# NATIONAL EXAMS MAY 2017

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-defection 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.
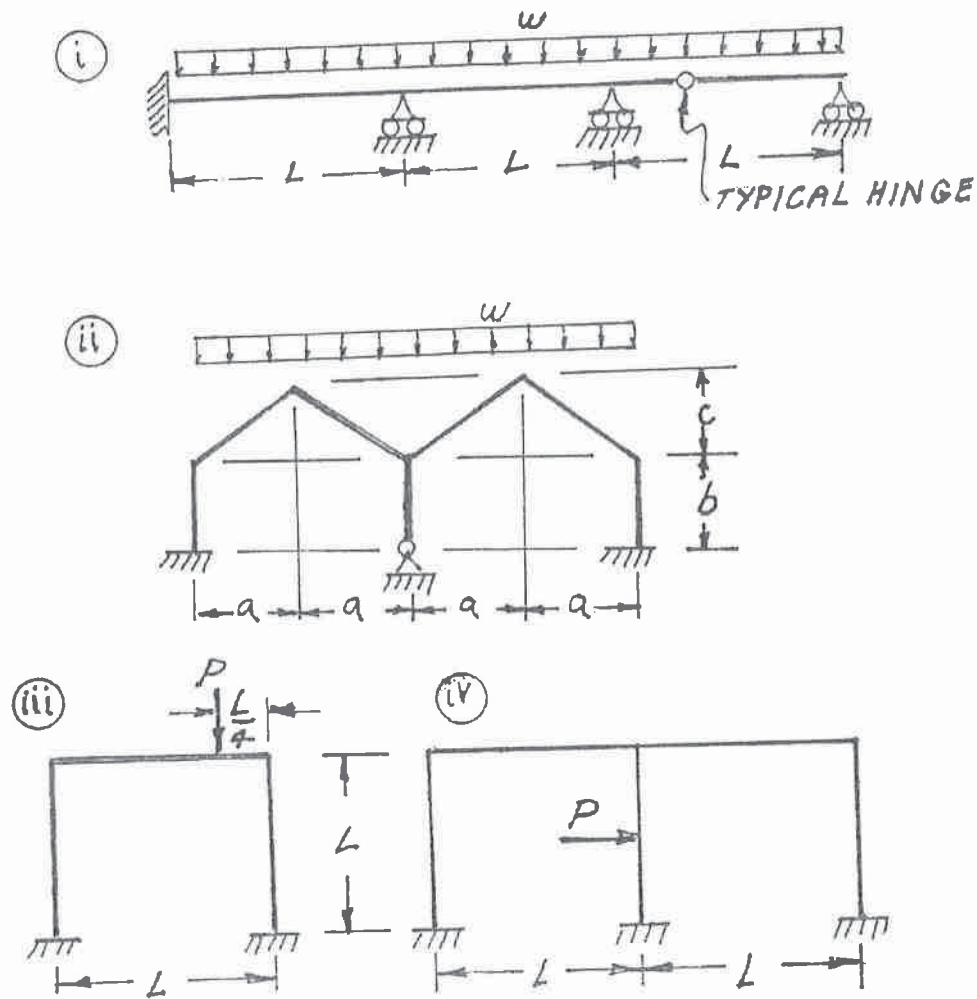
QUESTION #2 MUST BE ANSWERED.

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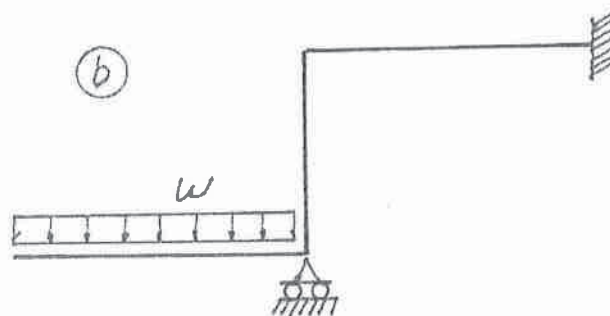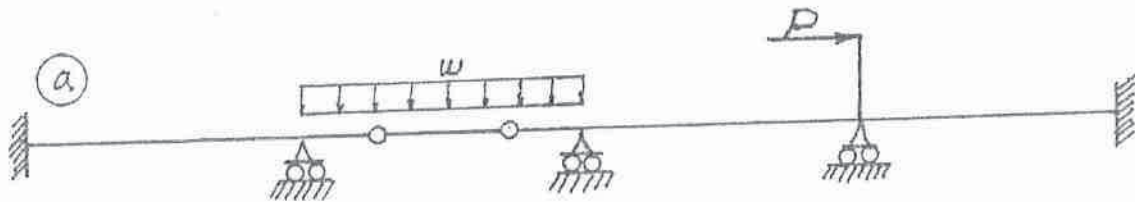

SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 3, 4, OR 5.

(16) 3.   Use Castigliano's theorem (the least work theorem) to analyze the structure shown. Calculate the force in each of the three truss members. EA is the same for all members.
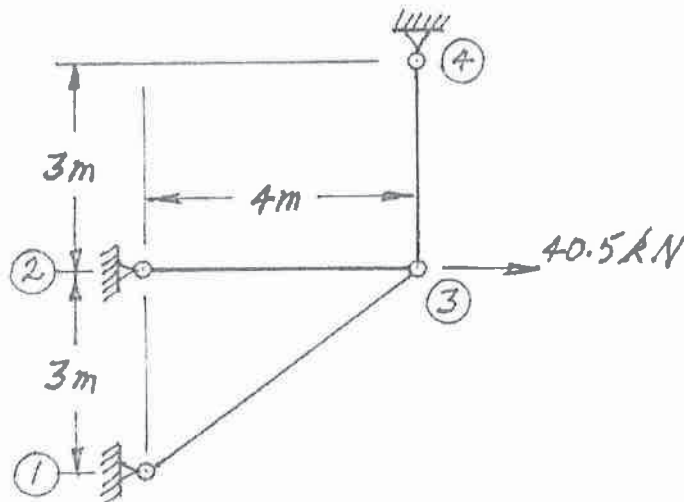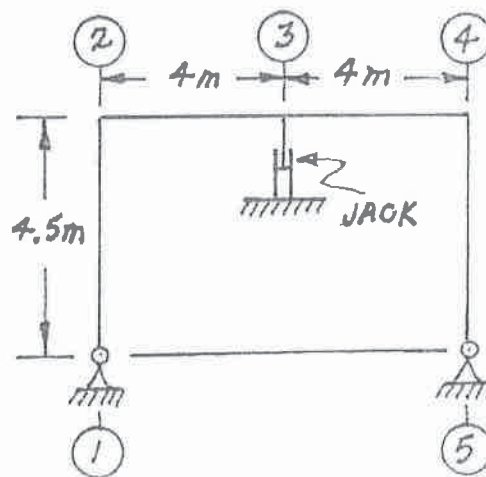
SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 3, 4, OR 5.

(16)   4.   Use Castigliano's theorem to determine the vertical deflection at point $\textcircled{B}$ on the structure shown. Both beams have the same EI value which is 51200 kN.m^2.
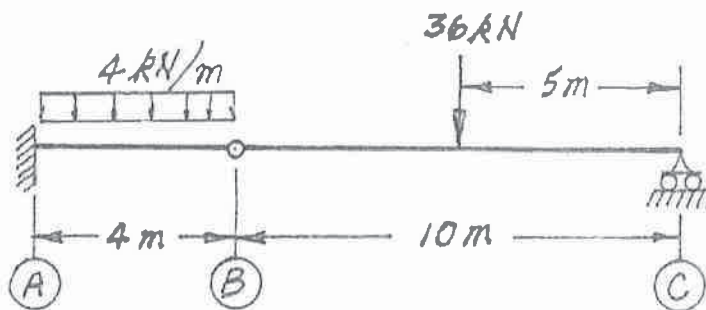

(16)   5.   For the structure shown below, using the slope-deflection or moment-distribution methods, calculate and plot the shear force and moment diagrams. The centre of the plane frame, joint $\textcircled{3}$, is lifted 0.02 m by the jack. All members are inextensible and have the same EI which is 8.0×10^4 kN.m^2.

