Department of Civil and Environmental Engineering,   Fall Semester, 2023

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.

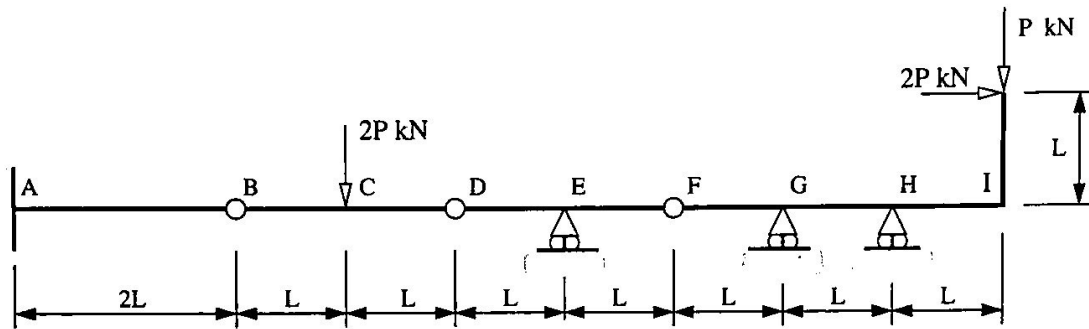Consider the multi-span beam structure shown in Figure 1.

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

The cantilever is fully-fixed to the wall at Point A. Points B, D and F are hinges. Horizontal and vertical point loads **P** (kN) and **2P** (kN) are applied as shown in Figure 1.
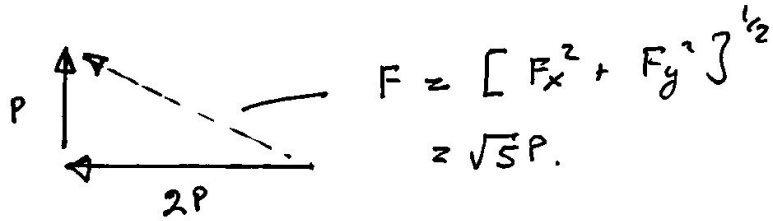
[1a] (3 pts). Compute the degree of indeterminacy for the beam structure.

$$r = 12 \;\Big\} \; r - 3n \;=\; 12 - 3\times 4 \;=\; 0.$$
$$n = 4 \;\Big\} \;\Rightarrow\; \text{Statically determinate.}$$

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

$$V_e = 2P$$
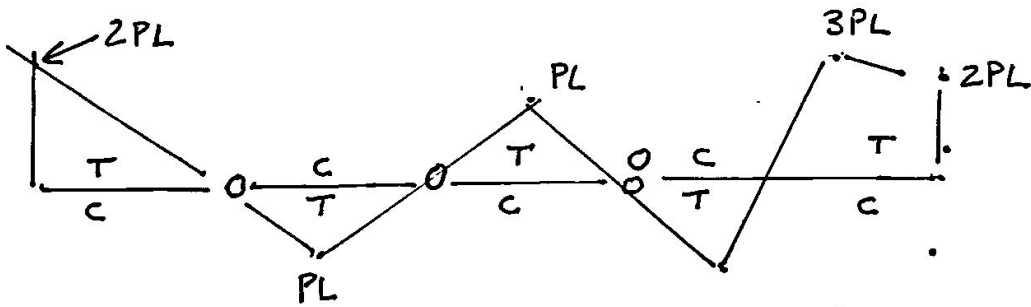
$$V_G = -5P \qquad V_H = 5P$$

