

NATIONAL EXAMS MAY 2009

07-STR-A4 ADVANCED STRUCTURAL ANALYSIS

3 HOURS DURATION

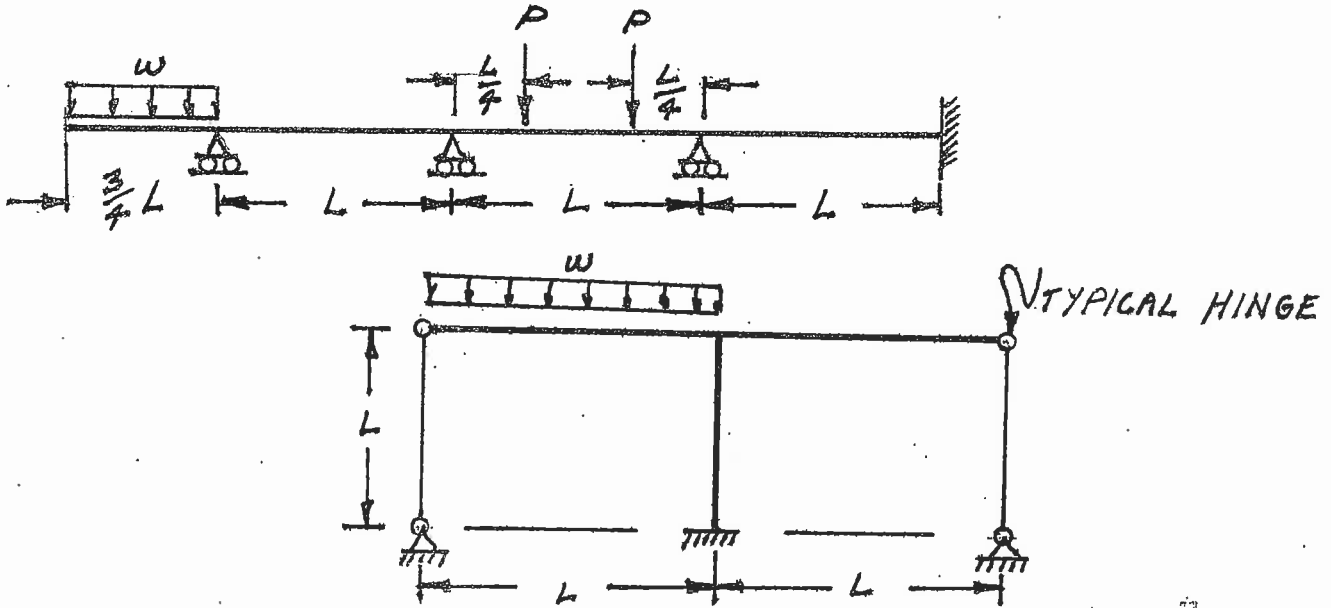
NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumption made.
2. Each candidate may use an approved model of Sharp or Casio calculator; otherwise, this is a CLOSED BOOK Examination.
3. Answer BOTH questions #1, and #2. Answer ONLY TWO of Questions #3, #4, or #5. Answer ONLY TWO of Questions #6, #7, #8 OR #9. SIX questions constitute a complete paper.
4. The marks assigned to each question are shown in the left margin.

FRONT PAGE

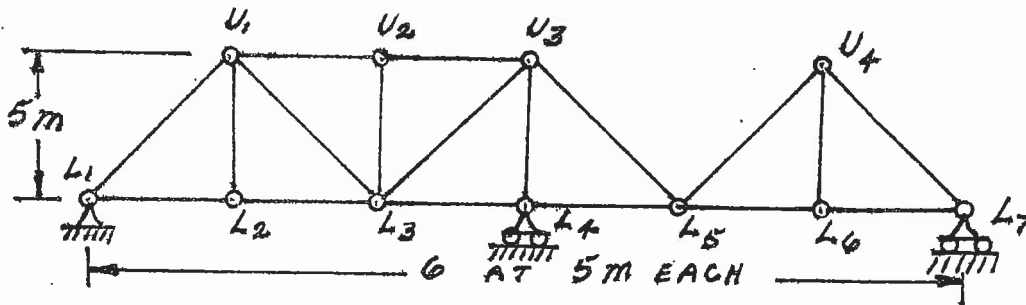
QUESTIONS #1 AND #2 MUST BE ANSWERED.

