Department of Civil and Environmental Engineering, Spring Semester, 2023

ENCE 353 Midterm 1, Open Notes and Open Book

Name : Austin.

E-mail (print neatly!): austin@umd.edu.

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.

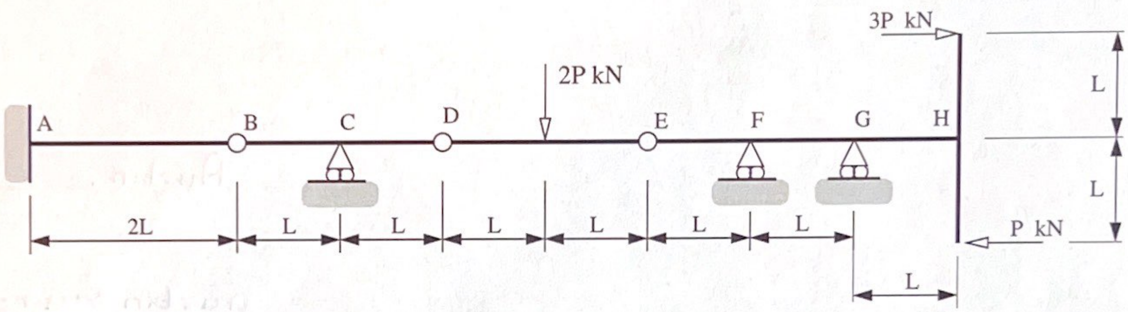


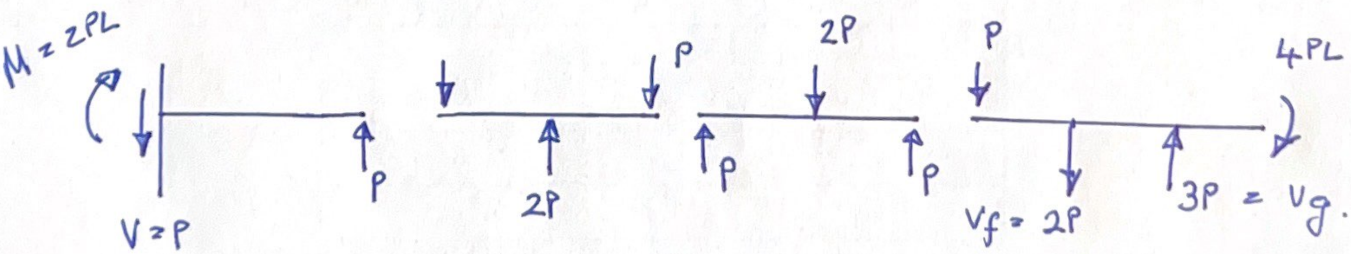
Figure 1. Front elevation view of multi-span beam structure.

The cantilever is fully-fixed to the wall at Point A. Points B, D and E are hinges. Horizontal point loads **3P** (kN) and **P** (kN) are applied as shown in Figure 1.

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

$$\left.\begin{array}{l} r = 12 \\ n = 4 \end{array}\right\} \quad r - 3n = 0 \implies \text{statically determinate.}$$

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



For subsystem E-F-G-H.

$$\left.\begin{array}{l} \Sigma F_y = 0 \implies V_f + V_g = P \\ \Sigma M_e = 0 \implies V_f + 2V_g = 4P \end{array}\right\} \quad \begin{array}{l} V_f = -2P \\ V_g = 3P. \end{array}$$

[1c] (3 pts). Compute the **total force** at hinge B.