2
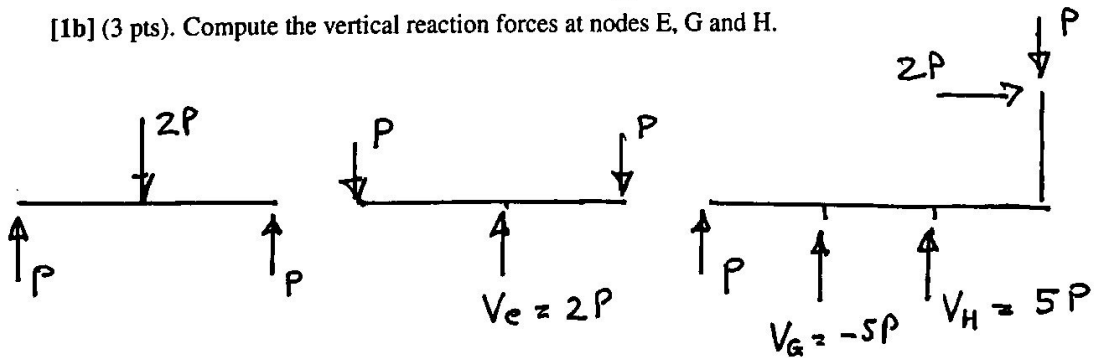
[1c] (3 pts). Compute the **total force** at hinge F.

$$F = \left[F_x^2 + F_y^2 \right]^{1/2}$$
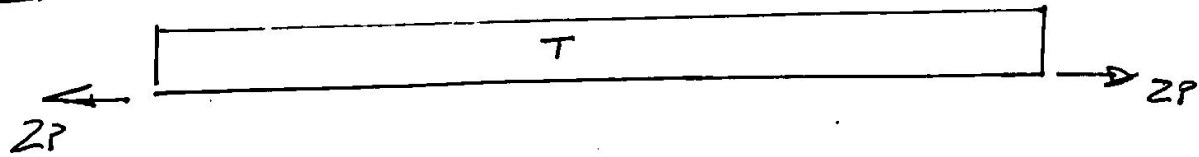
$$= \sqrt{5}\, P.$$

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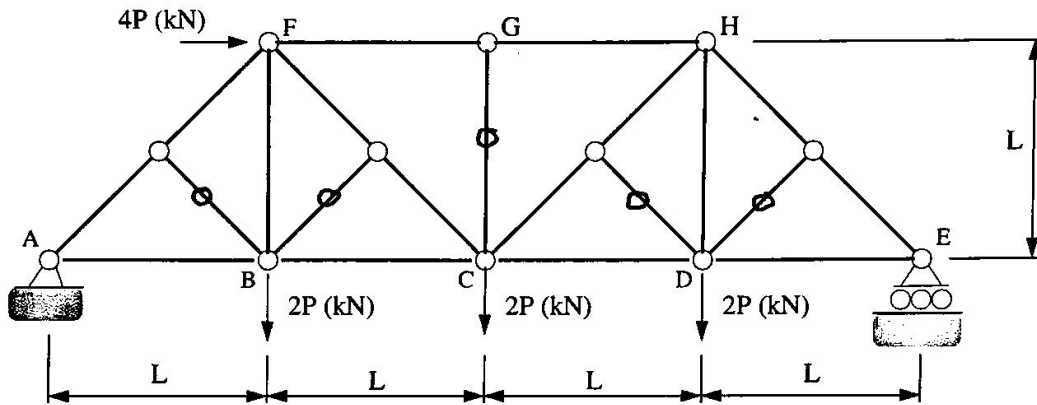
BMP

2PL   PL   3PL   2PL

T   C   T   O   C   T

C   T   C   T   C

PL

Axial.

T

2P   2P

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

Consider the truss structure shown in Figure 2.

Figure 2. Twenty one bar truss structure.

Vertical loads of **2P** kN are applied at nodes B, C and D. A horizontal load of **4P** kN is applied at node F.

[2a] (4 pts). Compute the **magnitude** of the **total support reactions** at points A and E.

$$\sum_1 M_A = 0 \implies V_e = 4P.$$

$$\sum_1 V = 0 \implies V_A = 2P.$$

$$\sum_1 H = 0 \implies H_A = -4P.$$

Magnitude $V_e = 4P$

Magnitude $V_A = [4^2 + 2^2]^{\frac{1}{2}} P$

$$= \sqrt{20}\, P.$$

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

See Fig. 2.