- (8) 1. Schematically show the shear force and bending moment diagrams for the following structures. All members have the same EI and are inextensible.



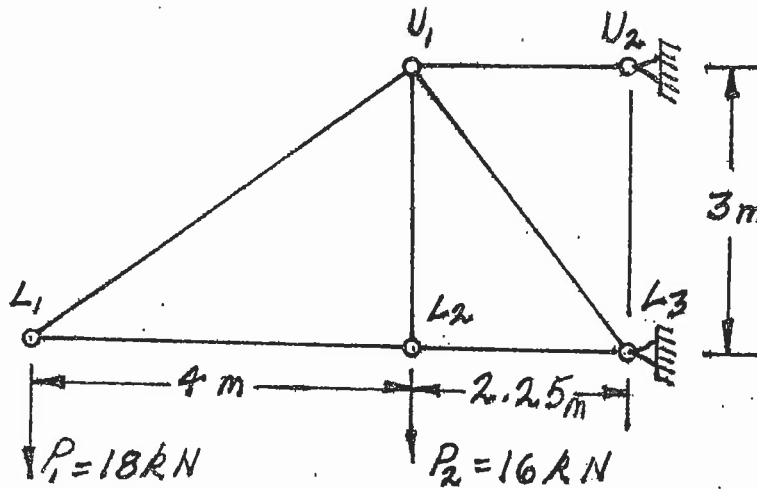
- (12) 2. For loading applied to beams at the bottom chord level of the pin-jointed truss structure shown below, schematically show influence lines for the forces in the truss members listed below. Calculate and label the ordinate magnitude which has the maximum absolute value on each influence line. Indicate each of these magnitudes as tension or compression - T or C.

- a)  $U_1 - L_2$     b)  $L_2 - L_3$     c)  $L_3 - U_3$

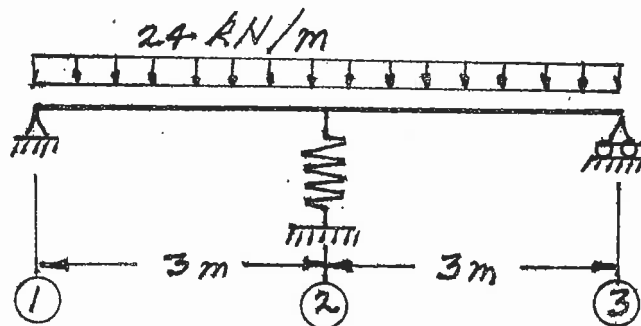


SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 3, 4, OR 5.

- (18) 3. Use Castigliano's theorem to determine the vertical deflection at joint  $L_2$  of the pin-jointed truss shown below. The  $AE$  value for all members is  $62500 \text{ kN}$ .

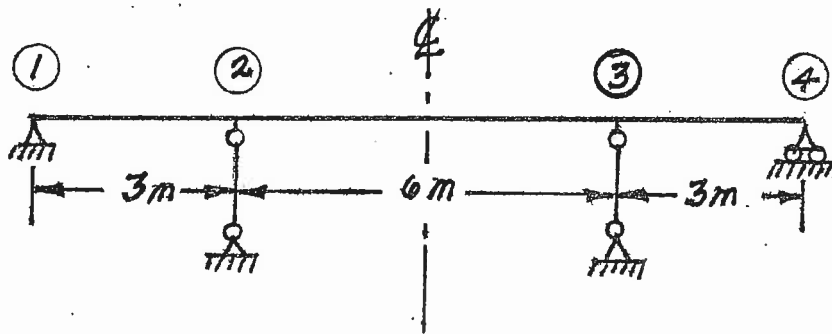


- (18) 4. The beam shown is simply supported at both ends and supported at mid span by a spring which deflects  $1.0 \text{ mm}$  under a load of  $10 \text{ kN}$ ; thus, the stiffness is  $10000 \text{ kN/m}$ . Use Castigliano's theorem (the least work theorem) to calculate the reactions at the ends of the beam. Draw the shear and bending moment diagrams for the structure. For each diagram, label the magnitude of the maximum and minimum ordinates (Minimum ordinates are frequently negative values). The beam has  $EI = 3.6 \times 10^4 \text{ kN.m}^2$ .



