

NATIONAL EXAMS MAY 2014

ADVANCED STRUCTURAL ANALYSIS

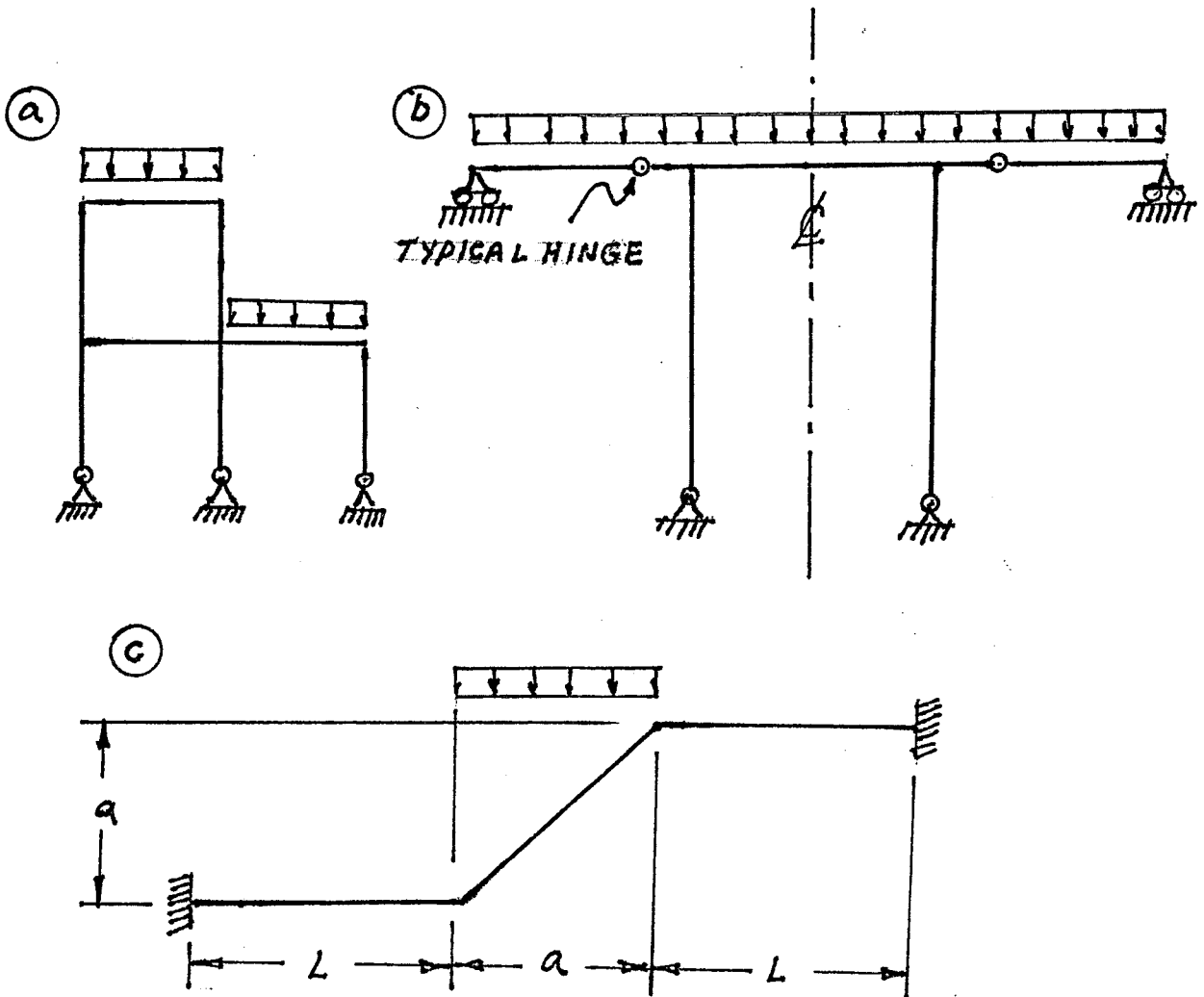
3 HOURS DURATION

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.

