NATIONAL EXAMS DECEMBER 2015

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

QUESTION #1 MUST BE ANSWERED.

(8) 1. a) Determine the statical indeterminacy, r, of the structures shown below.

b) Indicate with arrows (⟳ a rotation; ⟶ a translation) on each structure and list beside each structure the number of structural degrees of freedom, k, that are required to do an analysis by the slope-deflection method. In each case, use the minimum number of structural degrees of freedom; where they occur, take into account symmetry, anti-symmetry and joints that are known to have zero moments.

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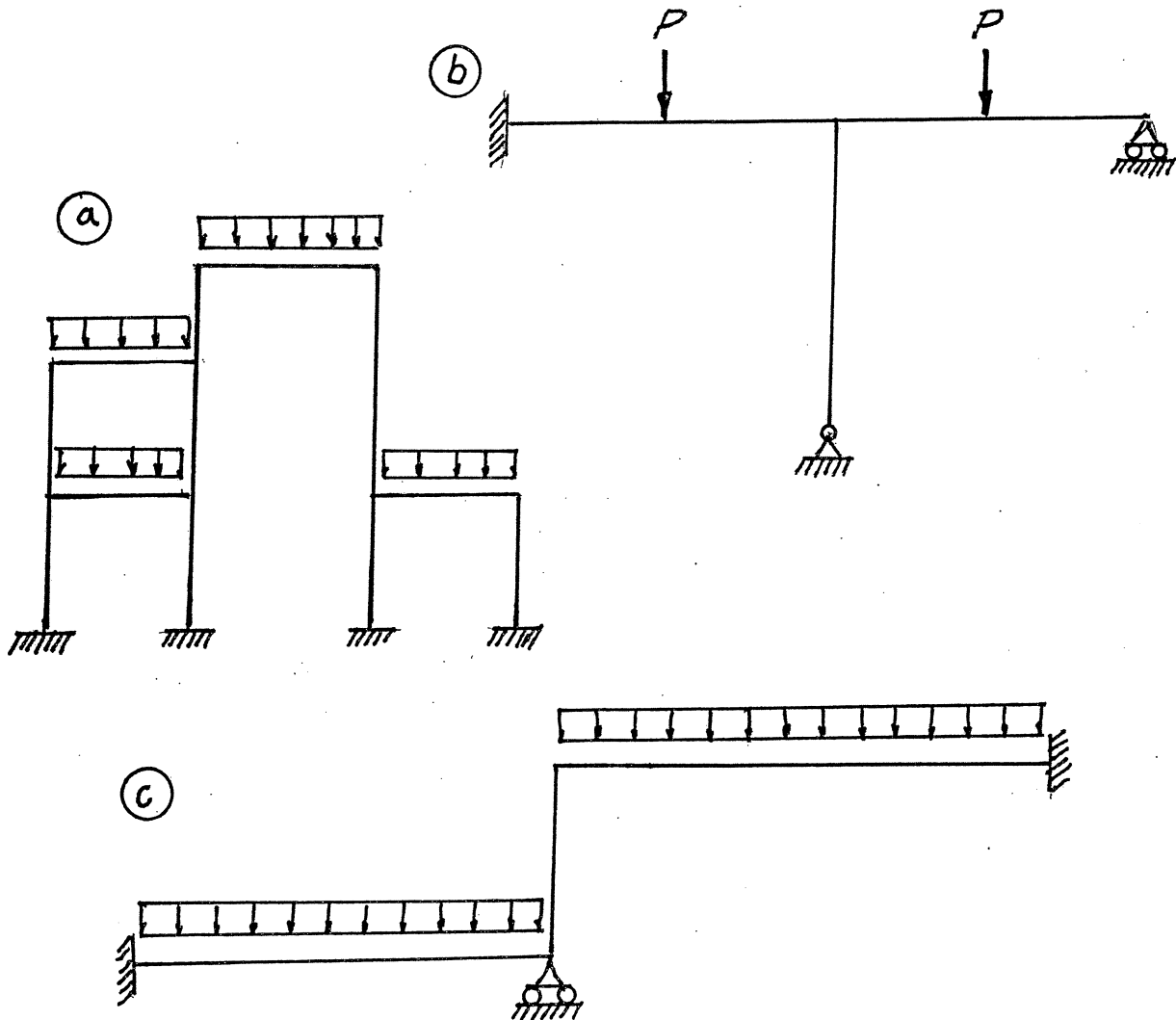
(12)   2.   Schematically show the shear force and bending moment diagrams for the following
            structures. All members have the same EI and are inextensible.
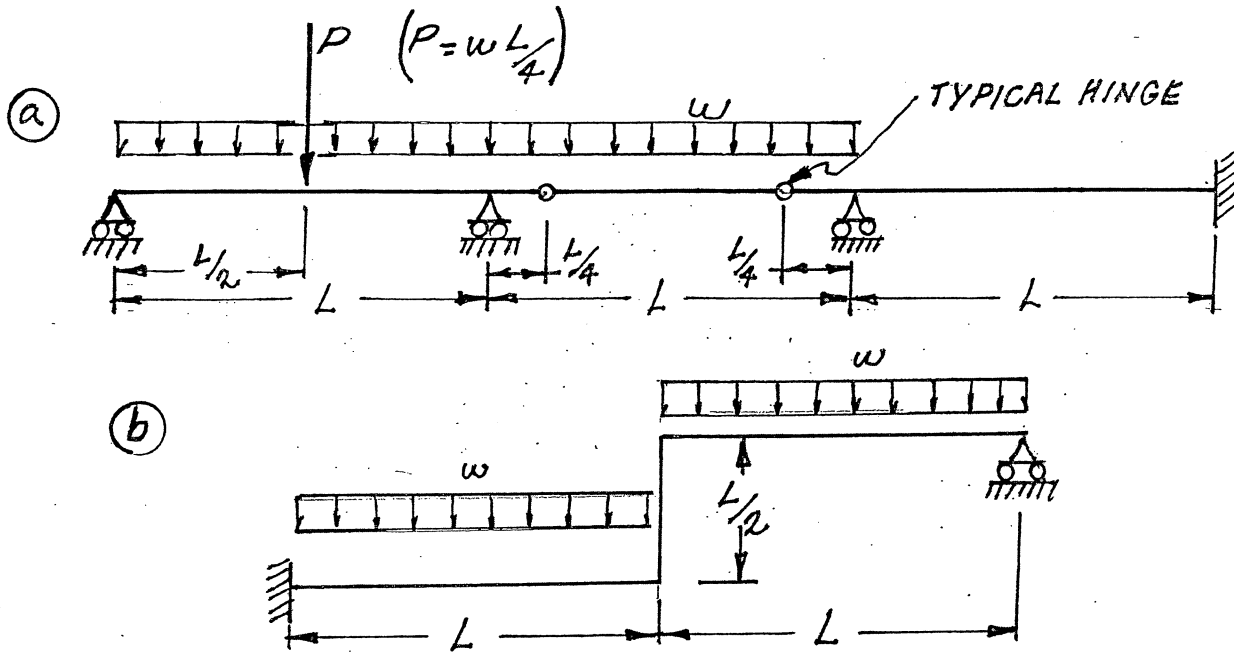

