UNIVERSITY OF RUHUNA

Faculty of Engineering

End semester examination in Engineering: July 2017

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

[Three Hours]

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

Q1. a) Straight elastic beam AB of uniform cross section with constant flexural rigidity of EI deployed in a jetty is shown in the Fig Q1. Jetty beam is fixed at support A and floats on top of a cylindrical buoy radius R (in m) at point B as shown in Fig. Q1. Beam is expected to support a uniform distributed load of intensity w kN/m at critical conditions. Using three moment theorem, calculate the reaction at the floating support B. Ignore the self-weight of the beam AB and the self-weight of the float (Buoy). Consider float is at same level of the fixed support when the beam is in unloaded conditions. The buoyancy force of the float (uplift force acting on the structure due to water pressure) for 1 m length of immersion shall be taken as k (=$\pi R^2 \rho g$). Assume that the water level remain constant along the section of the water way where the jetty is constructed.

[Three Moment Theorem equation with usual notations is as follows]

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

[8 Marks]

b) Complete the bending moment and shear force diagram for the beam AB, considering the radius of the float (buoy) is 1m, span length (L) of the beam is 4m, and the applied uniform distributed load is 12 kN/m. Take the stiffness EI of the beam AB is 5×10^2 kNm^2, ρ=1000 kg/m^3 and g=9.81 ms^{-2}.

[2 Marks]

c) Discuss the structural implication of the jetty beam during fluctuation of water levels in the waterway.

[2 Marks]

Q2. Fig. Q2.(a) shows a portal frame ABCD subjected to both horizontal and vertical loadings. Fig. Q2.(b) and Fig. Q2.(c) show the applied horizontal loading and vertical loadings on the frame separately.

a) Considering only the vertical loading, Fig Q2.(b), on the frame, calculate the bending moment of the joints of the frame ABCD using moment distribution method.

[4 Marks]

b) Calculate the bending moments of the joints of the frame ABCD by considering only the horizontal loading (see Fig. Q2. (c)).

(Hint: In the calculation of bending moment of the frame due to lateral (horizontal) loading, first, assume joint moment for the unknown horizontal load P and thereafter calculated and calibrate the joint moments for the applied load based on the calculated values of the assumed horizontal load P).

[6 Marks]

c) Using the principal of superposition produce the bending moment and shear force diagram of the frame ABCD using the results obtained from parts Q2.(a) and Q2.(b).

[2 Marks]

Q3. Fig. Q3 shows idealized frame structure ABC. The beam; the horizontal member, has twice the stiffness of the column; the vertical member. Beam is expected to carry uniformly distributed transversely applied load of 12kN/m. In addition to the transverse loading, the frame is horizontally loaded with a 25 kN lateral force applied at joint B. Take stiffness (EI) of the beam element as 2.5×10^4 kNm^2.

a) Calculate the rotation and horizontal sway at joint B using slope deflection relationship and force equilibrium.

[8 Marks]

b) Based on the results obtained from part (a), calculate the bending moment at joints and hence complete the bending moment and shear force diagram of the frame ABC.

[4 Marks]

Q4 Fig. Q4.(a) shows a statically determinate roof truss ABCDE spanning 8m and supported at points A and D. Roof loads are applied as point load to the joint B and C. All members behave linear elastically with extension due to applied load given by $e=FL/AE$.

a) Calculate force in members AB, BC, CD, AE, BE, CE and DE using any of the methods.

[4 Marks]

b) Calculate the downward deformation of the joint E due to the applied load at B and C. Take Young's modulus as 205 kN/mm^2 and cross sectional area of the members 10.5 cm^2.

(Hint: Use a point load P_o at E in addition to the applied loads at B and C in computing the Energy/complementary energy of the system (see Fig. Q4. B)). Displacement at E due to applied load at B and C is equal to partial differential of the Energy/complementary strain energy of the system with respect to P_o when P_o is equal to zero).

[8 Marks]

Q5 Fig. Q5. (a) shows statically indeterminate frame structure proposed as an extension to the existing structure. Point A is fixed to the ground and point D is fixed to the existing building. Cantilever tip (Point B) of the Member BCD is expected to carry 12kN point load.

a) Considering suitable virtual force systems and writing virtual work expression, calculate the support reactions at joints A and D.
(Hint: Fig Q5. (b) and (c) are considered two options of virtual force systems to

find unknown reactions of the frame ABCD)

[6 Marks]

b) Now, by considering suitable additional virtual force system calculate the deflection at the tip of the cantilever end B of the beam BCD. Take the stiffness of the section (EI) as 2.5×10^4 kNm^2
(Hint: Use Fig Q5. (d) as virtual force system to calculate the deflection at point B)

[4 Marks]

c) Complete the bending moment and shear force diagrams of the frame ABCD.