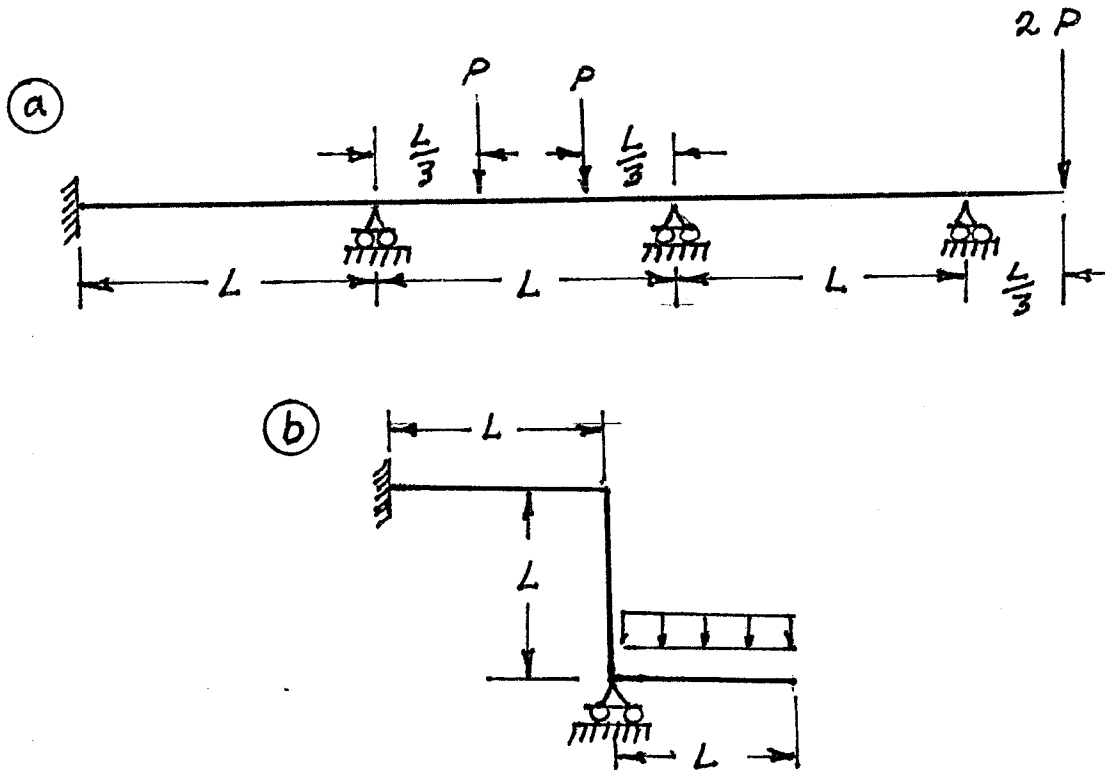
## QUESTION #1 MUST BE ANSWERED.

- (8) 1. a) Determine the statical indeterminacy,  $r$ , of the structures shown below.
- b) Indicate with arrows ( $\curvearrowright$  a rotation;  $\rightarrow$  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.



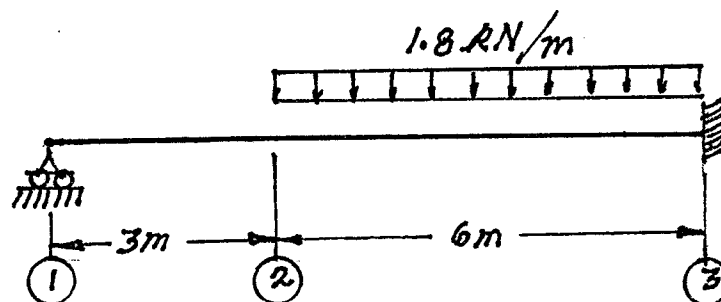
QUESTION #2 MUST BE ANSWERED.