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[2c] (5 pts). Using the method of joints (or otherwise) compute the distribution of tension and compression forces throughout the truss structure. Draw and label a diagram showing the distribution of forces.
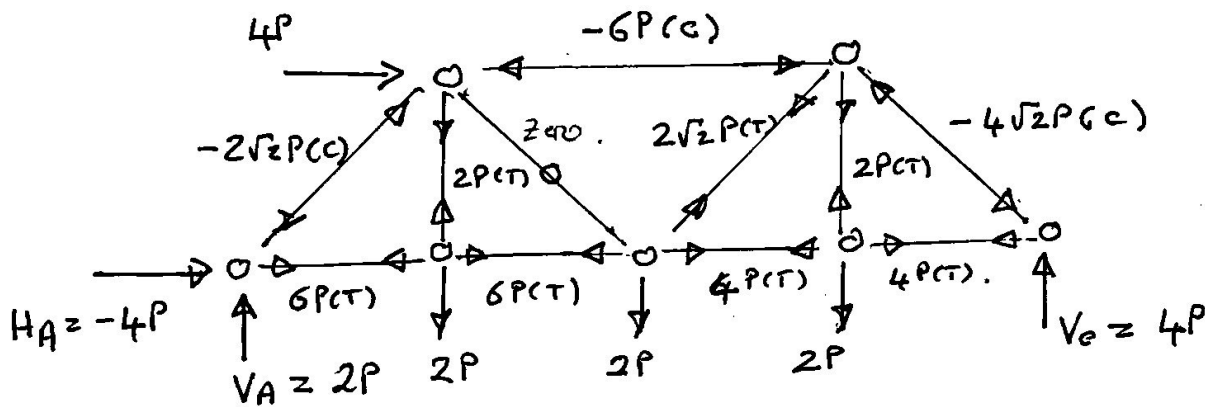
$$\text{Max Tensile force} = 6P(T)$$
$$\text{"} \quad \text{Compressive force} = -6P(c).$$

[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 truss structure can safely carry.

Limiting load:
$$6P(c) \leq 7 \, kN$$
$$\Rightarrow P = \frac{7}{6} \, kN.$$

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

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

$f = 9$

$r = 2$

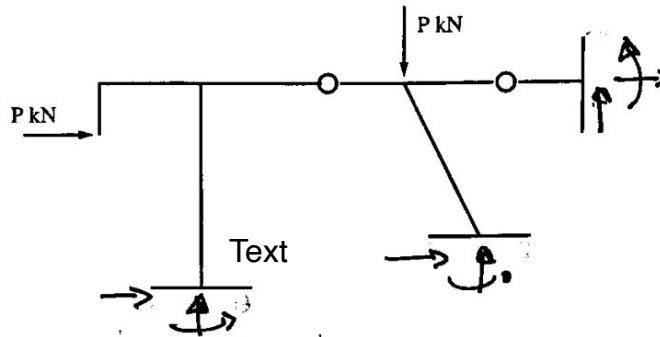$\hat{i} = f - 3 - r$

$= 4.$

Text

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.
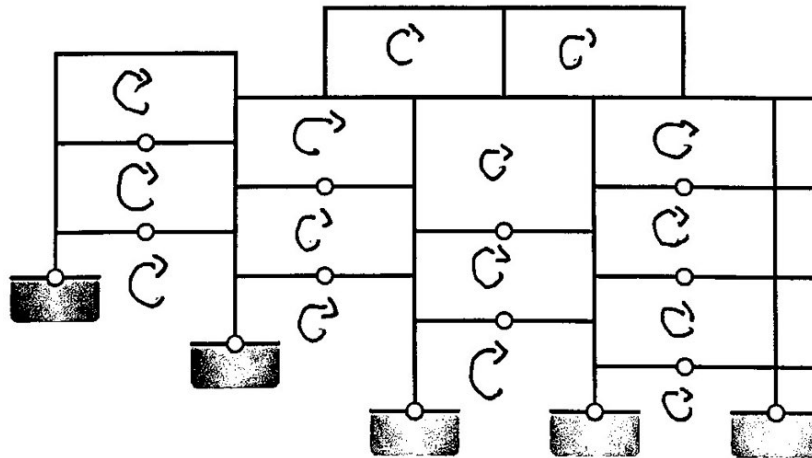
Ring Method

$n = 15$

$r = 14$

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

$= 31.$

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

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