NATIONAL EXAMS DECEMBER 2019

16-CIV-B1 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.

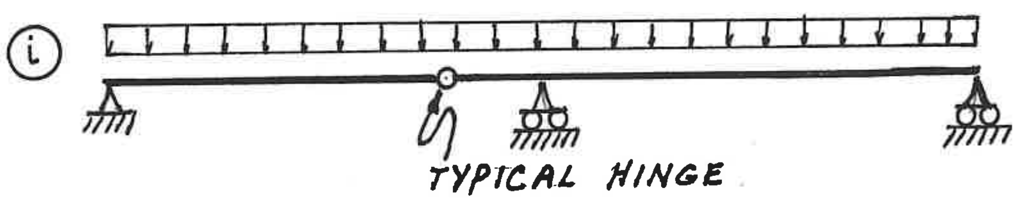
3. Answer BOTH questions #1, and #2. Answer ONLY TWO of questions #3, #4, or #5. Answer ONLY TWO of questions #6, #7, #8 OR #9. SIX questions constitute a complete paper.

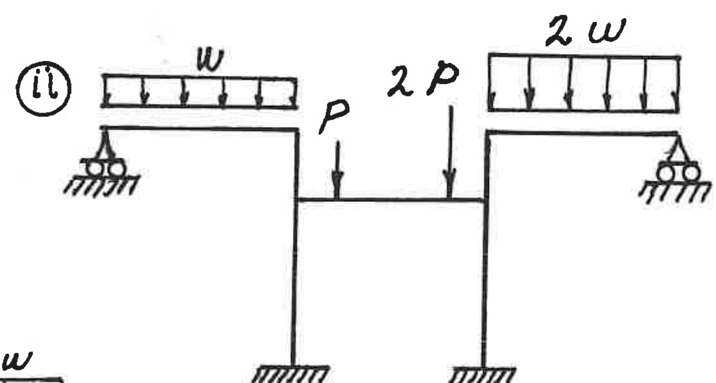
4. The marks assigned to each question are shown in the left margin.

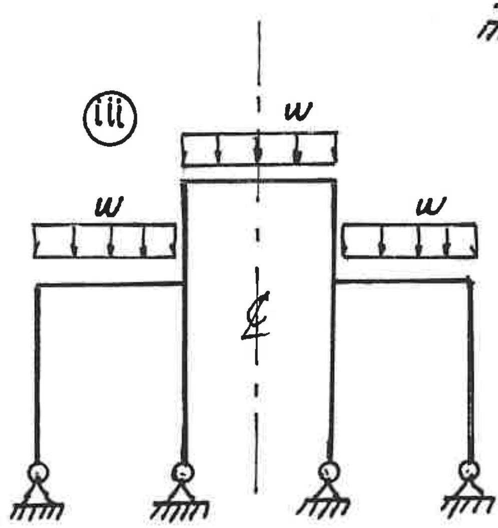
QUESTION #1 MUST BE ANSWERED.

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

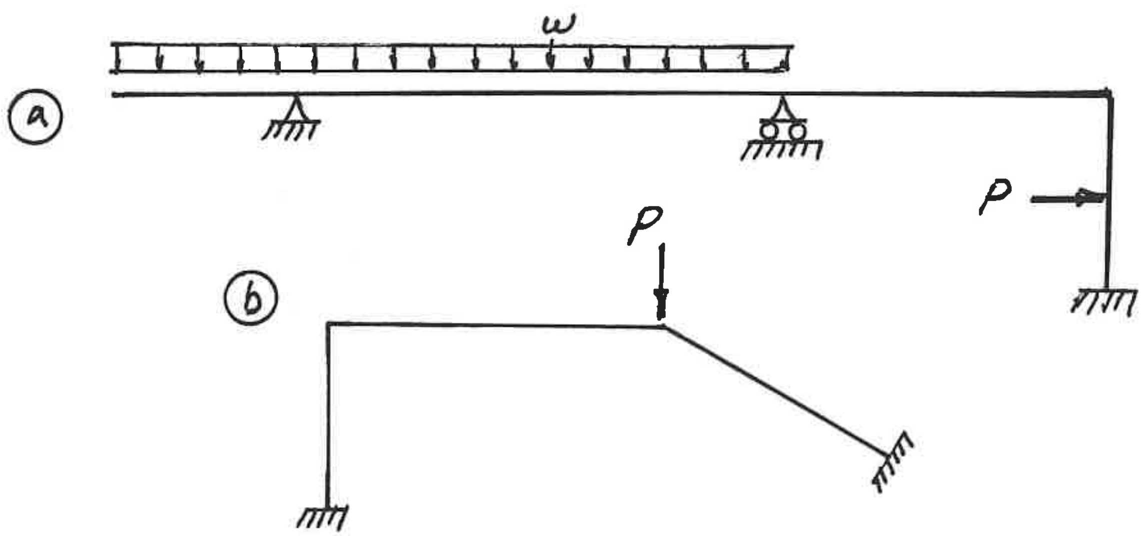
b) Indicate with arrows (↻ a rotation; ➞ a translation) on each structure and list beside each structure the number of structural degrees of freedom, k, that are required to do an analysis by the slope-deflection method. In each case, use the minimum number of structural degrees of freedom; where they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