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



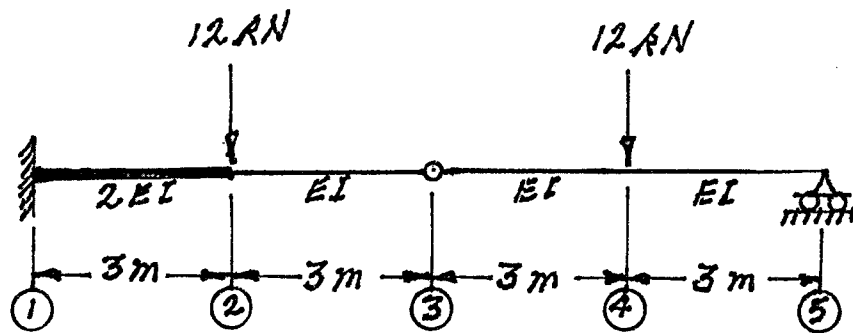
SELECT AND ANSWER TWO QUESTION ONLY FROM QUESTIONS 3, 4, OR 5.

- (16) 3. Use Castigliano's theorem (the least work theorem) to analyze the structure shown. Calculate the bending moment and shear on the beam at point ③. The beam has constant  $EI$  and is inextensible.

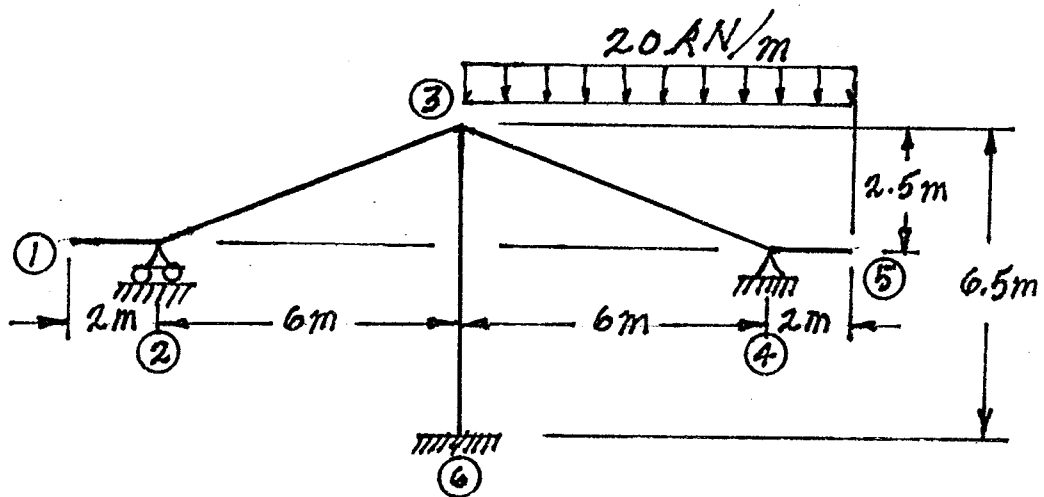


SELECT AND ANSWER TWO QUESTION ONLY FROM QUESTIONS 3, 4, OR 5.

- (16) 4. Use Castigliano's theorem to determine the vertical deflection at point ③ on the structure shown.  $EI = 1.8 \times 10^4 \text{ kN.m}^2$ .

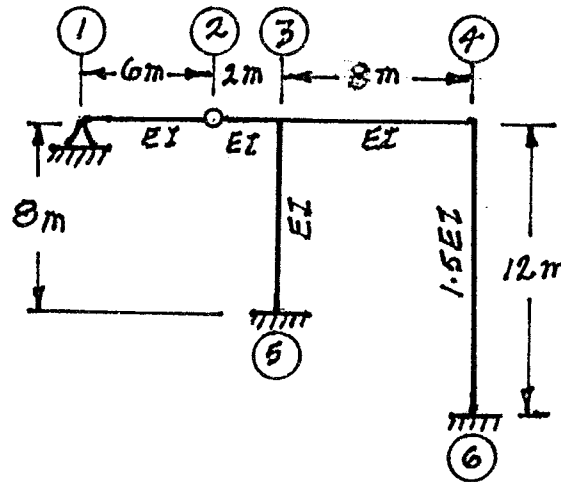


- (16) 5. Analyze the structure shown below using the slope-deflection or moment-distribution method; calculate and plot the shear force and moment diagrams. On each diagram for each member, label the maximum and minimum ordinates (Minimum ordinates are frequently negative values). All members have the same EI and are inextensible.

