GX498

**Ollscoil na hÉireann, Gaillimh**

**National University of Ireland, Galway**

**SECOND SEMESTER EXAMINATIONS, 2000**

**Third Civil Engineering Examination**

**Solids and Structures II**

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Time allowed: *Three* hours

Attempt *Five* Questions

Answer parts A and B on separate answer books

## Part A Mechanics of Solids

1. The portal frame shown in figure Q1 is fixed at A & D, has rigid joints at B & C and has a constant load of 5kN/m acting downwards on member B to C. The frame behaves linear elastically, it has constant EI and the self-weight may be neglected.
   a) Using the Moment Area method or otherwise find the fixing moments and the horizontal reactions at the supports A & D. Also find the bending moments at the rigid joints B & C.
   b) Plot on graph paper the bending moment diagram for the portal frame.

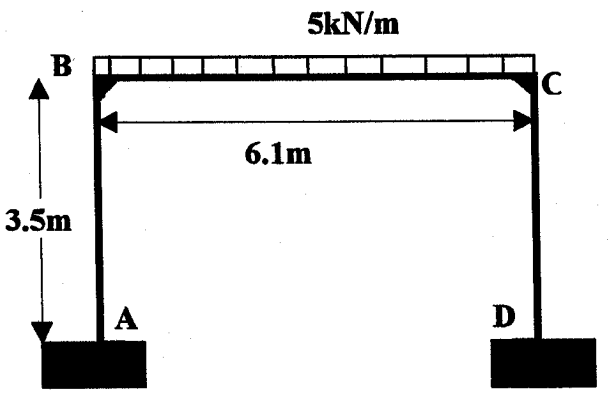


**FIGURE Q1**

2. a) Find from first principles the natural frequencies and mode shapes of a uniform simply supported beam, of span L, vibrating laterally in bending, (only bending should be considered). The only load on the beam is its self-weight which is constant and the flexural rigidity EI is also constant.
   b) Evaluate the first natural frequency of a uniform simply supported beam of span 10m, EI = $8.2 \times 10^9$kNmm$^2$ and the mass per meter length is 53kg.

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3. a) The prismatic pinned-pinned beam-column shown in figure Q3 is subject to an axial load P and a transverse load F. The beam-column is of span L and has constant EI and its self-weight may be neglected. Find an expression for the deformed shape of the section A to C of the beam-column for axial loads less than the critical axial load.

   b) Show that the maximum deflection for the deformed shape in (a) is given by:

   $\{(F)/(2Pk)\}[\tan(kL)/2 - (kL)/2]$ where $k^2 = P/(EI)$

   c) Find the critical load for a beam-column of span 10m and $EI = 8.2 \times 10^3 kNm^2$

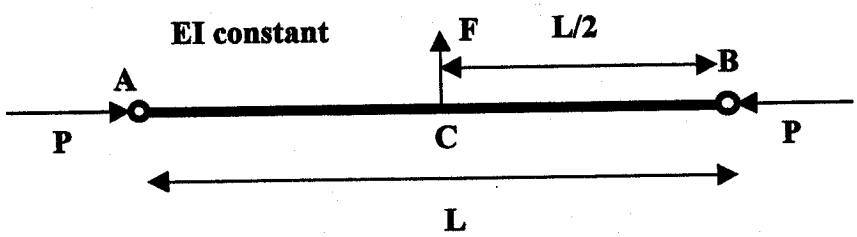


**FIGURE Q3**

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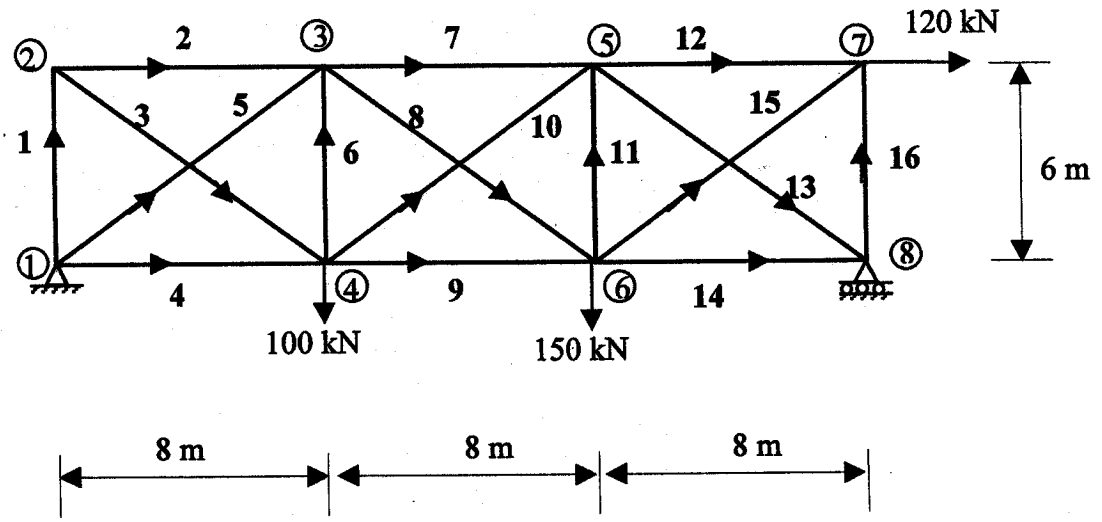
## SECTION B: Theory of Structures

4. (a) Calculate the stiffness matrices for members 3, 6, and 9 of the truss of Fig. Q4. The member connectivity is shown on the figure by means of arrowheads. Young's modulus and the cross-sectional areas are also given on the figure.