SELECT AND ANSWER TWO QUESTION ONLY FROM QUESTIONS 3, 4, OR 5.

(18)   3.   Use Castigliano's theorem (the least work theorem) to analyze the truss structure
            shown. As a result of the analysis, list the force in each member and indicate whether
            it is in tension or compression. The members have the AE values shown.
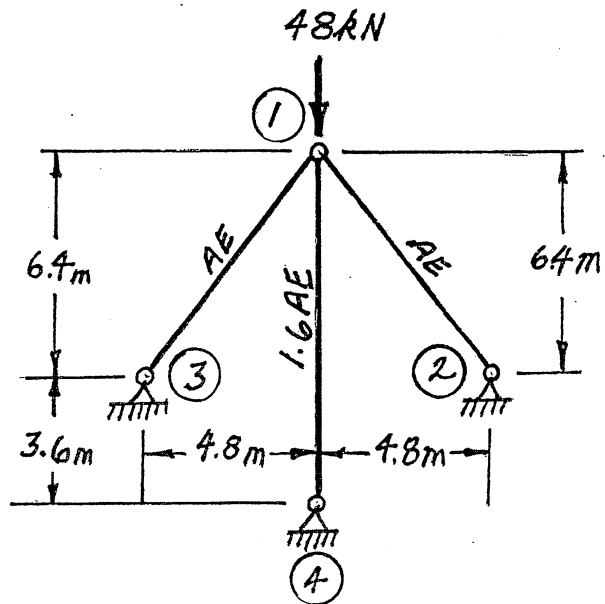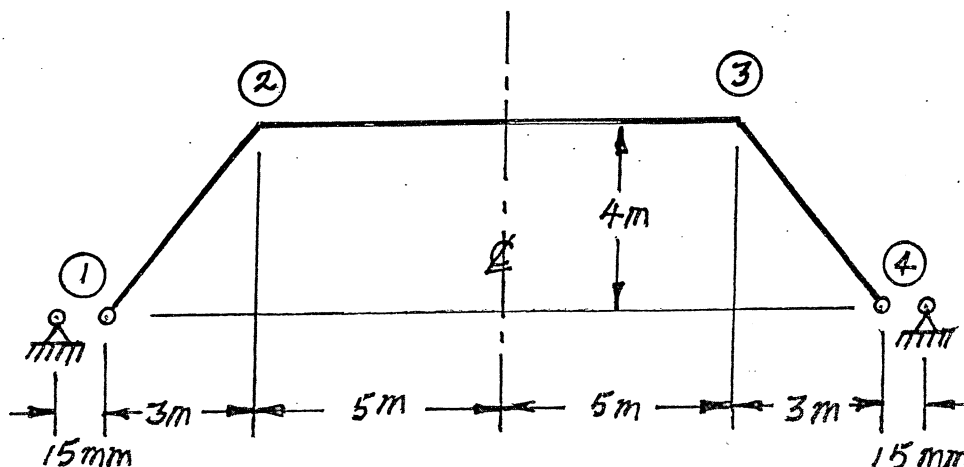
SELECT AND ANSWER TWO QUESTION ONLY FROM QUESTIONS 3, 4, OR 5.

(18)   4.   Use Castigliano's theorem to determine the horizontal deflection at point ① on the frame structure shown. All three members have the same EI and are inextensible; EI = 1.44×10^5 kN.m^2.
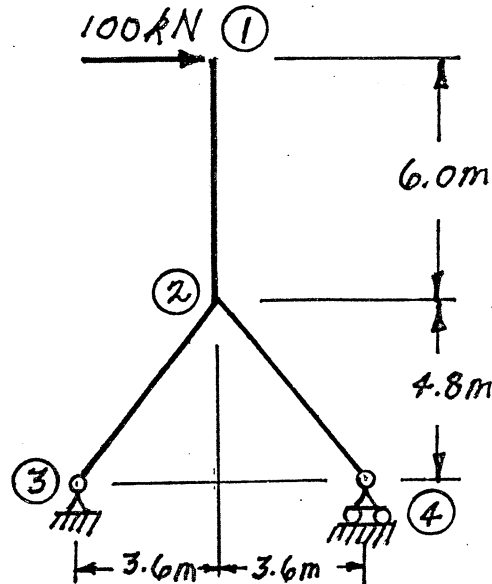

(18)   5.   Use the slope-deflection method or moment-distribution method, to analyze the structure shown below. Calculate and plot the shear force and moment diagrams. There are no loads on the structure, but supports ① and ④ were placed 30 mm too far apart – 16.03 m apart, not 16.0 m. The frame was fabricated for the 16.0 m dimension and forced into place. All members have the same EI and are inextensible; EI = 5.0×10^5 kN.m^2. Take advantage of symmetry.
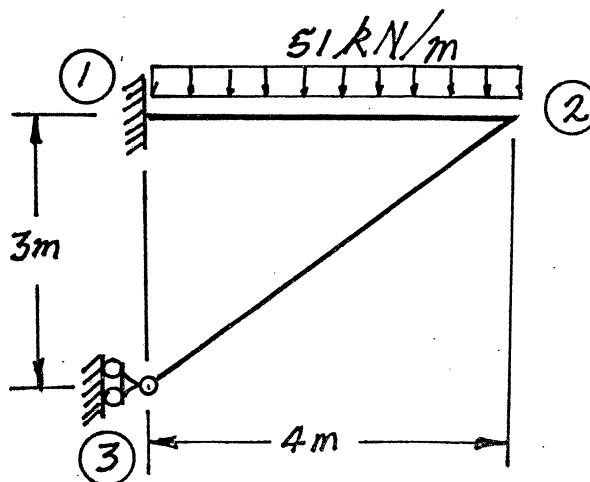
SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 6, 7, 8 OR 9.

