UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: July 2016

Module Number: CE3205 **Module Name: Structural Analysis I**

[Three Hours]

[Answer **all question**, each question carries twelve marks]

Q1 Fig. Q1 shows a portal frame structure with horizontal and vertical loading. Beam element of the portal frame is having stiffness twice the column element.

a) Considering only the vertical loading (i.e. Loading on the beam BC), calculate the fixed end moment at the joints A,B,C, and D using the moment distribution method.

[4 Marks]

b) Considering only the horizontal loading (i.e. the point load at B), recalculate the fixed end moment of the portal frame at A,B,C, and D.

[6 Marks]

c) Based on the results of Q1. a) and Q1. b) above and using the principal of superposition, complete the bending moment diagram of the portal frame structure shown in Fig. Q1.

[2 Marks]

Q2 Fig. Q2 shows a continuous beam ABCD with transversely applied uniformly distributed loads. Support A is fixed while support B, C, D are on rollers. The beam ABCD is a steel girder having second moment of area about the axis of bending equal to 1.5×10^{-6} m^4 and the Young's modulus of 200 GPa (kN/mm^2).

a) Using slope deflection relationship, calculate joint rotations at joints B, C, D of the beam ABCD.

[8 Marks]

b) Based on the joint rotations calculated in Q2.a) above and the due consideration of the applied loads, complete the bending moment diagram.

[4 Marks]

Q3. a) Considering two adjacent spans of a continuous beam, and based on the first moment of area and the second moment of area method, prove the three moment theorem given below. Note that the notations used in the formulae have their usual meaning.

$$\frac{M_1 l_1}{E_1 I_1} + 2M_2\left(\frac{l_1}{E_1 I_1} + \frac{l_2}{E_2 I_2}\right) + \frac{M_3 l_3}{E_3 I_3} = 6\left[\left(\frac{\delta_1 - \delta_2}{l_1} - \frac{\delta_3 - \delta_2}{l_2}\right) - \left(\frac{A_1 a_1}{E_1 I_1 l_1} + \frac{A_2 a_2}{E_2 I_2 l_2}\right)\right]$$

[4 Marks]

b) Fig. Q. 3 shows a propped cantilever beam AB fixed at A and spring supported at B. Spring support at B has a stiffness K. That is for applied reaction R_B, support B will be settled by R_B/K. Beam AB caries a uniform distributed load of w kN/m.

Calculate the support reaction at A. Show that the reaction at the spring support at B is given by.

$$R_B = \frac{3wL^3}{8\left(\frac{3EI}{KL}+L^2\right)}$$

Take the stiffness of the beam AB is equal to EI.

[8 Marks]

Q4 Fig. Q4 shows a two dimensional portal frame structure with beam carrying a uniform distributed load of w kN/m. Beam element of the portal frame (i.e. member BC) has twice the stiffness of the column element. Take the stiffness of the column element EI.

a) Assuming an appropriate virtual force/displacement arrangement of the real structure, calculate the reactions of the portal frame structure ABC and hence complete the bending moment diagrams of the portal frame ABC.

[5 Marks]

b) By generating the additional equations required using Castiglione's theorems of strain energy or complementary strain energy, as appropriate, calculate the reactions of the structure ABC above.

[5 Marks]

c) Compare the results obtained in parts (a) and (b) and comment on the two methods used to find the solutions for indeterminate structures.

[2 Marks]

Q5 a) Name different methods to produce influence line. Taking simply supported beam as an example, explain how Muller-Breslau principal can be utilized to determine the shape of the influence lines of the two support reactions, and the bending moment and shear force at a given point on the beam.

[2 Marks]

b) Considering a cantilever beam as shown in Fig Q5 (b) draw influence line of support reactions (i.e. Vertical reaction and moment at A), and bending moment and shear force at point C.

[4 Marks]

c) Draw the influence lines of bending moment and shear force at point D. Point D happens 4 m right to support A as shown in Fig. Q5. (c).

[6 Marks]

