THE OPEN UNIVERSITY OF SRI LANKA
Department Of Civil Engineering
Diploma in Technology (Civil)/ Bachelor of Technology(Civil) – Level 3

CEX3234 – Strength of Materials

FINAL EXAMINATION – 2010/2011

Time Allowed: Three Hours

Date: 2011 - 03 – 07 (Monday) Time: 09.30 – 12.30 hrs

The Paper consists of 8 questions, **Answer** 5 questions only

1. A simply supported beam is shown in Figure Q1.

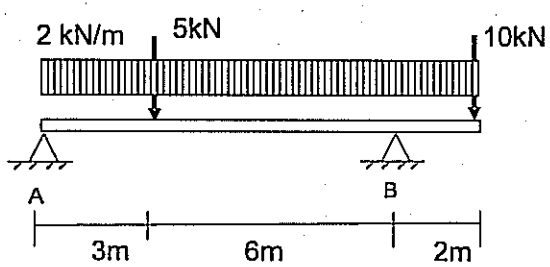

Figure Q1.

a. Find the support reactions at A and B. (4-Marks)
b. Determine the moment at B (4-Marks)
c. Write the equations for the variation of bending moment and shear force along the beam. Hence draw the bending moment and shear force diagrams (Note:- show your origin and sign convention clearly.(12-Marks)

2. An uniform cantilever structure shown in Figure Q2 is a part of a support structure for a chimney. Due to the wind the cantilever structure is subjected to a load / unit length of $q(z) = \frac{q_0}{L}(L - y)$

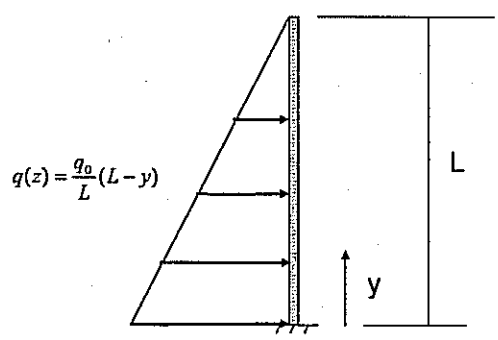

Figure Q2.

a) Derive the expressions for Bending Moment (BM) and Shear Force (SF) at a distance y away from the bottom (8-Marks)

b) The cantilever structure has the bending stiffness EI and is straight and vertical when unloaded. Find the deflection at the tip of the cantilever.(12-Marks)

3 a) Show that the circumferential (hoop) stress and longitudinal stress in a cylinder with internal pressure p is given by

hoop stress, $\sigma_1 = pr/t$ and longitudinal stress, $\sigma_2 = pr/2t$ where r is the radius and t is the thickness of the cylinder.(6-Marks)

b) Due to these stresses longitudinal strain and circumferential strain can be written in the following forms.

$$\varepsilon_1 = \frac{1}{E}(\sigma_1 - \nu\sigma_2)$$

$$\varepsilon_2 = \frac{1}{E}(\sigma_2 - \nu\sigma_1)$$

Write the expression for the change in volume of the cylinder whose radius is r and length equal to unity. Assuming ε_1 and ε_2 are small quantities show that the volumetric strain can be simplified to $2\varepsilon_1 + \varepsilon_2$ (6-Marks)

c) A cylindrical air vessel which is made of steel is 2 m long. The external diameter of the cylinder is 45 cm and its thickness is1 cm. Find the increase of external diameter and increase of length when pressurized to 1 MN/m². E-200 GN/m² and υ- 0.25. (8-Marks).

4 a) A steel column is shown in Figure Q4a. Calculate the Euler buckling loads
i) When both ends are fixed
ii) When both ends are pinned (8-Marks) L- 4m ; E - 200GN/m²

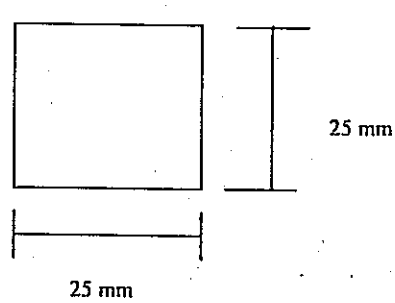

Figure Q4(a)

b) It was further found that the member is not perfectly straight. This initial curvature v_0 can be approximately assumed as $v_0 = \delta_0 \sin(\frac{\pi x}{L})$

Consider the case when both ends are pinned (Figure Q4(b))

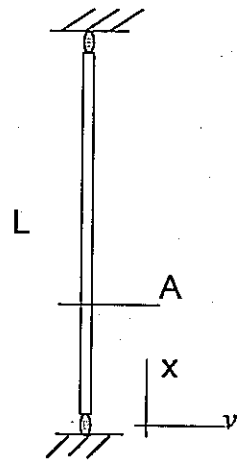

Figure Q4(b)

i) Show that the bending moment at A can be written as $M = P(v_0 + v)$ where v is the deflection at A (3-Marks)

ii) Show that the differential equation for the column can be expressed as

$$\frac{d^2v}{dx^2} + k^2v = -k^2v_0 \text{ where } k^2 = p/EI \text{ and } v_0 = \delta_0 \sin(\frac{\pi x}{L})$$ (3-Marks)

iii) The general solution for the above differential equation is

$$v = A\cos kx + B\sin kx + \frac{k^2 a}{\frac{\pi^2}{L^2} - k^2}\sin\frac{\pi x}{L}$$ Show that A and B become zero using appropriate boundary conditions. (Points-3)

iv) Show that the deflection at the mid span is given by $v = \delta_0(\frac{p_E}{p_E - p})$ where P_E, $p_E = \frac{\pi EI}{L^2}$ and P is any load that is always less than P_E.(3-Marks)

