UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: August 2015

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

[Three Hours]

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

Q1. a) Fig. Q1 (a) shows beam with fixed ends subjected to a point load P and a uniformly distributed load w. Using moment curvature relationship and principal of superposition prove that the fixed end moment at A, M_{FAB} , is given by $\frac{PL}{8}+\frac{wL^2}{12}$, Where a, b and l are as shown in the Fig. Q1(a)

[5 Marks]

b) Beam having two cantilever parts are supported at points A, B, C and D as shown in Fig. Q1 (b). Draw the bending moment and shear force diagram of the beam using principals of moment distribution. Assume that the beam section is uniform throughout the length and it has constant EI for the entire length.

[7 Marks]

Q2. a) Indeterminate truss is shown in Fig. Q2. Assuming appropriate virtual force system, calculate the member forces using principals of Virtual Work. Consider that the external member (i.e. members AB, BC & CD) of the truss are subjected to temperature rise of 10°C at service compared to the time of its fabrication and that the member DB is initially reported to be 4 mm shorter than its expected dimensions. All members of the truss is fabricated using steel having cross section are 500 mm^2 and the Young's modulus of 200 GPa. Applied vertical load at B is 100 kN. Coefficient of thermal expansion of steel $\alpha = 10 \times 10^{-6}\,{}^0C^{-1}$.

[8 Marks]

b) Calculate the horizontal deformation of the truss at Node B due to the applied load.

[4 Marks]

Q3. a) Define Castigliano's theorem of strain energy and complimentary strain energy in your own wards.

[2 Marks]

b) Fig Q3 show a portal frame with pin support used for validating the Castigliano's theorem. Calculate the horizontal reaction due to knife edge load of 5 kg applied at the center of the beam BC. Assume same uniform cross sectional area, second moment of area (in the plan of bending) and Young's modulus for all the members of the portal frame. Consider only the bending energy of the system in the calculation of horizontal reaction.

[5 Marks]

c) Assuming a suitable virtual force or virtual displacement system and calculate the horizontal reaction of the portal frame described in the Q3 b) above using virtual work method.

[5 Marks]

Q4. a) Draw shear force and bending moment influence lines at the center of simply supported beam and compare the results with a bending moment and shear force diagram of the same beam carrying unit load at the center.

[3 Marks]

b) By way of mathematical expressions find the influence line-bending moment and influence line shear force of the point S1 of the beam ABC as shown in Fig. Q4.

[5 Marks]

c) Using the Muller Breslau principle draw qualitative influence line bending moment and influence line shear force for the point S2 as shown in Fig. Q4.

[2 Marks]

d) Explain the advantages of the influence line in the design of structures subjected moving loads.

[2 Marks]

Q5. a) Straight elastic beam ABC of uniform cross section with constant flexural rigidity of EI rests on 3 identical diameter cylindrical floats of radius R (in m) as shown in Fig. Q5. Beam is expected a uniform distributed load of intensity w kN/m at critical condition. Using three moment theorem, calculate the load carried by the central float and end floats. Ignore self-weights of the jetty. The buoyancy force of each float (uplift force acting on the structure due to water pressure) for 1 m length of immersion shall be taken as k ($=\pi R^2 \rho g$).

[Three Moment Theorem equation can be written with usual notations

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

[8 Marks]

b) Consider the diameter of the float is 1m, span lengths (L) are 4m each, applied uniform distributed load is 2 kN/m and the stiffness EI of the continuous beam ABC is 1.35×10^4 kNm^2. Calculate the required minimum height the cylindrical floats. Take ρ =1000kg/m^3 and g=9.81 ms^{-2}.