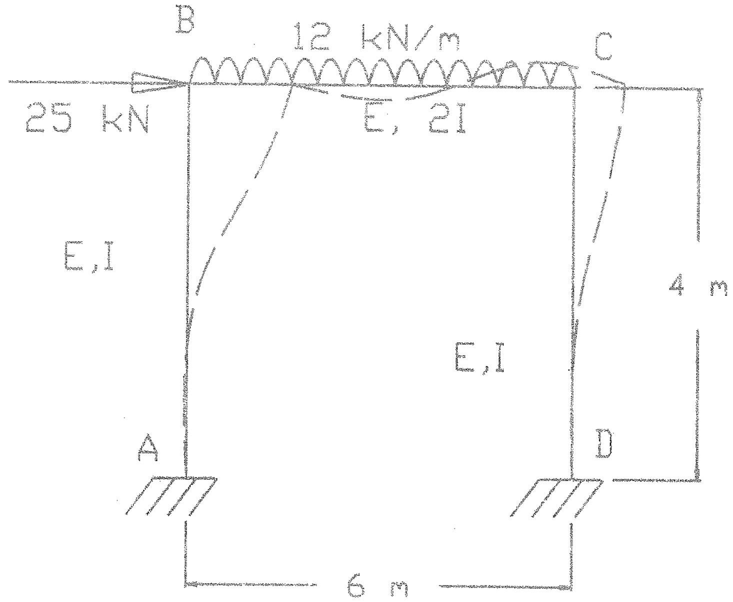

Fig. Q1

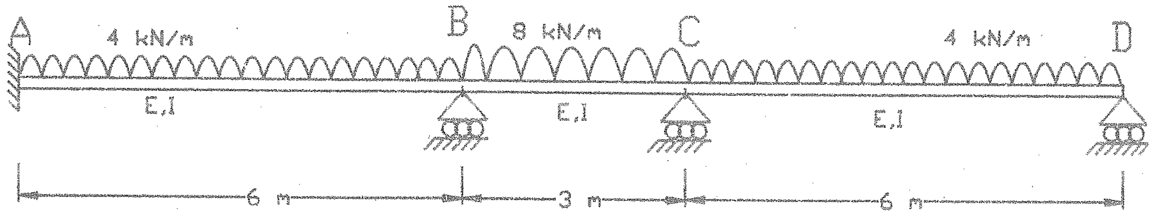

Fig. Q2

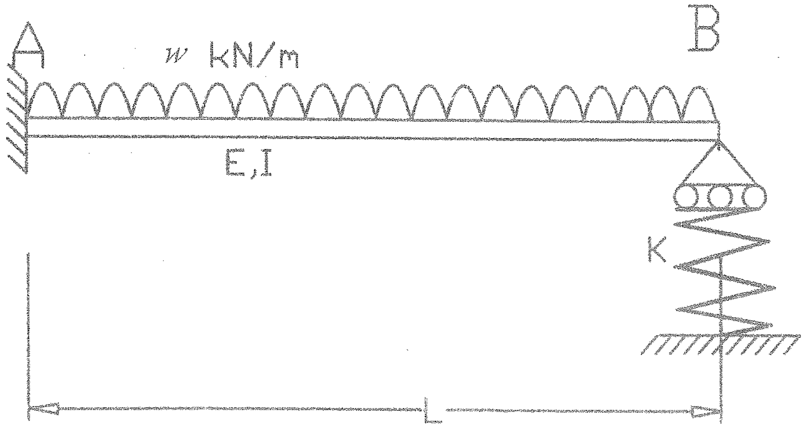

Fig. Q3

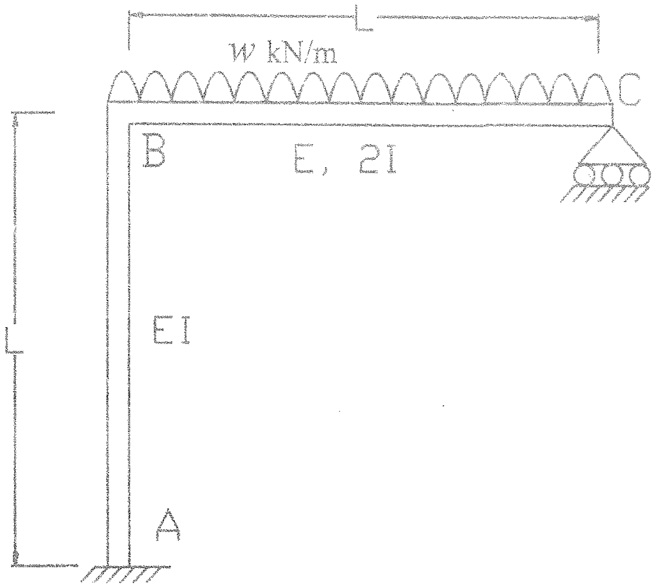

Fig. Q4

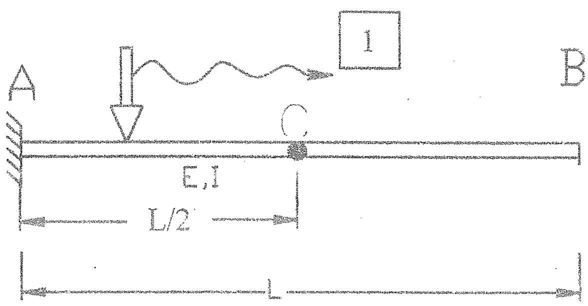

Fig. Q5 (b)

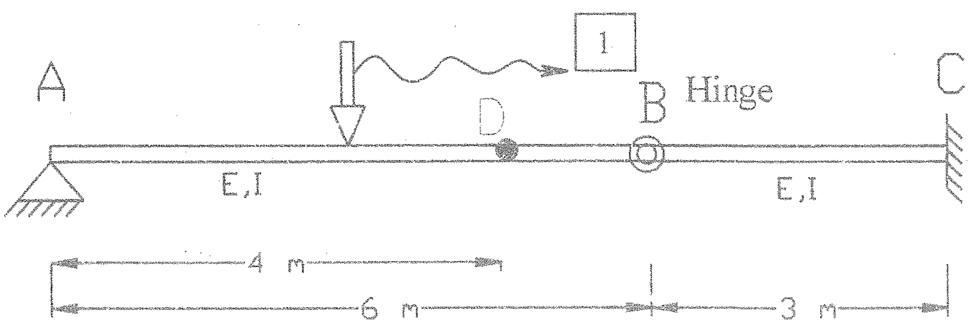

Fig. Q5 (C)