

**ENCE 353 Midterm 1, Open Notes and Open Book**

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**Exam Format and Grading.** This take home midterm exam is open notes and open book. You need to comply with the university regulations for academic integrity.

There are three questions. Partial credit will be given for partially correct answers, so please show all your working.

Please see the **class web page** for instructions on how to submit your exam paper.

Question	Points	Score
1	15	
2	15	
3	10	
Total	40	

**Question 1 (15 points): Support Reactions and Bending Moments in a connected Beam Structure.**

Consider the multi-span beam structure shown in Figure 1.

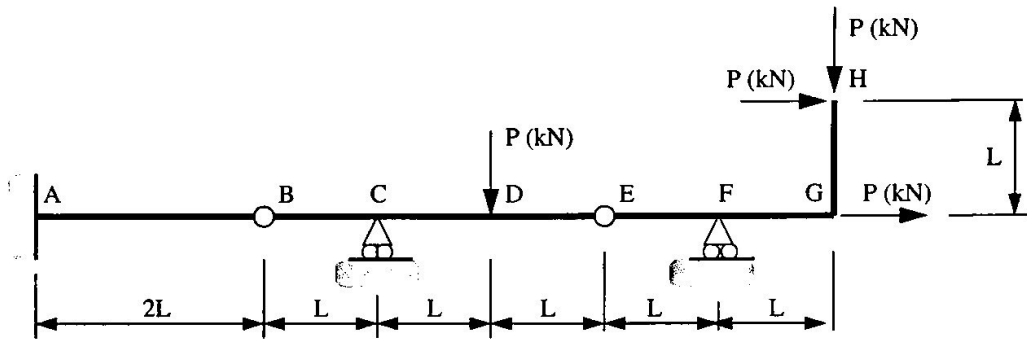


Figure 1. Front elevation view of multi-span beam structure.

The cantilever is fully-fixed to the wall at Point A. Points B and E are hinges. Horizontal and vertical point loads  $P$  (kN) are applied at points D, G and H.

[1a] (3 pts). Compute the degree of indeterminacy for the beam structure.

$$i = f - 3 - r; \quad f = 5, \quad 2 \text{ releases.}$$

$$= 5 - 3 - 2 = 0 \leftarrow \text{statically determinate.}$$

[1b] (3 pts). Compute the vertical reaction forces at nodes C and F.

$$\sum M_e = 0 \rightarrow PL + 2PL - V_f \cdot L = 0$$

$$\rightarrow V_f = 3P.$$

$$\sum V = 0 \text{ (for right-most substructure)}$$

$$P + X = V_f \Rightarrow X = 2P.$$

$$\sum M_b = 0 \quad V_c L + 2P(3L) - 2PL = 0$$

$$\Rightarrow V_c = -4P.$$

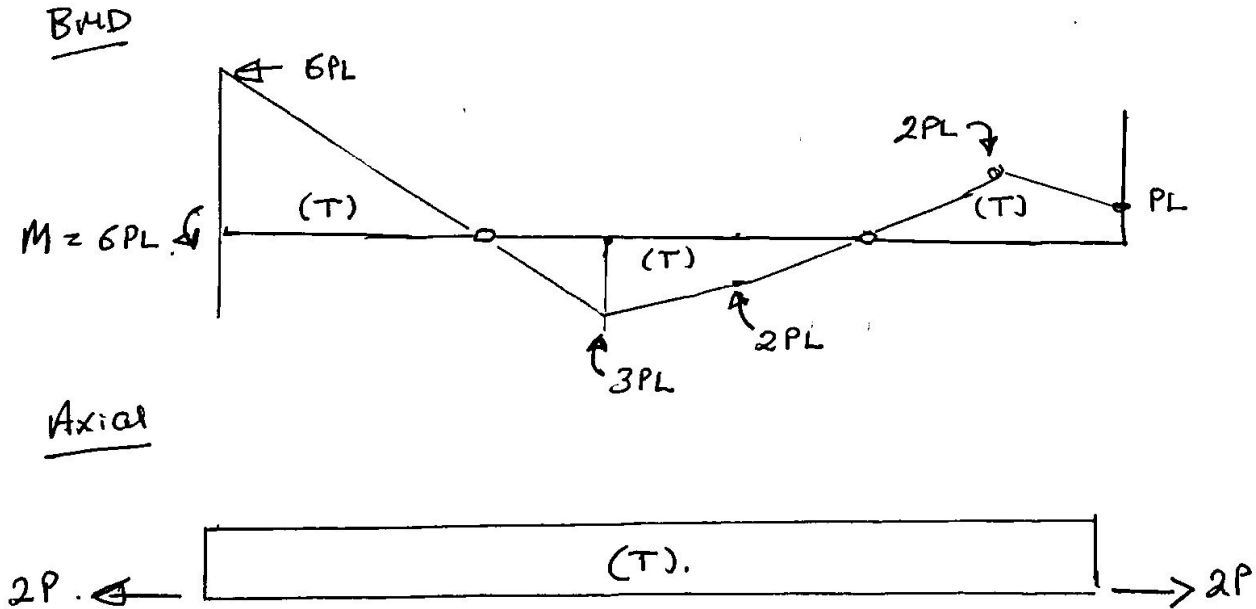
$$\sum V = 0 \Rightarrow V_b = y = 3P.$$

$$M = 6PL.$$

[1c] (3 pts). Show that the total force at hinge B is  $\sqrt{13}P$ .