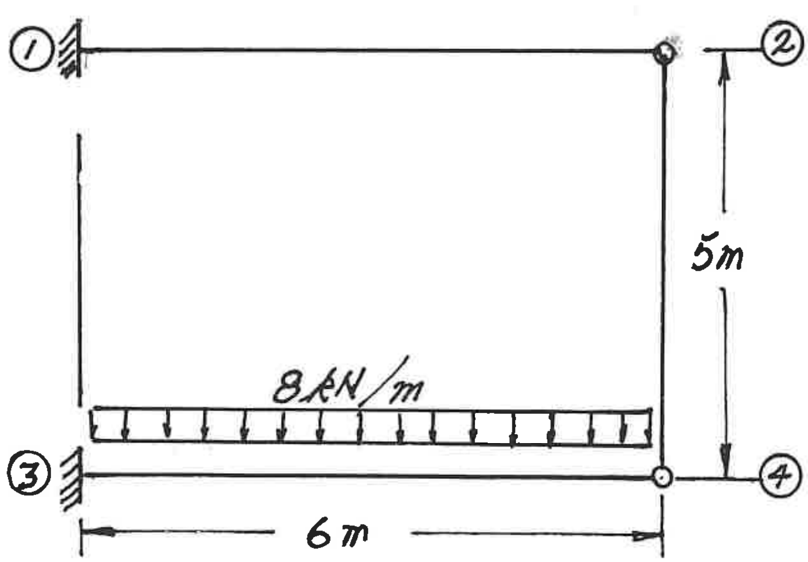


(12) 2. Schematically show the shear force and bending moment diagrams for the following structures. All members have the same EI and are inextensible.



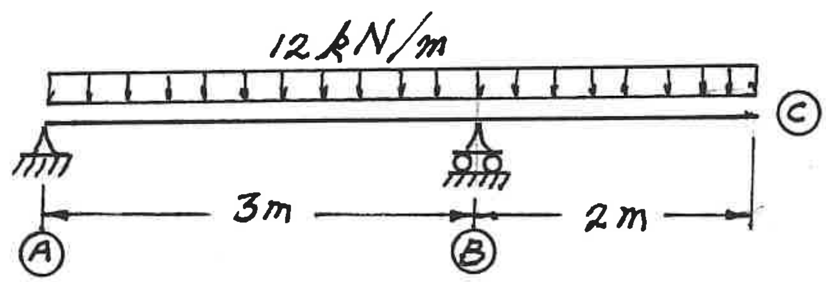
SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 3, 4, OR 5.

(18) 3. Use Castigliano's theorem (the least work theorem) to analyze the structure shown. Calculate the moment and shear force at the left end of beam 3-4. The two beams are inextensible and have EI = 1.8×10^5 kN.m^2; the vertical, tension member has AE = 5.0×10^4 kN.

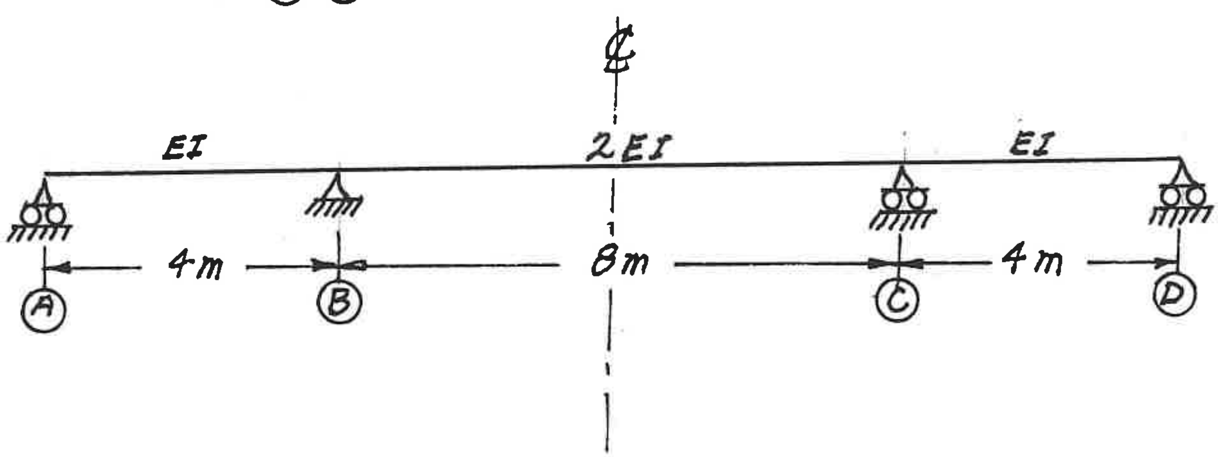


SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 3, 4, OR 5.

(18) 4. Use **Castigliano's theorem** to determine the vertical deflection at point C on the beam structure shown. Both members have the same EI and are inextensible; EI = 5000 kN.m^2.