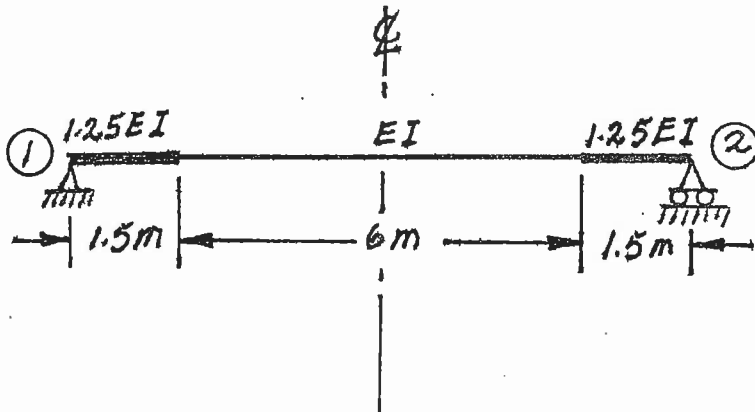
SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 3, 4, OR 5

- (18) 5. Use the slope-deflection or moment-distribution method to analyze the beam structure shown. Draw shear and bending moment diagrams. Indicate on both diagrams the magnitude of maximum and minimum ordinates. There are no loads on the structure, but at joints ② and ③ cables are attached to the beam and at each location the beam is pulled down 5 mm. All segments of the beam have the same EI value which is  $3.6 \times 10^4 \text{ kN.m}^2$ . Take advantage of symmetry.



SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 6, 7, 8 OR 9.

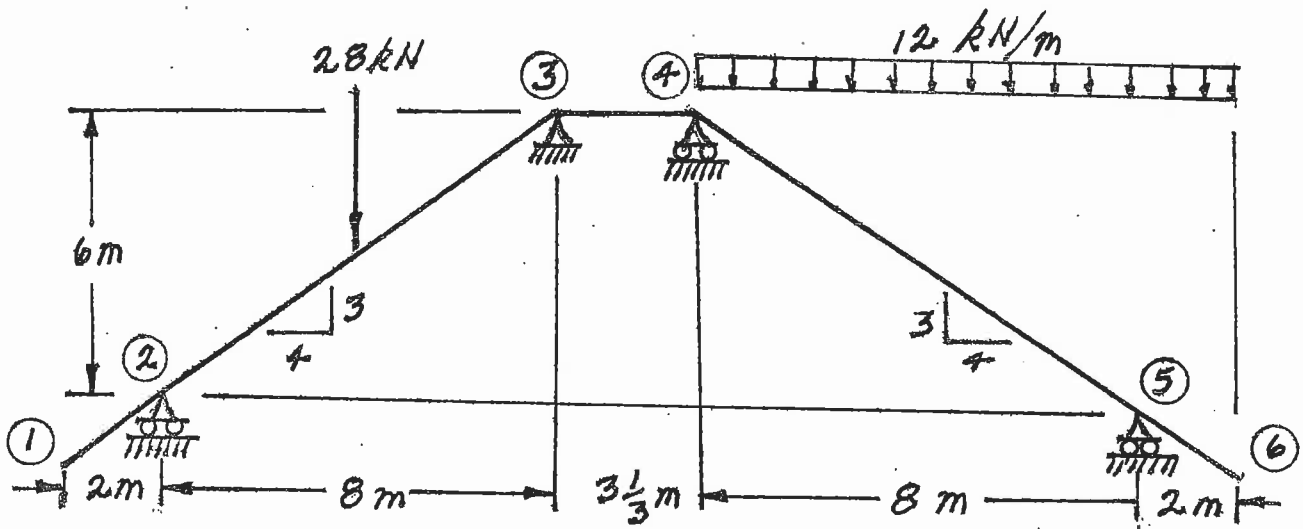
- (22) 6. Using a flexibility (force) method, calculate the four stiffness coefficients in the stiffness matrix for the non-prismatic beam; the stiffness matrix is shown beside the beam below.  $M_{12}$  and  $M_{21}$  are applied moments and  $\phi_1$  and  $\phi_2$  are rotations at supports ① and ② respectively; all are positive counter clockwise. Take advantage of symmetry.