[2 Marks]

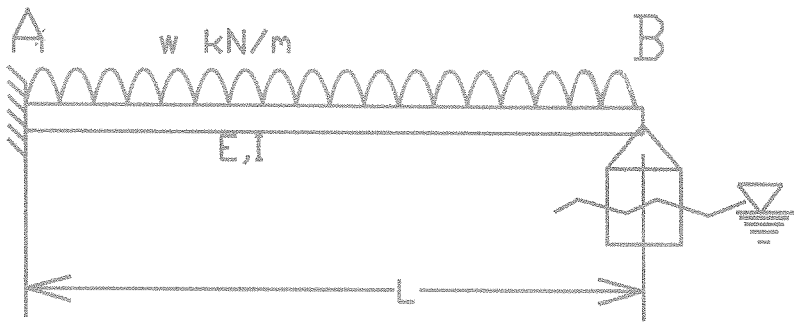

Fig. Q1

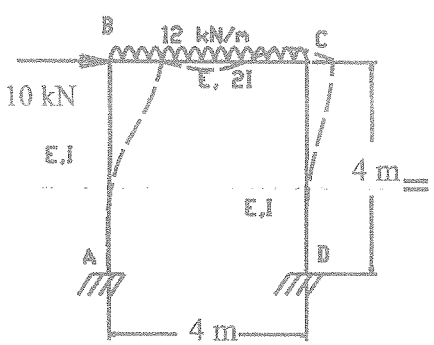

Fig.Q2 (a)

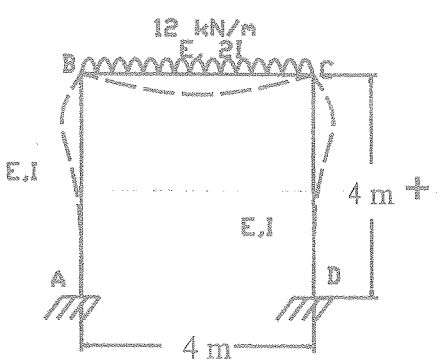

Fig.Q2 (b)

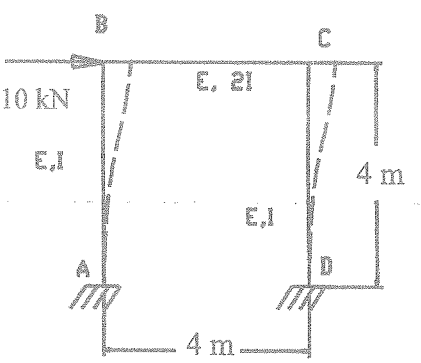

Fig.Q2 (c)

Fig. Q2

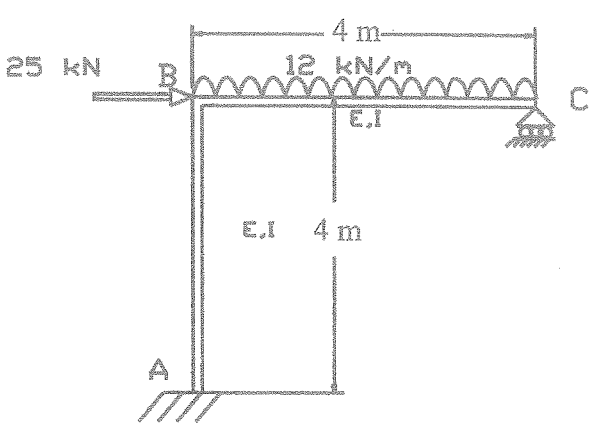

Fig Q3

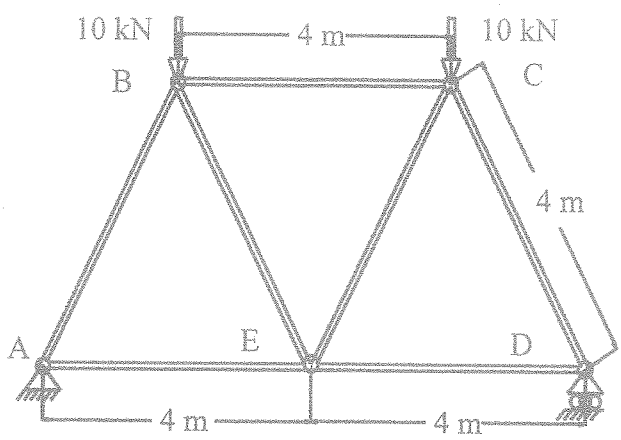

Fig. Q4(a)