[4 Marks]

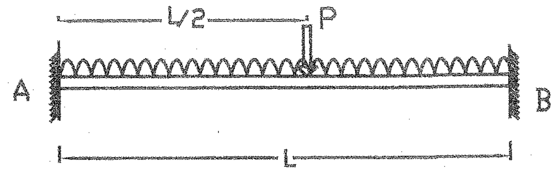

Fig. Q1 (a)

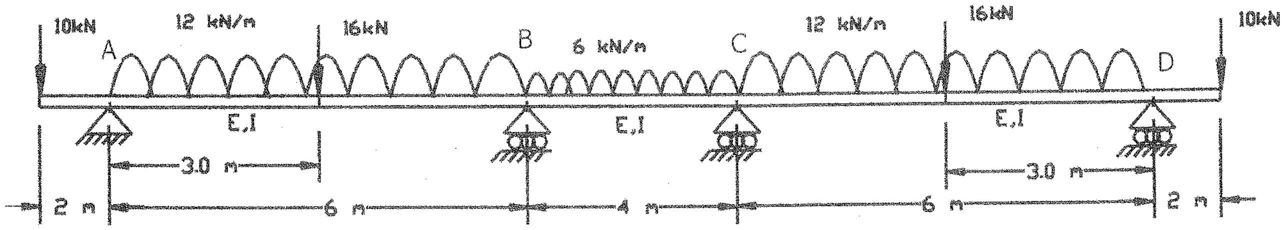

Fig. Q1 (b)