(22)   6.   Use the slope-deflection method or the moment-distribution method to analyze the three-span beam shown. Draw shear and bending moment diagrams. For each member on both diagrams, indicate the magnitudes of maximum and minimum ordinates (Minimum ordinates are frequently negative values). In addition to the effects of the loads shown on the structure, stresses and strains are caused because support ③ is 36 mm below the elevation of supports ② and ④. The continuous, three-span beam is straight and inextensible; it has EI = 3.2 x 10^4 kN.mm^2.
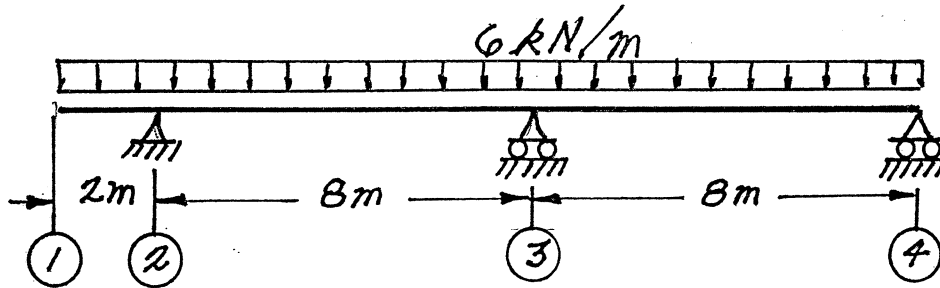

(22)   7.   Using a **flexibility (force) method**, analyze the frame structure shown. Both members have the same EI value and are inextensible. Draw shear and bending moment diagrams. For each member on both diagrams, indicate the magnitudes of the maximum and minimum ordinates (Minimum ordinates are frequently negative values).

SELECT AND ANSWER TWO QUESTION 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). Both members are inextensible and have the relative EI values shown on the diagram below.
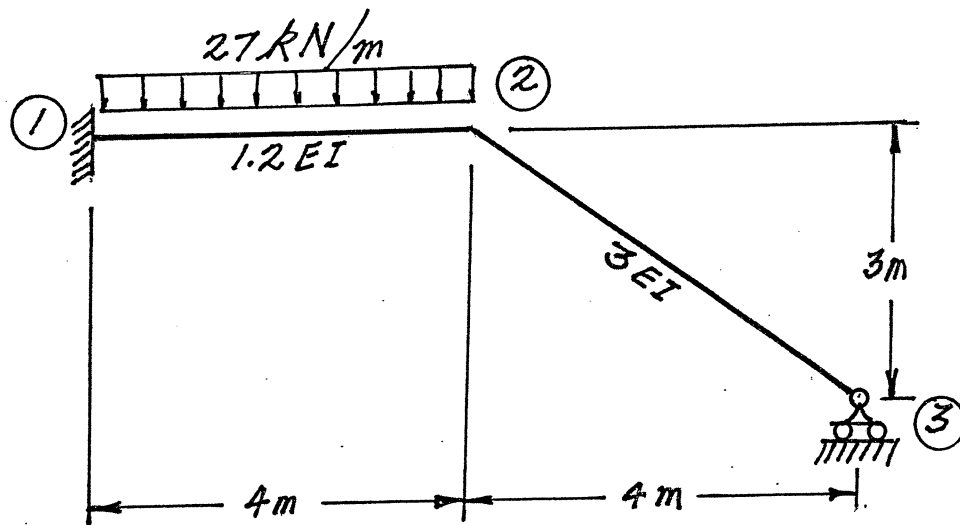
(22) 9. a) For the frame shown, derive the equilibrium equation for the translation at joint ② indicated on the diagram. Neglect the effects of axial strain. The members have the relative EI values shown on the diagram.

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:

$$[K] \left\{ \begin{array}{c} \theta_2 \\ \theta_3 \\ \delta \end{array} \right\} = \{P\}$$

DO NOT SOLVE THE EQUATIONS.

The unknowns of the problem shall be:

δ = translation at joint ② (positive in the direction indicated)

θ_2 = rotation of joint ②

θ_3 = rotation of joint ③

(positive counter clockwise)