kN$$

$$Check:\ 13.615+2.063-3.713-11.965=0$$



For the bottom storey,

$$\sum M_O \Rightarrow 120\times\left(3.5+\frac{3.5}{2}\right)+180\times\frac{3.5}{2}=V_1\times 15.5+V_2\times 8.5-V_3\times 5-V_4\times 0$$

$$\Rightarrow 120\times\left(3.5+\frac{3.5}{2}\right)+180\times\frac{3.5}{2}=V_1\times 15.5+\left|\frac{1.25V_1}{8.25}\right|\times 8.5-\left|\frac{2.25V_1}{8.25}\right|\times 5$$

$$\Rightarrow V_1=61.267kN$$

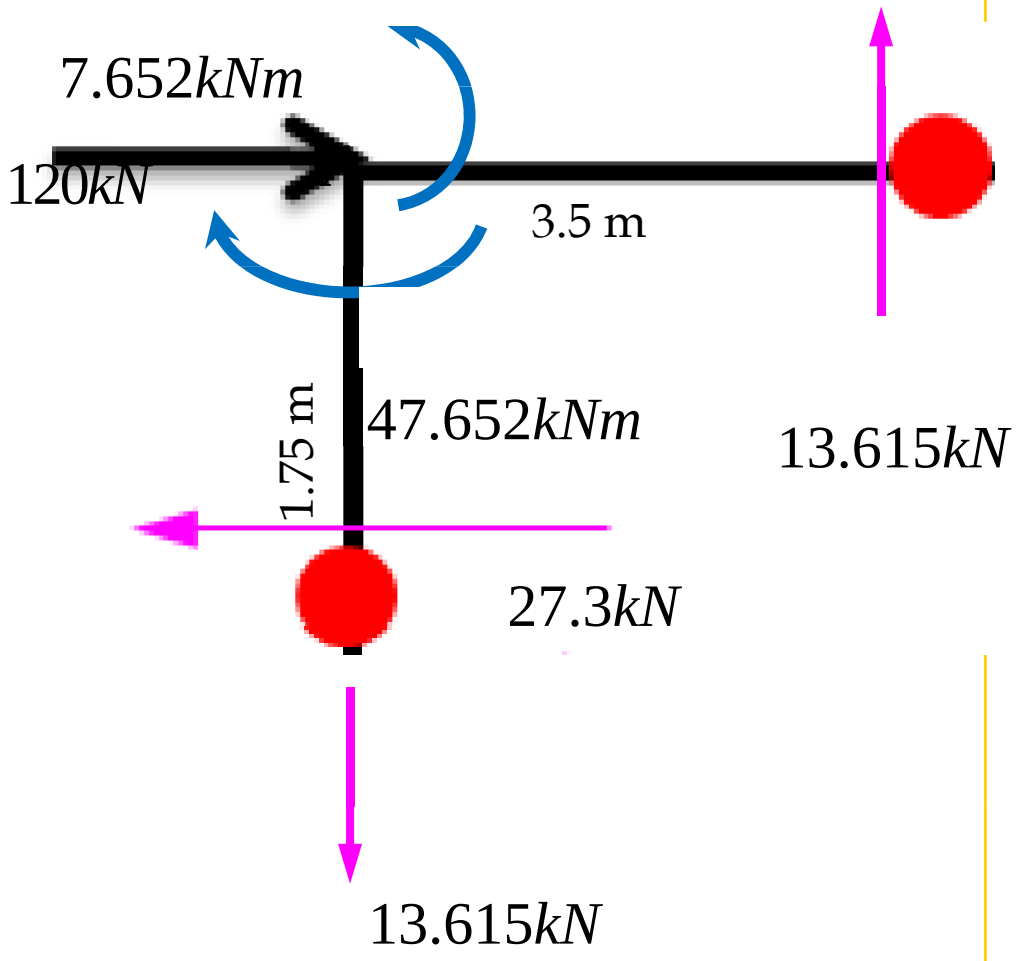
$$V_2=\frac{1.25\times 61.267}{8.25}=9.283kN,$$