   (b) How are these matrices inserted into the global stiffness matrix?




$E = 200$ kN/mm$^2$.
$A = 4000$ mm$^2$ for members 2, 7, and 12;
$A = 2000$ mm$^2$ for members 1, 4, 6, 9, 11, 14, and 16;
$A = 1000$ mm$^2$ for the other members.

**Fig. Q4**

5. The tied portal frame of Fig. Q5 can be analyzed by means of the flexibility method, resulting in the following equation for the axial force $P_A$ in the tie:

$$\int m_A \frac{M}{EI} dx + t_A \frac{TL}{AE} + P_A f_{AA} = 0$$

Standard convention for symbols has been adhered to. A released primary structure was introduced by cutting the tie at the point A.

(a) By means of free bodies, evaluate the functions $m_A$ and $M$; $t_A$ and $T$.

(b) Evaluate $f_{AA}$.

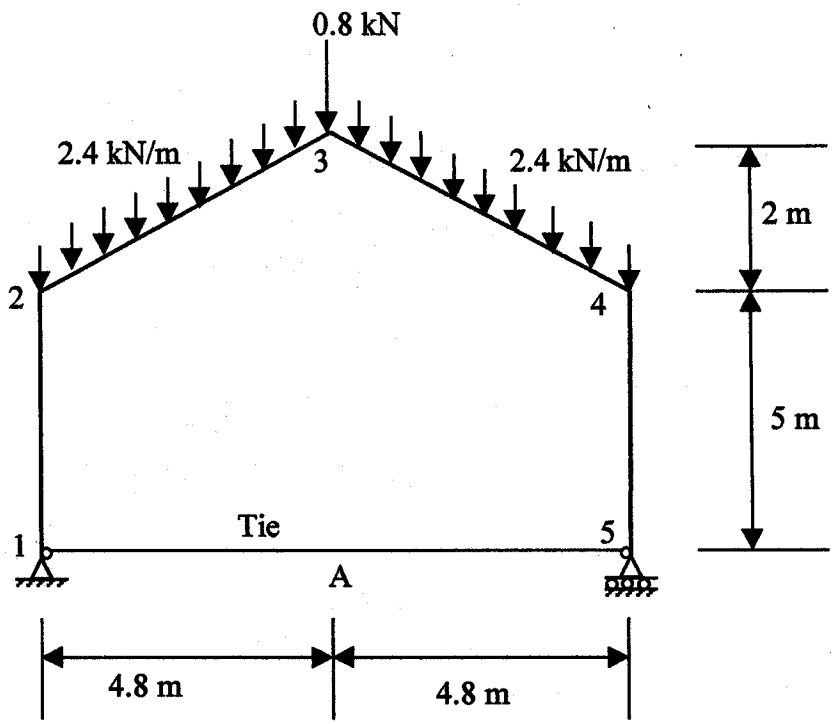



**Fig. Q5**

6. For the frame of Fig. Q6, use an approximate method of analysis to determine the bending moment, shear force, and axial force in members AB, BC, AD, EB, and CF. All assumptions must be stated, and free body diagrams must accompany statements of equilibrium.

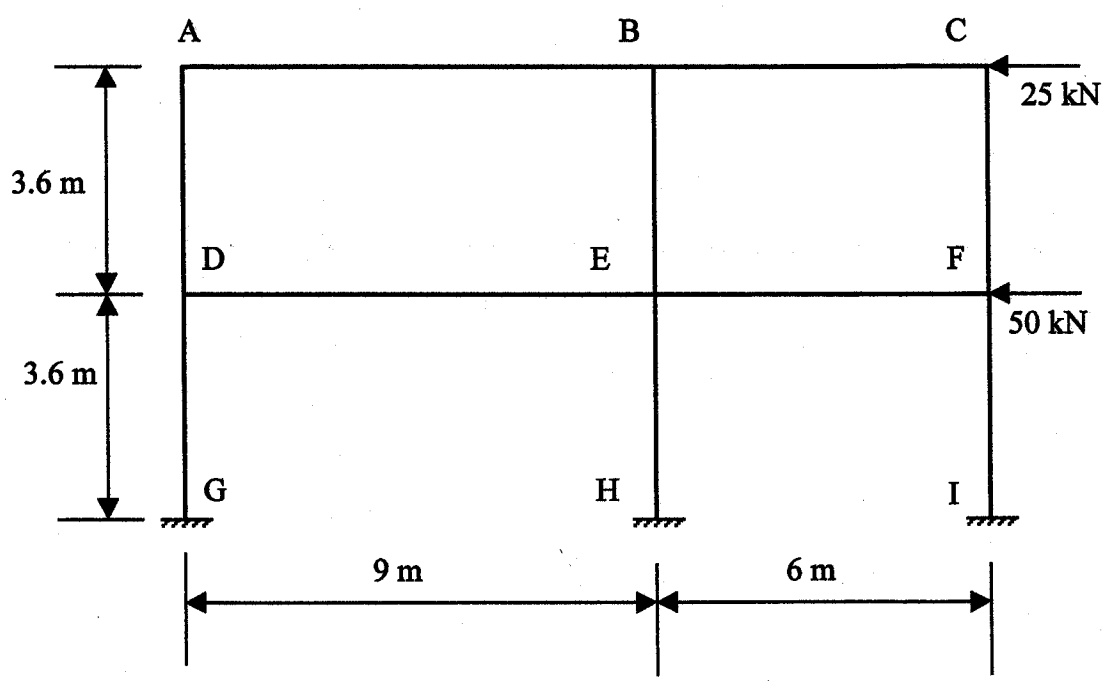



**Fig. Q6**