Forces at B

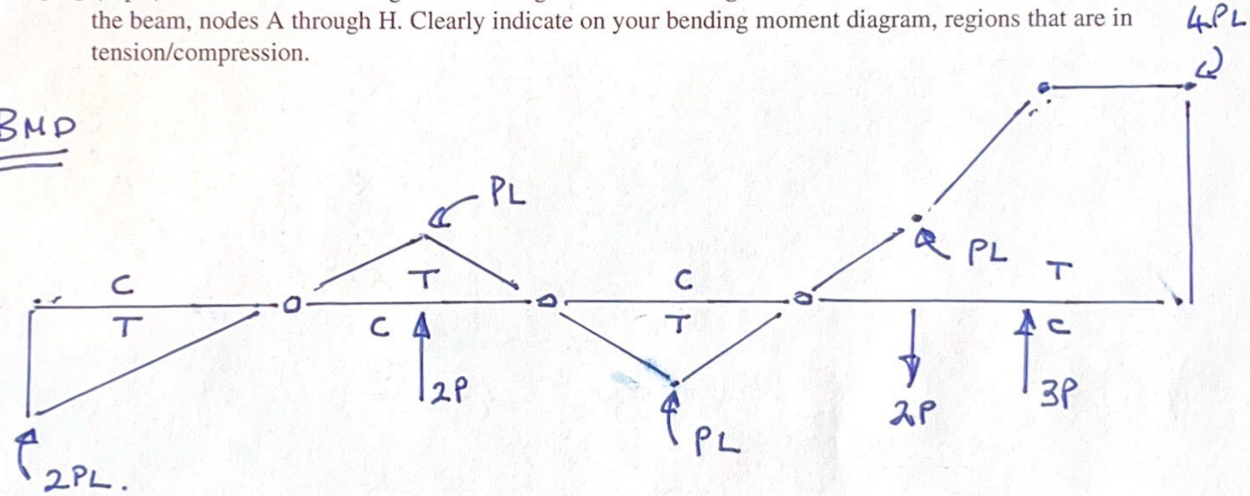
$\downarrow P$

$2P \leftarrow \circ$

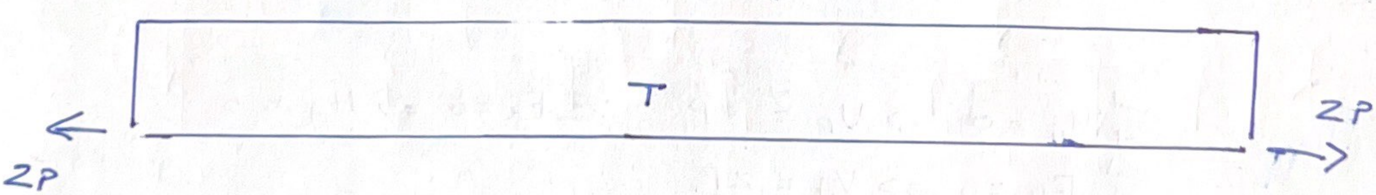
$$\text{Total force} = (2^2 + 1^2)^{1/2} P = \sqrt{5}\,P.$$

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

BMD



Axial Force



Question 2 (15 points): Tension, Compression and Zero-Force Members in a Crane Tower Structure

Consider the crane tower structure shown in Figure 2.

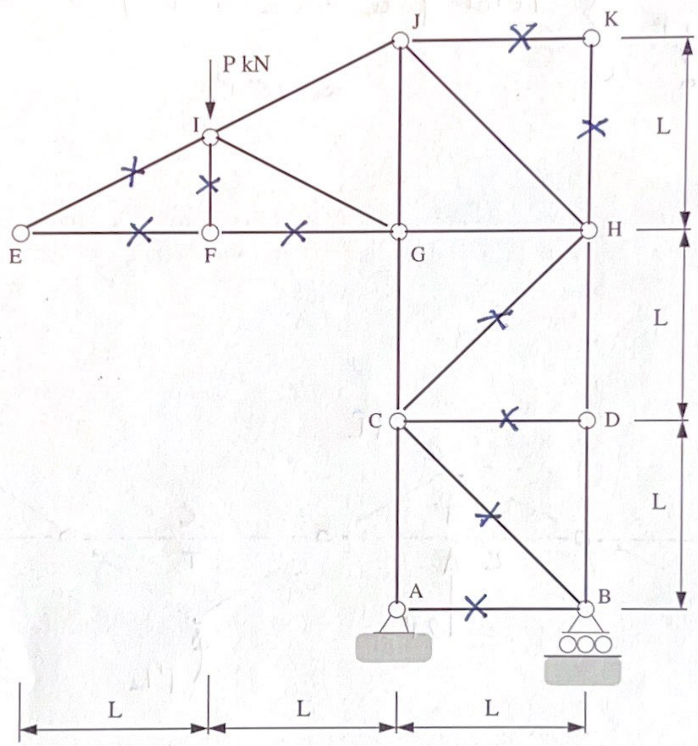


Figure 2. Elevation view of a simple crane tower.

A single point load **P** (kN) is applied at node I as shown in the figure.