$$\begin{bmatrix} M_{12} \\ M_{21} \end{bmatrix} = \begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix}$$

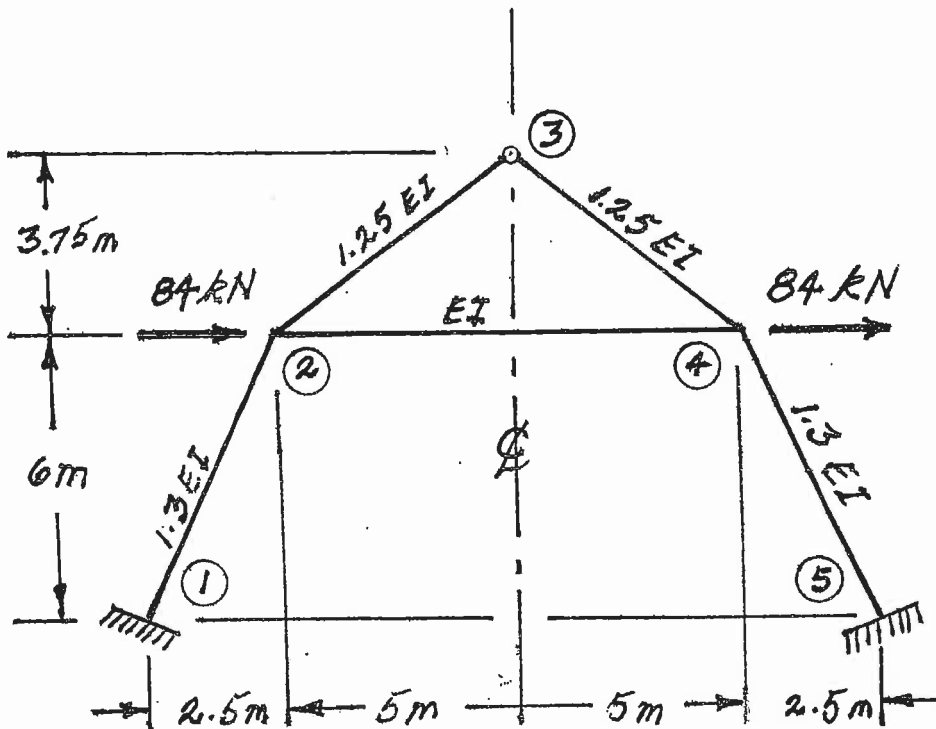
SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 6, 7, 8 OR 9.

- (22) 7. For the frame shown below, using the moment-distribution method or the slope-deflection method, calculate and plot the shear force and bending moment diagrams. On both diagrams for each member, indicate the value of the maximum and minimum ordinates (Minimum ordinates are frequently negative). All members are inextensible and have the same EI value.



SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 6, 7, 8 OR 9.

- (22) 8. Using the slope-deflection method, analyze the frame structure shown below. Plot shear force and bending moment diagrams. For each member on each diagram, indicate the magnitude of the maximum and minimum ordinates (Minimum ordinates are frequently negative values). All members are inextensible and have the EI values shown. Take advantage of symmetry.



SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 6, 7, 8 OR 9.

- (22) 9. a) For the frame shown, derive the equilibrium equation for translation at joint ②. Neglect the effects of axial strain. EI has the same value for all members.
- b) Derive the equilibrium equations for moment equilibrium at joints ② and ③.
- c) Present your results in matrix form by giving the terms of the stiffness matrix [K] and the load vector {P} in the following equation:

$$[K] \begin{Bmatrix} \delta \\ \theta_2 \\ \theta_3 \end{Bmatrix} = \{P\}$$

DO NOT SOLVE THE EQUATIONS.

The unknowns of the problem shall be:

$\delta$  = translation at joint ② (positive in the direction shown)

$\theta_2$  = rotation of joint ②  
 $\theta_3$  = rotation of joint ③ } (counter clockwise positive)