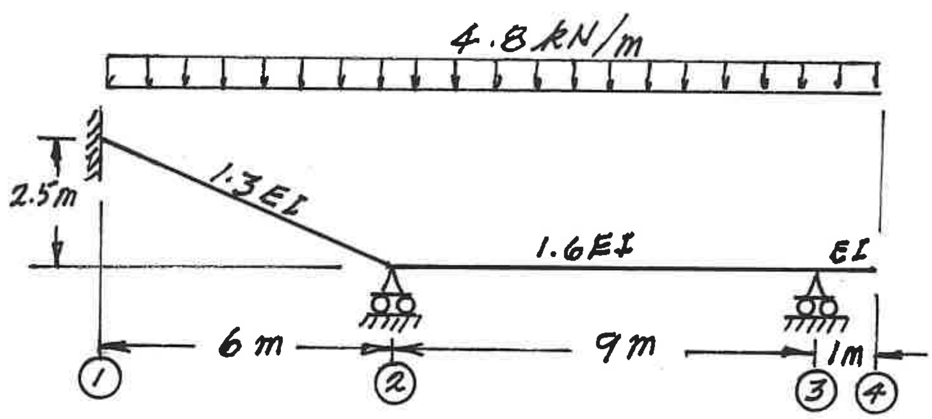


(18) 5. From point A though point D sketch the influence lines for: a) bending moment over support B and b) shear force immediately right of support B. Using the slope-deflection method or moment-distribution method, analyze the structure and **calculate** and **label** the ordinates of **both** influence lines at the centre line of the structure – the centre of span B-C. The three members have the relative EI values shown.

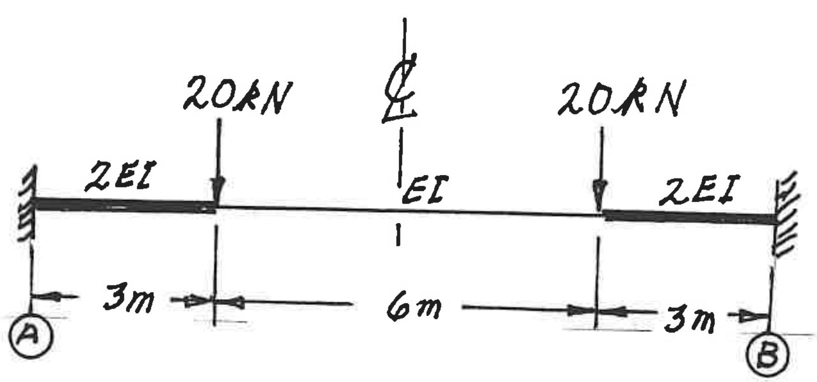


SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 6, 7, 8 OR 9.

(22) 6. Use the slope-deflection method or the moment-distribution method to analyze the three-beam structure 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 vertical, uniformly-distributed loading on all three members, stresses and strains are caused because support 3 settles (moves downward) 8 mm from the original position shown. The continuous, three-span beam is inextensible. Each member has the relative EI shown; EI = 8.1×10^4 kN.mm^2.

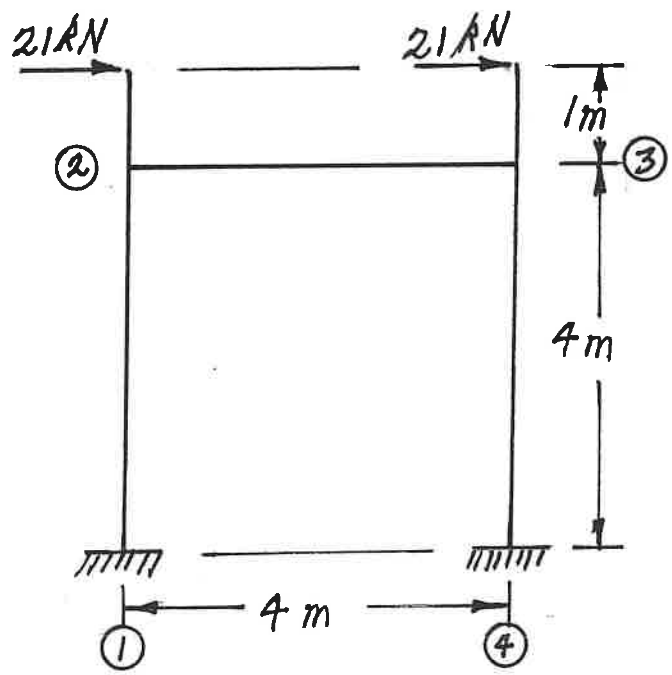


(22) 7. Using a **flexibility (force) method**, determine the moments at the ends of the fixed-ended, non-prismatic beam shown below. The relative EI values are shown.



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 same EI value.



(22) 9. a) For the frame shown, derive the equilibrium equation for the translation at joint 3 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:

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

DO NOT SOLVE THE EQUATIONS.

The unknowns of the problem shall be:

δ = translation at joint 3 (positive in the direction indicated)

θ_2 = rotation of joint 2

θ_3 = rotation of joint 3

(positive counter clockwise)