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

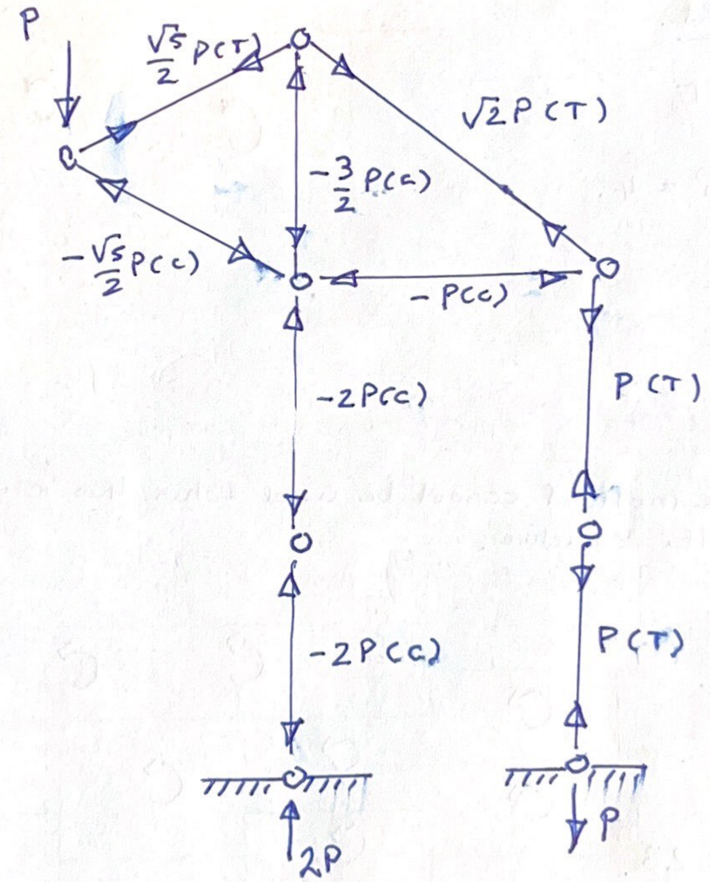
$\overset{\curvearrowleft}{\Sigma} M_A = 0 \Rightarrow V_B = -P$ $\quad \overset{\rightarrow}{\Sigma} F_x = 0 \Rightarrow H_A = 0$

$\overset{\uparrow}{\Sigma} F_y = 0 \Rightarrow V_A = 2P.$

[2b] (4 pts). Identify **all** of the zero-force members. If you wish, you can simply annotate Figure 2.

See fig 2.

[2c] (6 pts). Using the method of joints (or otherwise) compute the distribution of tension and compression forces throughout the crane structure. Draw and label a diagram showing the distribution of forces in the simplified crane tower structure.



Max tension $= \sqrt{2}P(T)$

" compression $= -2P(c)$

[2d] (2 pts). If the maximum force any member can support is 10 kN in tension and 7 kN in compression, determine the maximum value of P that the crane tower can safely carry.

Limiting constraint $\Rightarrow -2P = 7\text{kN}$.

$\Rightarrow P_{max} = 3.5\text{kN}$.

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

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

<u>Ring Method.</u>

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

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

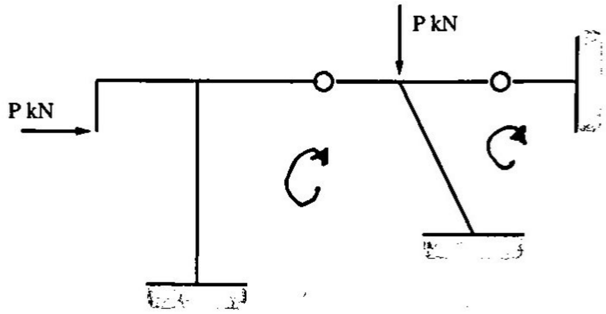


Figure 3. Simple portal frame.

[3b] (2 pts). Briefly explain why the method of trees cannot be used to compute the degree of indeterminacy of Figure 3.

Tree method cannot be used when there are releases in the structure.

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

<u>Ring Method.</u>

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

$\left.\begin{array}{l} n = 15 \\ r = 17 \end{array}\right\} \hat{i} = 28$

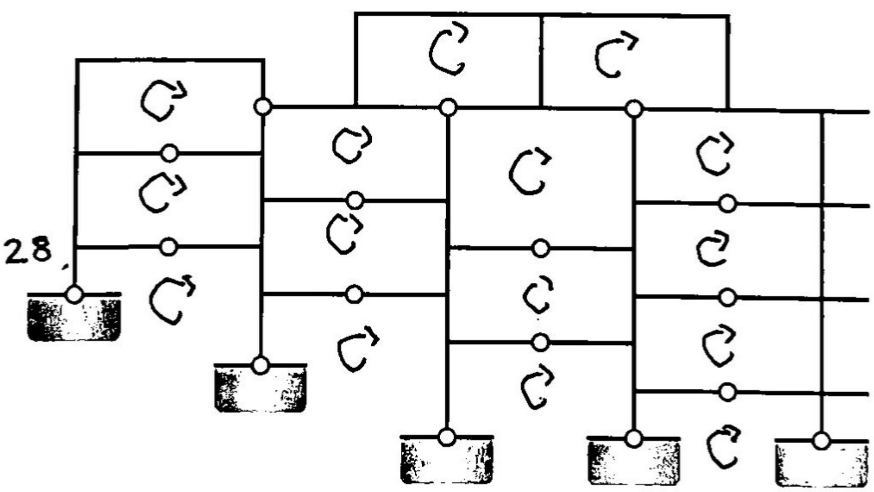


Figure 4. Elevation view of large moment-resistant frame.