5. The governing equation for a cylindrical shaft under torsion can be expressed as

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$$

a) Explain the meaning of each term. You may use a figure to elaborate your explanations. (6-Marks)

b) Write three assumptions associated with the above tosion formula.(3-Marks)

c) The power transmitted by a shaft is $P=T\,w$ where T is torque and w is the angular velocity (rad/sec)

A ships propeller has external and internal diameters 25 cm and 15 cm respectively.
i) Determine the power that can be transmitted at 110 rev/min with the maximum shearing stress 75 MN/m² (6-Marks)
ii) Find the twisting angle in degrees of a 10 m long G= 80 GN/m²(5-Marks)

6. At a point of a material the stresses forming a two dimensional system are

$\sigma_x = 50$

$\sigma_y = 30$

$\sigma_{xy} = 20$

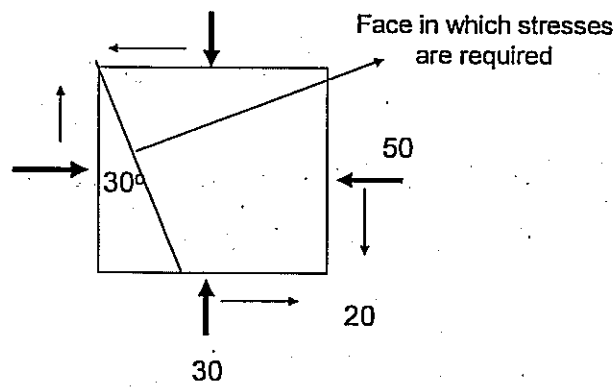

Figure Q6

All stresses are in MN/m²

a) Draw the Mohr's circle showing the important points. (5-Marks)
b) Determine the major and minor principle stresses. (5-Marks)
c) Determine the maximum shear stress and the direction. (5-Marks)
d) Determine the stresses in the plane given above.(5-Marks)

7. a.) Cross section of a steel cantilever beam is shown in Fig Q7
The length of the cantilever is 3m from the fixed end. If the allowable stresses in tension and compression is 150 MPa. Find the maximum uniformly distributed load that can be applied to the beam. (12-Marks)

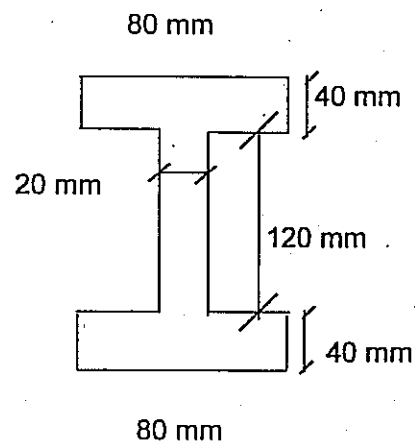

Figure Q7.

b.) If a solid circular section is to be used instead of the above section what is the radius of the section (You may neglect the effect of self weight).(8-Marks)

8. a) Three moment theorem given below is for the structure in Figure Q8(a). Explain the meaning of each term in relation to the structure. You may use the numbers in the figures to explain their meaning. (6-Marks)

$$M_L\frac{L_1}{E_1I_1}+M_c\left[\frac{L_1}{E_1I_1}+\frac{L_2}{E_2I_2}\right]+M_R\frac{L_2}{E_2I_2}=-\left[\frac{6\overline{X}_LA_1}{E_1I_1}+\frac{6\overline{X}_RA_2}{E_2I_2}\right]$$

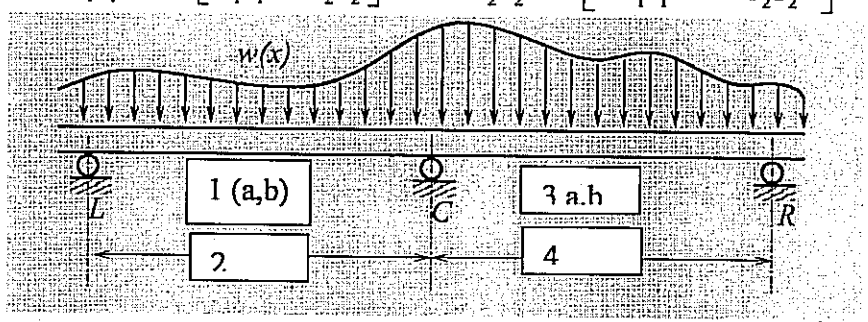

Figure Q8 (a)- Loading system

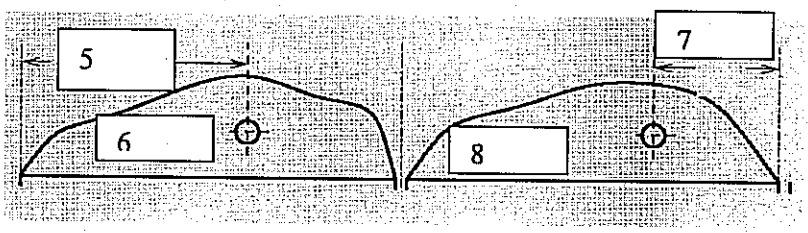

Figure Q8 (b)- Free bending moment diagrams

b) Find the bending moment at C using Three moment theorem and draw the bending moment diagram for the structure shown in Figure Q8(c). (Hint, Assume *EI* is constant) (14-Marks)

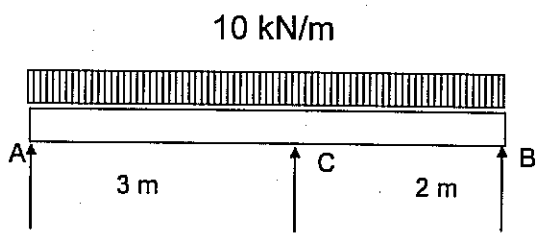

Figure Q8(c)- Loading system