$$\left. \begin{array}{l} \text{Axial force at B} = 2P \\ \text{Shear force at B} = 3P \end{array} \right\} \text{Total force} = [3^2 + 2^2]^{1/2} P = \sqrt{13} P.$$

[1d] (6 pts). Draw and label diagrams showing how the bending moment and axial force vary along the beam, nodes A through G. Clearly indicate on your bending moment diagram, regions that are in tension/compression.



**Question 2 (15 points): Tension, Compression and Zero-Force Members in a Truss Structure.**

Consider the truss structure shown in Figure 2.

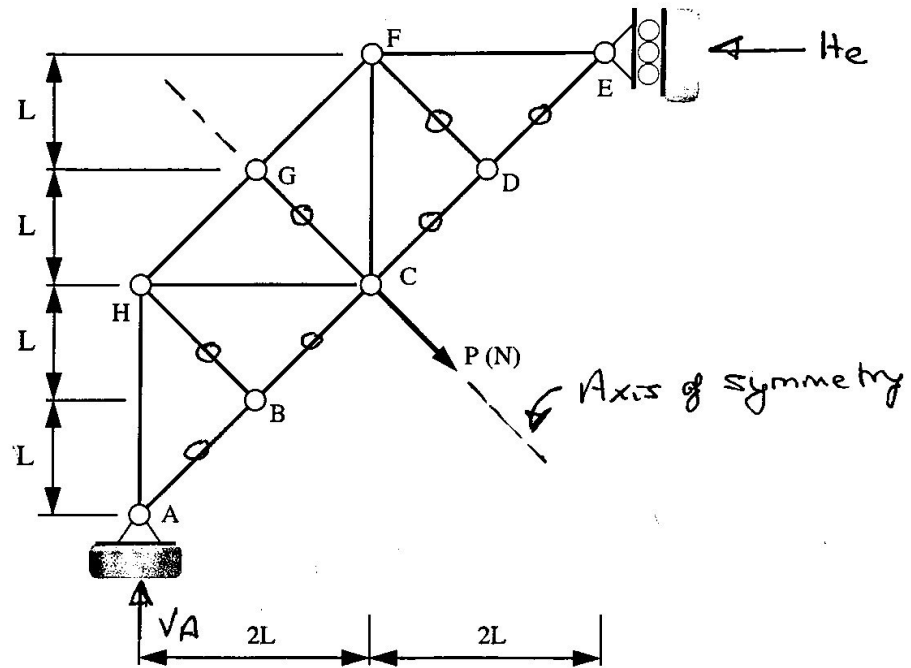


Figure 2. Elevation view of simple truss structure.

A single point load  $P(N)$  is applied at node C as shown in the figure.

[2a] (3 pts). Identify the zero-force members and the axis of symmetry in this problem (If you wish, you can simply annotate Figure 2).

See fig. 2.

[2b] (4 pts). Compute the support reactions at A and E.

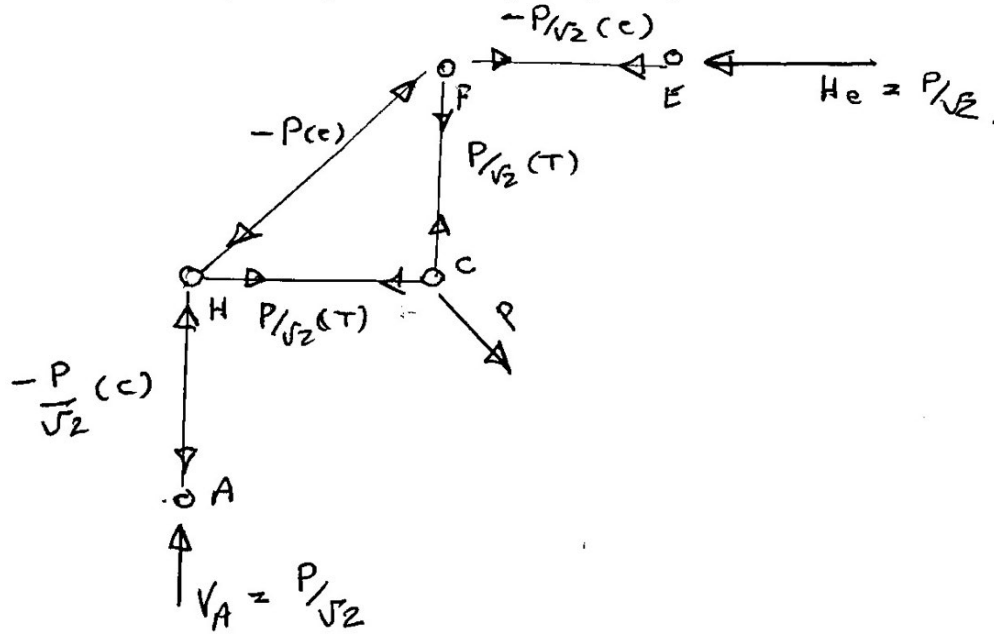
$$\sum M_A = 0 \Rightarrow P(2\sqrt{2})L - H_e(4L) = 0$$