$$V_3=\frac{2.25\times 61.267}{8.25}=16.709kN,$$

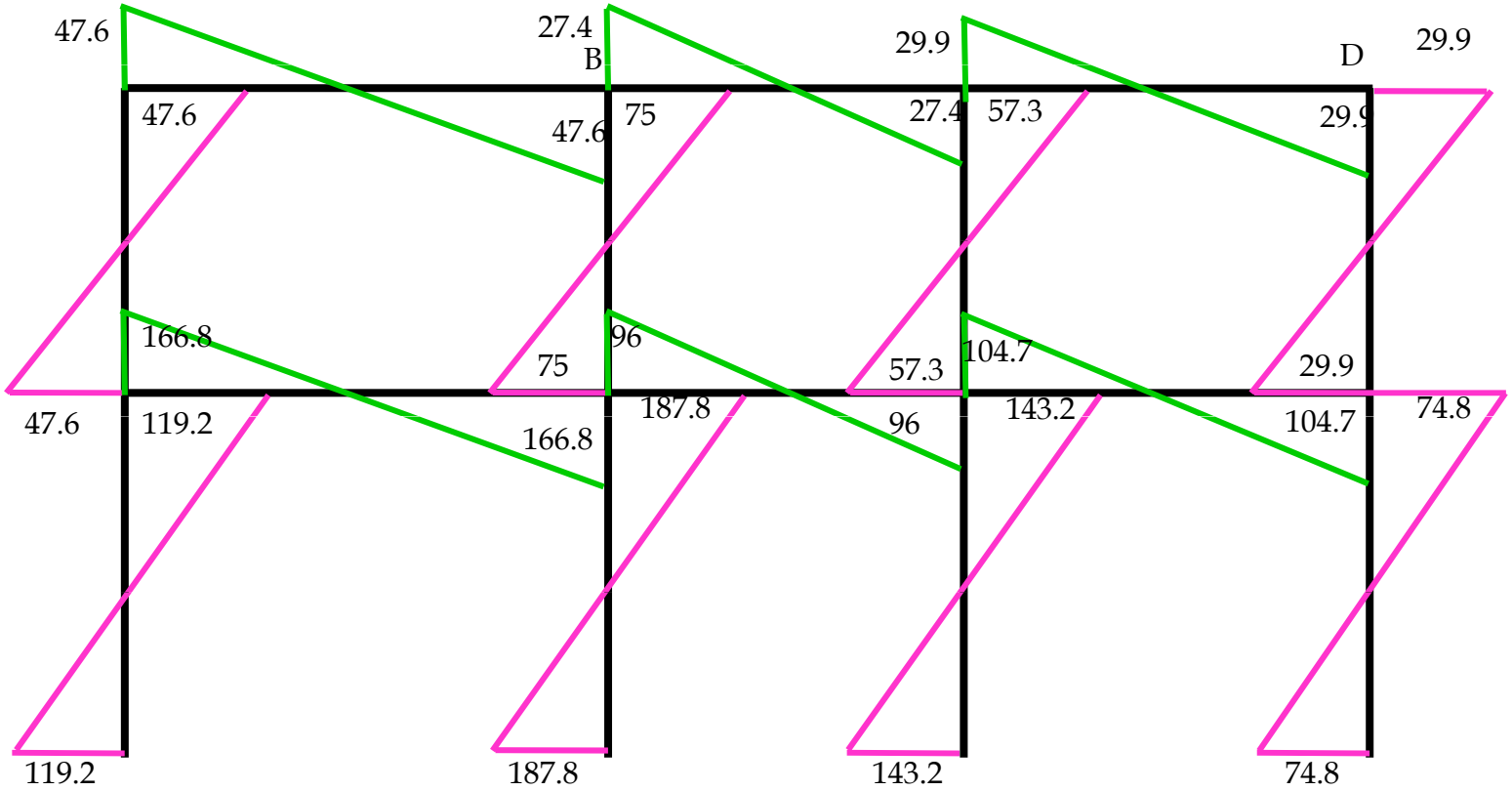
$$V_4=\frac{7.25\times 61.267}{8.25}=53.841kN$$

$$Check:\ 61.267+9.283-16.709-53.841=0$$

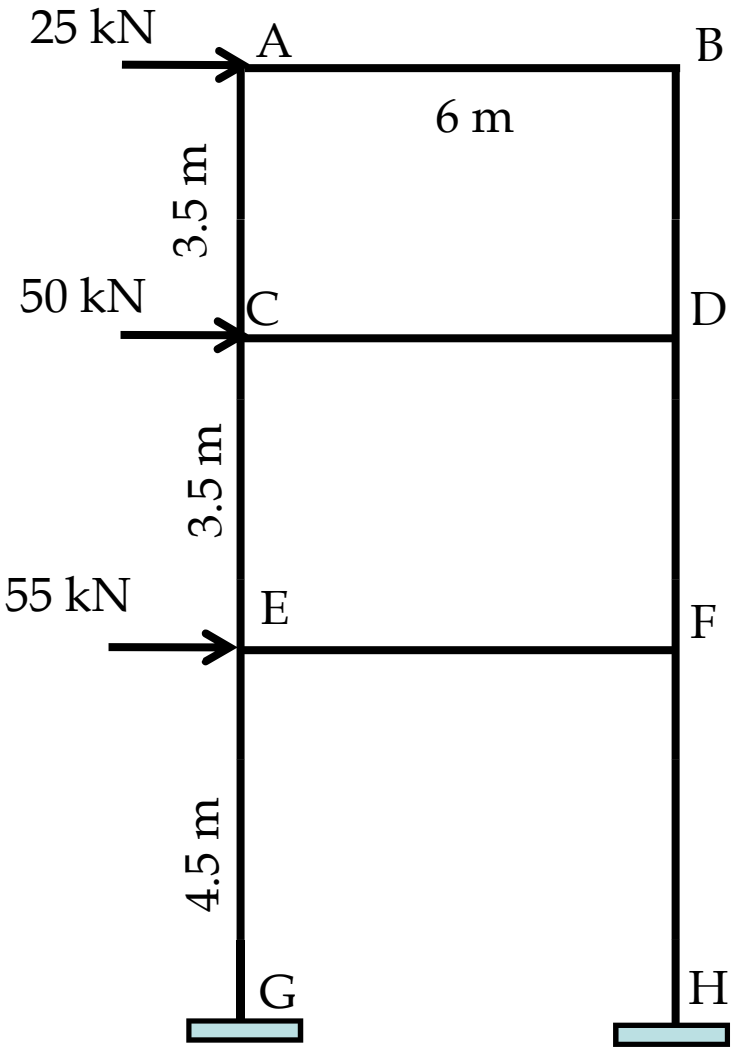
Moments:



Beam and Column moments:



Home work



- Factor method.