

ENCE 353 Midterm 1, Open Notes and Open Book

Name : _____

E-mail (print neatly!): _____

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	17	
3	8	
Total	40	

Question 1 (15 points): Bending Moments and Qualitative Displacements in a Multi-span Beam Structure.

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

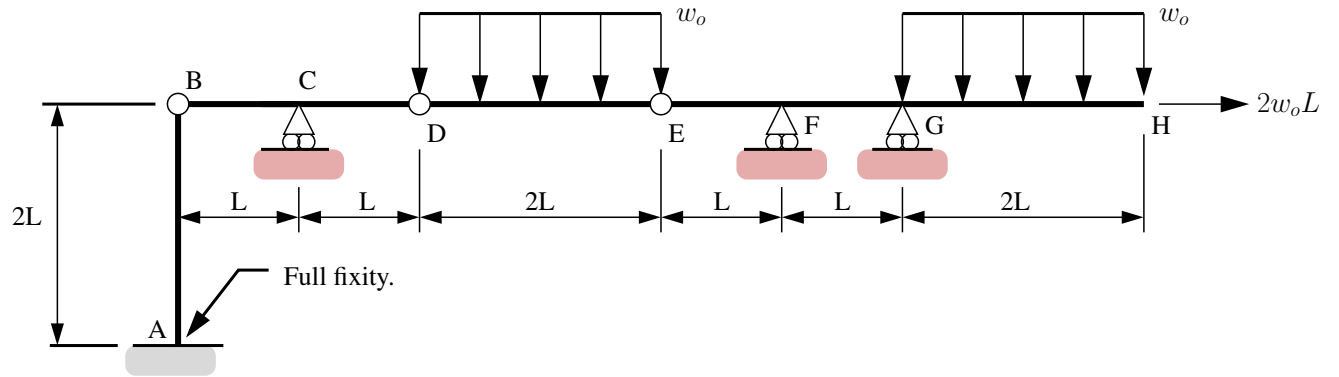


Figure 1. Front elevation view of multi-span connected beam/column structure.

The cantilever is fully-fixed to the foundation at Point A. Points B, D and E are hinges. The beam segments D-E and G-H carry a uniformly distributed load w_o (force/per unit length). Finally, a horizontal point load $2w_oL$ is applied at point H.

- [1a]** (3 pts). Compute the vertical reaction forces at nodes C, F and G, and shear, moment, and axial reaction forces at node A.

[1b] (4 pts). Draw and label diagrams showing how the **bending moment** and **axial force** vary along the beam, nodes B through H. Clearly indicate on your bending moment diagram, regions that are in tension/compression.

[1c] (4 pts). Draw and label a diagram showing how the **bending moment** and **axial force** in column element A-B. Clearly indicate on your bending moment diagram, regions that are in tension/compression.

Now suppose that the flexural stiffness of the beam and column elements is EI throughout.

[1d] (4 pts). With your solutions to Parts 1b and 1c in mind, create a sketch of the beam and column displacements, highlighting in an **exaggerated qualitative way**, movement of the nodes and curvature in the beam elements and column.

Question 2 (17 points): Analysis of a Zigzag Truss Structure.

Consider the zigzag truss structure shown in Figure 2.

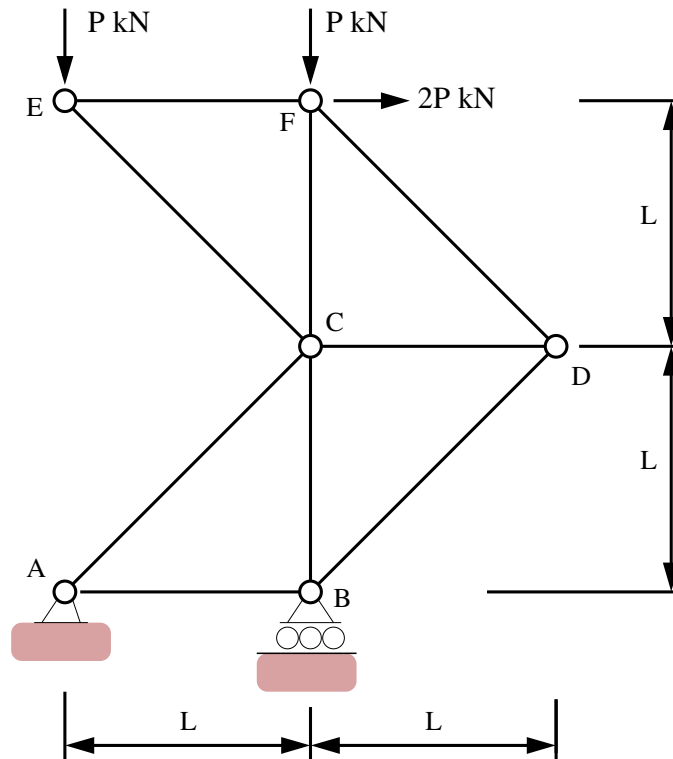


Figure 2. Elevation view of a crooked truss structure.