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

(24) 6. Using the slope-defection 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). All members are inextensible and have the same EI value. Sidesway is **not** prevented.
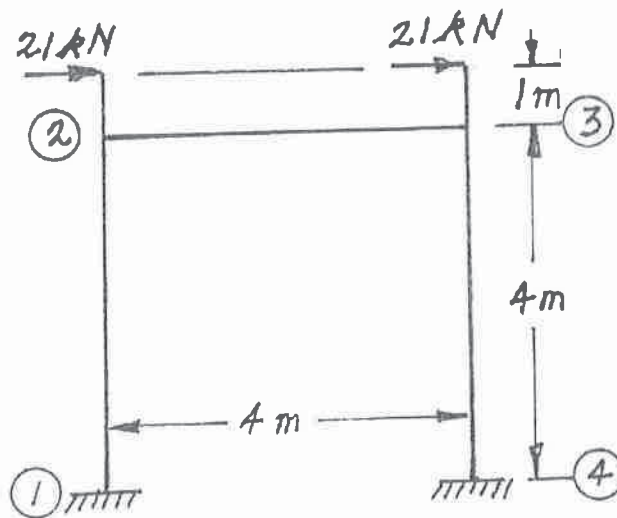
(24) 7. Using a **flexibility (force) method**, determine the fixed-end moment at the Ⓑ support of the non-prismatic beam shown below.
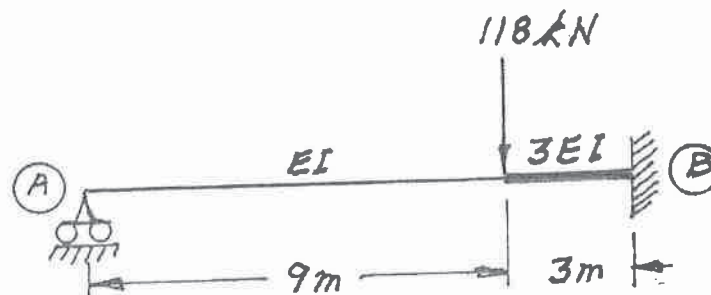

SELECT AND ANSWER TWO QUESTIONS ONLY FORM QUESTIONS 6, 7, 8 OR 9.

(24) 8. Using the slope-defection method, analyze the frame structure shown below. Plot shear force and bending moment diagrams. For both frame member on each diagram, indicate the magnitude of the maximum and minimum ordinates (Minimum ordinates are frequently negative values). All members are inextensible and both frame members have the same EI value. Member ③-④ is an inextensible strut. Sway of the frame in the plane of the structure **is not prevented**.
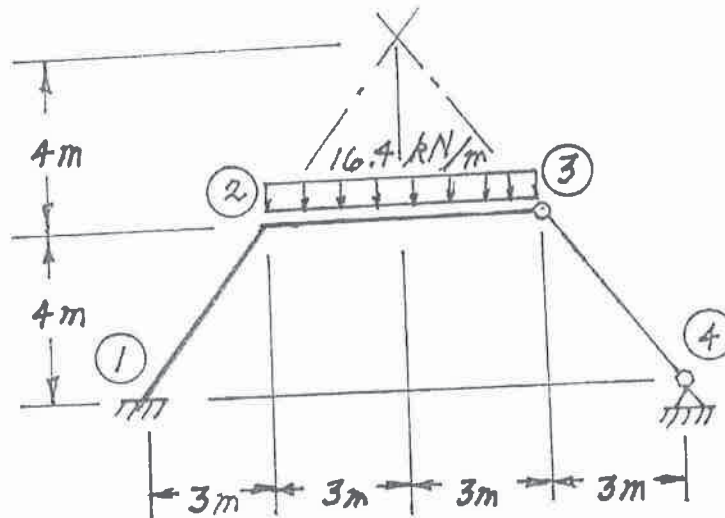
(24)   9.   a)   For the frame shown, derive the equilibrium equation for translation at
                 joint ③. Neglect the effects of axial strain. All members have the same EI
                 value.

        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 to the right)

θ_2 = rotation of joint ②

θ_3 = rotation of joint ③   (counter clockwise positive)