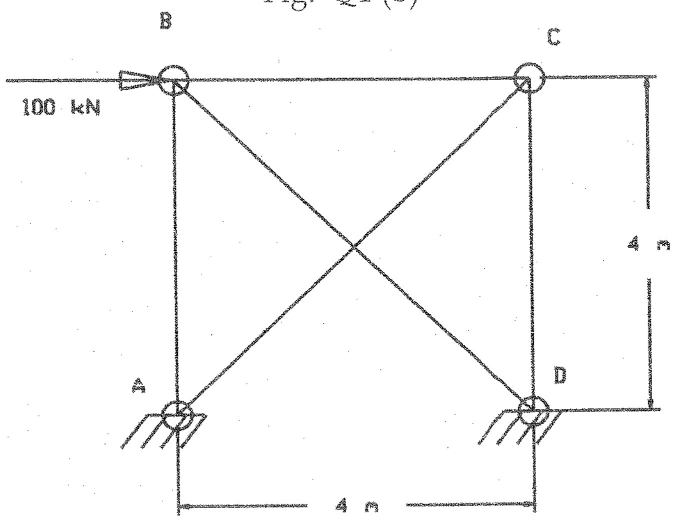

Fig. Q2

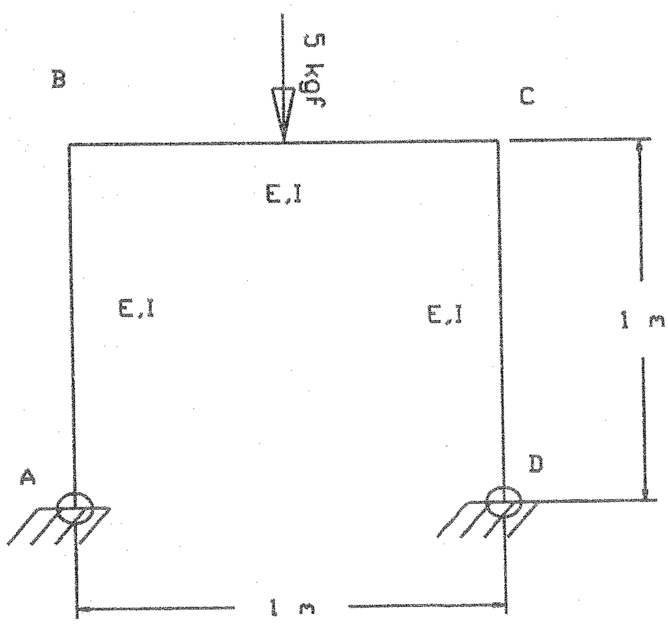

Fig. Q3

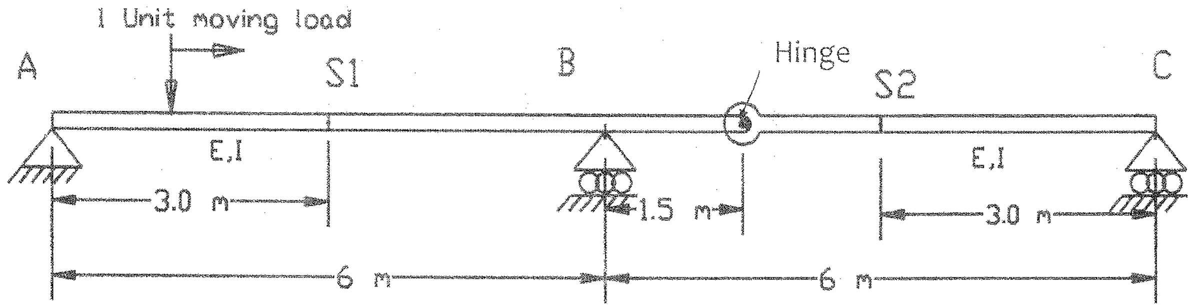
1 Unit moving load
A
S1
B
Hinge
S2
C
E,I
E,I
3.0 m
1.5 m
3.0 m
6 m
6 m

Fig. Q4

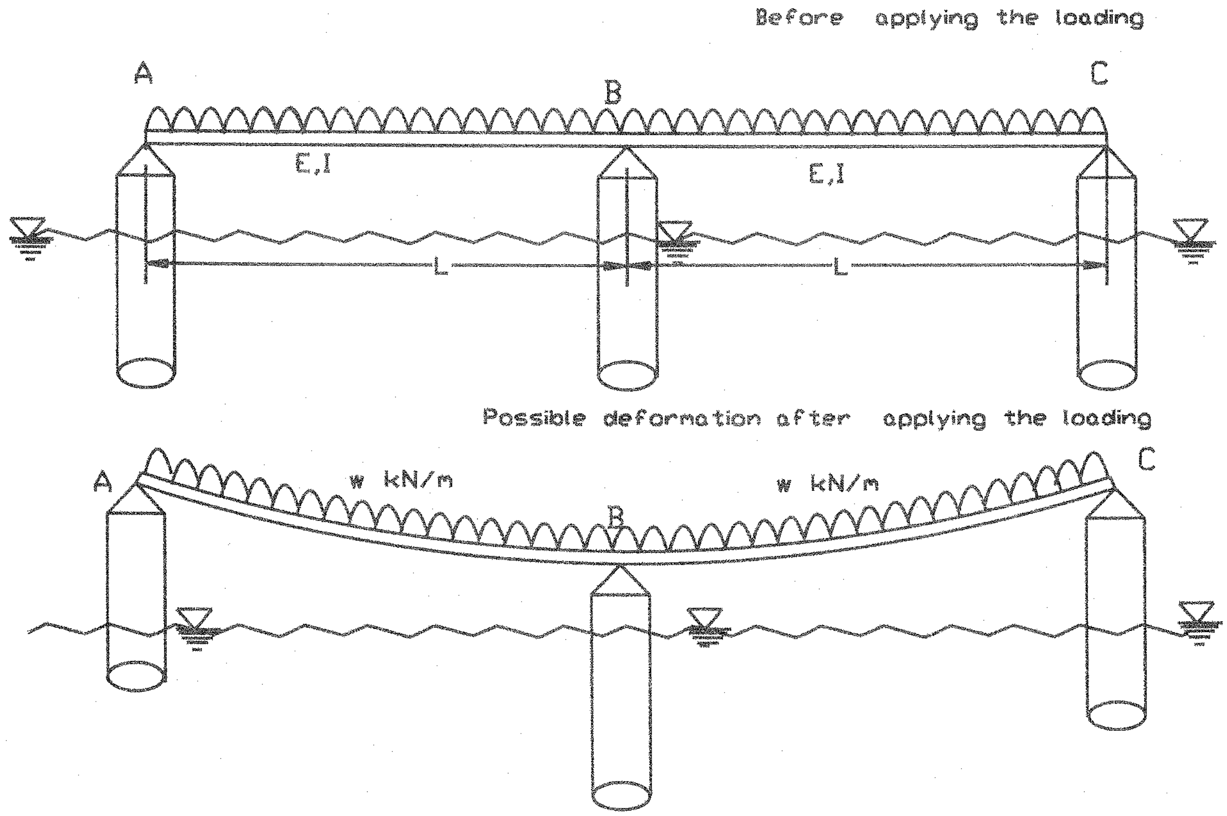
Before applying the loading
A
B
C
E,I
E,I
L
L
Possible deformation after applying the loading
A
w kN/m
B
w kN/m
C

Fig. Q5