$$\Rightarrow H_e = P/\sqrt{2}$$

From symmetry.  $V_A = P/\sqrt{2}$ .

[2c] (8 pts). Using the method of joints (or otherwise) compute the distribution of tension and compression forces in the truss structure.

Note: You can simplify the problem by eliminating the zero-force members from the analysis and taking advantage of the axis of symmetry in the problem.



Equilibrium at C.

$$2 \frac{(CF)}{\sqrt{2}} = P \Rightarrow \overline{CF} = \overline{CH} = \frac{P}{\sqrt{2}} (T)$$

Equilibrium at F.

$$\overline{HF} = -P(c).$$

Question 3 (10 points): Degree's of Indeterminacy.

[3a] (4 pts). Compute the degree of indeterminacy for the structure shown in Figure 3.

Ring Method

$$\hat{i} = 3n - r$$

$$\left. \begin{array}{l} n = 2 \\ r = 2 \end{array} \right\} \hat{i} = 4$$

Method 2

$$\hat{i} = f - 3 - r; \quad f = 9 \\ r = 2 \\ = 4.$$

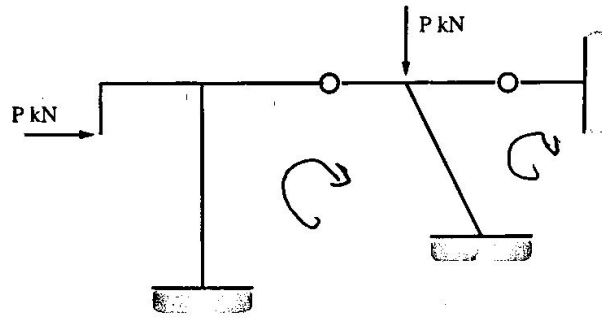


Figure 3. Simple portal frame.

[3b] (6 pts). Compute the degree of indeterminacy for the large moment-resistant frame shown in Figure 4.

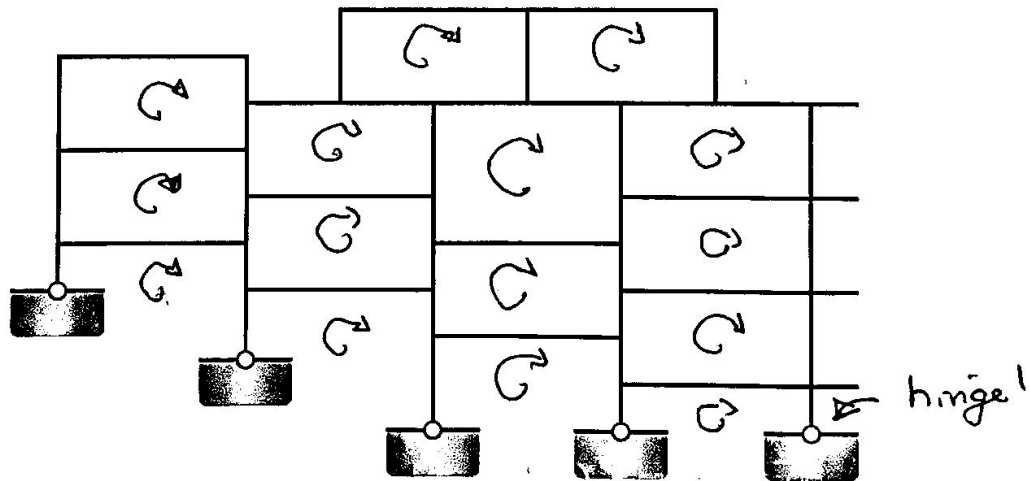


Figure 4. Elevation view of large moment-resistant frame.

Ring Method

$$\hat{i} = 3n - r$$

$$\left. \begin{array}{l} n = 15 \\ r = 5 \end{array} \right\} \hat{i} = 3 \times 15 - 5 \\ = \underline{\underline{40}}$$