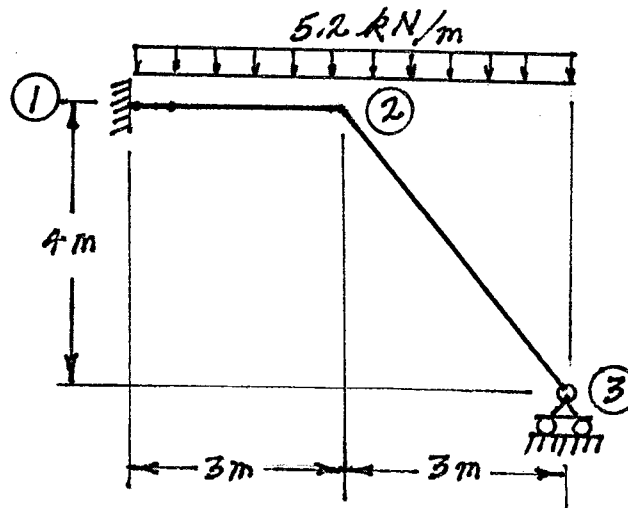


SELECT AND ANSWER TWO QUESTIONS ONLY FROM QUESTIONS 6, 7, 8 OR 9.

- (24) 6. Use the slope-deflection or the moment-distribution method to analyze the frame structure shown. Draw shear force and bending moment diagrams. For each member, indicate on both diagrams the magnitude of maximum and minimum ordinates (Minimum ordinates are frequently negative values). There are no loads on the structure, but member ①-② was intended to be exactly 6 m long; however, it was manufactured 6.06 m long and forced into place. The members of the structure have the relative EI values shown on the diagram; the value of EI is  $4.0 \times 10^4 \text{ kN.m}^2$  and all members are inextensible.

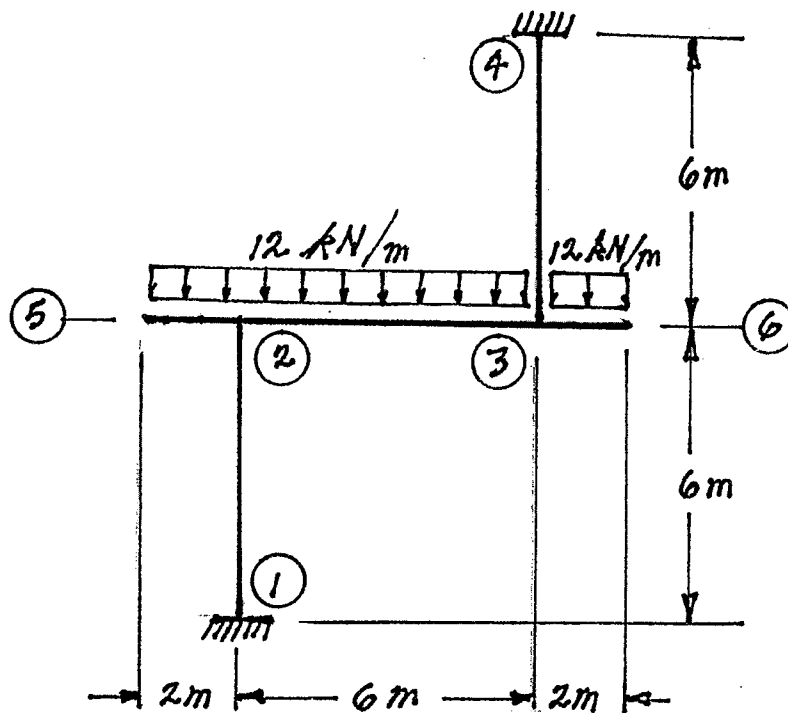


- (24) 7. Using a **flexibility (force) method**, analyze the frame structure shown. Both members have the same EI value and are inextensible. Draw shear force and bending moment diagrams. For each member, on each diagram indicate the magnitudes of the maximum and minimum ordinates (Minimum ordinates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



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

- (24) 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 positive and negative values. All members are inextensible and have the same EI value. Sidesway is not prevented.



- (24) 9. a) For the frame shown, derive the equilibrium equation for translation at joint ②. Neglect the effects of axial strain. The members have the relative values of  $EI$  shown on the diagram below.
- 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 to the left)

$\theta_2$  = rotation of joint ②

(counter clockwise positive)

$\theta_3$  = rotation of joint ③