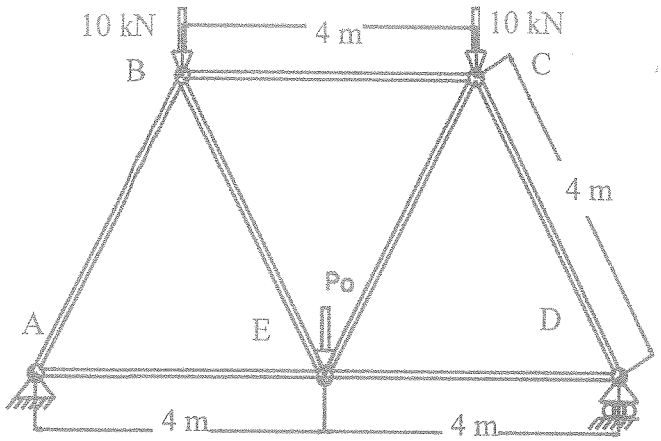

Fig. Q4(b)

Fig Q4

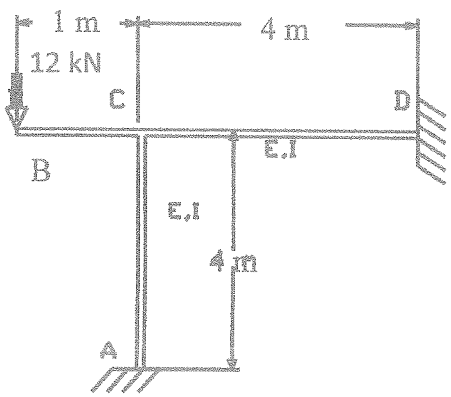

Fig. Q5 (a)

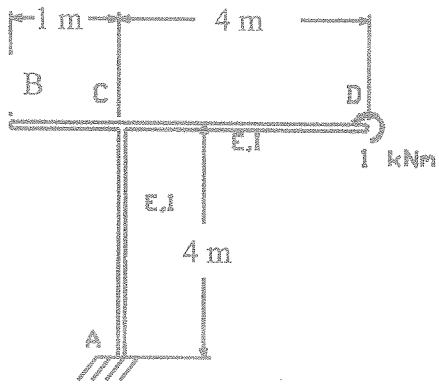

Fig. Q5(b)

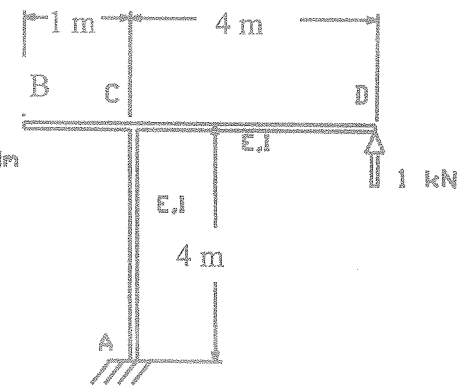

Fig. Q5(c)

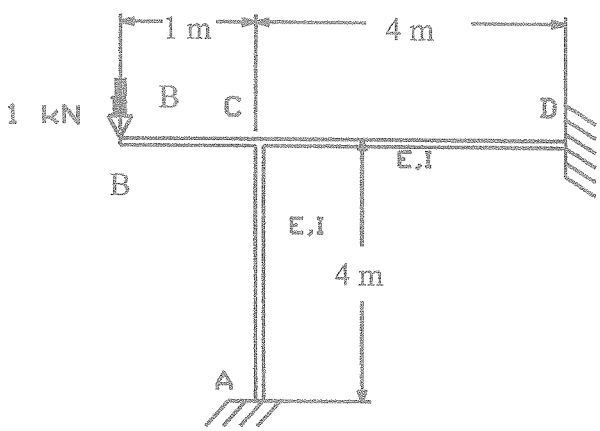

Fig Q5 (d)

Fig Q5