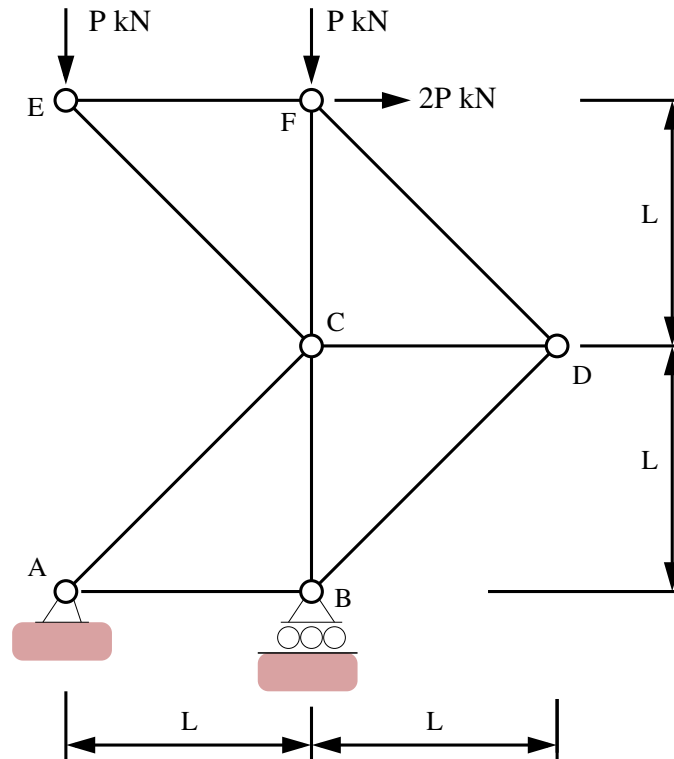
Horizontal and vertical loads P (kN) and $2P$ (kN) are applied at nodes E and F as shown in the figure.

[2a] (3 pts). Compute the degree of indeterminacy for this system.

[2b] (3 pts). Compute the **total support reactions** at A and B.

[2c] (8 pts). Using the method of joints (or otherwise) compute the distribution of tension and compression forces throughout the structure. Show all of your working.

To summarize, draw the distribution of tensile, compressive, and zero-force members on this diagram:



[2d] (3 pts). Now suppose that the maximum tensile force any member can support is 10 kN, and that the maximum allowable compressive force is:

$$P_{ci} = 5 \left(\frac{L}{L_i} \right)^2 \text{ kN}, \quad (1)$$

where L_i is the length of the i -th element, and P_{ci} is the maximum allowable compressive force of the i -th element before buckling.

Determine the maximum value of P (kN) that the zig-zag truss can safely carry.

Question 3 (8 points): Method of Sections.

The frame tower (see Figure 3) carries horizontal and vertical loads P kN and $2P$ kN at joints C, E, G and H.

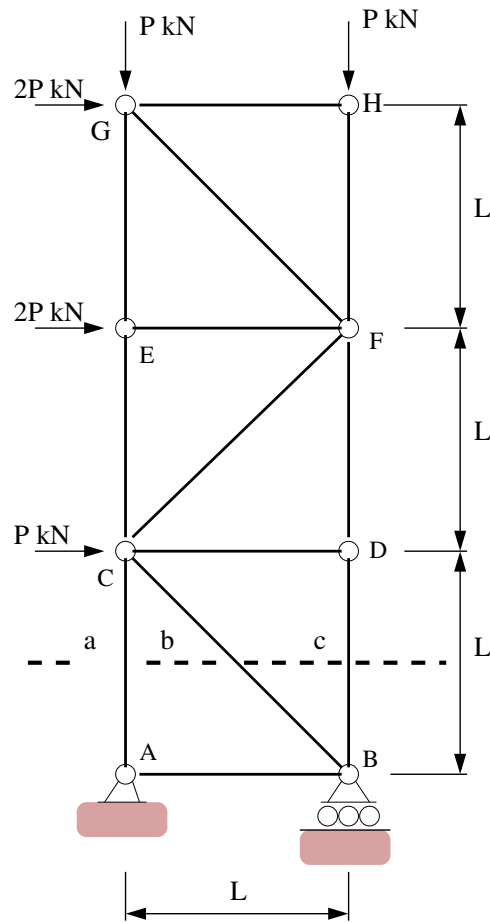


Figure 3. Elevation view of frame tower.

[3a] (8 pts). Use the **method of sections** to determine the forces in members a, b and c, as a function of the problem parameters L and P . Clearly indicate if the members are in tension or compression.

Show all of your working.

Question [3a] continued: