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The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: MEX5232/DMX5532Strength of Materials II**
Academic Year	: 2019/20
Date	:02 August 2020
Time	: 0930 h-1230 h
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Seven (7)** questions in **four (4)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. This is a Closed Book Test (CBT).
5. Answers should be in clear handwriting.
6. Do not use Red color pen

Q1 A beam AB simply supported at ends has been loaded as shown in Figure Q 1.

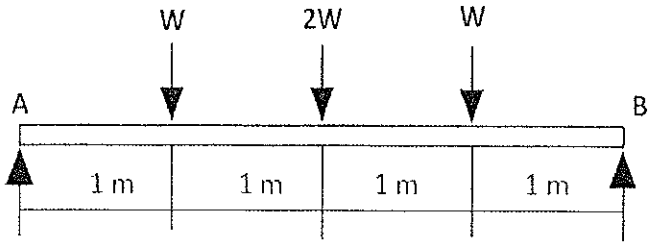

Figure Q1

(a) Find out the reactions at the supports A and B in terms W. (2 marks)

(b) Write down the second order differential equation of the elastic curve, using Macaulay's Method, the horizontal distance (x) being measured from the end A. (6 marks)

(c) Taking W as 5 kN, and the flexural rigidity (EI) of the beam as 800 kNm^2, find out the angular displacement at A and the vertical deflection at mid span of the beam. (8 marks)

(d) Sketch the bending moment diagram for the beam AB. (4 marks)

Q2 (a) Figure Q2 shows a cantilever beam propped at D and carrying two point loads. The flexural rigidity (EI) of the beam is 800 kNm².

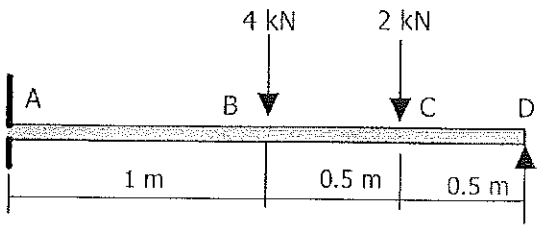

Figure Q2

(i) Sketch the bending moment diagrams separately for each load and the force exerted by the prop. Neglect the self-weight of the beam. (6 marks)

(ii) Determine the value of reaction force at D using first theorem of Moment – Area Method if the angular deflection at D is 2 degrees. (6 marks)

(iii) Find the vertical deflection at point B, using Second theorem of Moment Area Method. (8 marks)

Q3 (a) Write down the Lame's Equations for stresses in thick Cylinders (2 marks)

(b) A thick cylinder is subjected to an internal pressure of 40 MPa. Its' outer radius is 1.5 time the inner radius.

(i) Sketch the radial stress and the hoop stress against $1/r^2$. Where r is the any radius of the cylinder. (6 marks)

(ii) Hence, find out the maximum hoop stress in the cylinder (6 marks)

(iii) If the cylinder is subjected to an external pressure of 20 MPa, in addition to the already applied internal pressure, find out the hoop stress at inner surface of the cylinder. (6 marks)

Q4 A steel ring is fitted to a solid shaft of radius 100 mm. The outer radius of the ring is 150 mm. When the assembly rotates at a certain speed, the interface pressure is 20 MPa and the hoop stress at the inner radius of the ring is 200 MPa. The radial stress and the hoop stress in the ring can be expressed by the following equations.

$$\sigma_r = A - \frac{B}{r^2} - K_1 r^2 \omega^2$$

$$\sigma_r = A + \frac{B}{r^2} - K_2 r^2 \omega^2$$

(a) Find the constants A and B in terms of K_1 and ω^2 (8 marks)

(b) Hence determine the speed of rotation of the shaft with following values of K_1 and K_2 (12 marks)

$$K_1 = 3.1\ x\ 10^{-3}, \qquad K_2 = 1.8\ x\ 10^{-3}$$

Q5 (a) Show that the maximum shear stress (τ_{max}) and the angle of twist (ϕ) of a solid circular shat of diameter d and length L, subjected a torque T are given by the following two equations. (4 marks)

$$\tau_{max} = \frac{16T}{\pi d^3} \qquad \phi = \frac{TL}{GJ}$$

Where G = Modulus of Rigidity of the shaft material

J= Second Polar Moment of Area

(b) The shaft shown in Figure Q5 consists of 3 sections. The section BC is hollow with inner and outer diameters of 80mm and 120 mm, respectively. The sections AB and CD are solid with diameter *d*. The shaft is loaded with torques as shown.

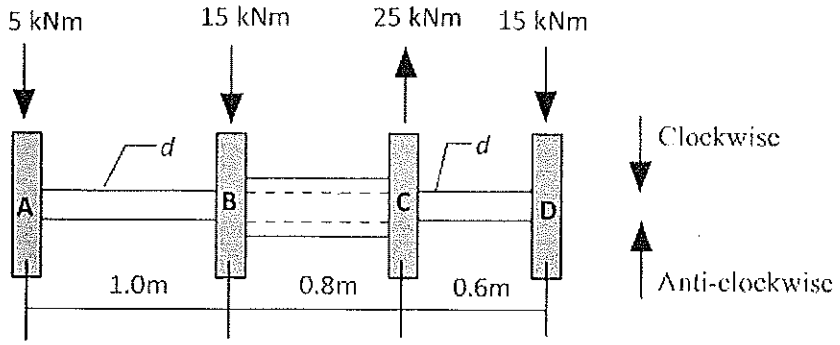

Figure Q5

Determine the following:

(i) Torques carried by the shaft sections, AB, BC, and CD (3 marks)

(ii) Maximum shear stress in the shaft section BC (3 marks)

(iii) Diameter, *d* of the sections AB and CD, if the allowable shear stress is 65 MPa (5 marks)

(iv) Angle of twist at D relative to end A, if the modulus of rigidity is 70 GPa (5 marks)

Q6 A Simply supported beam having a rectangular section carries a central load W as shown in Figure Q6. The section having maximum bending moment is close to yielding at the outer surface.

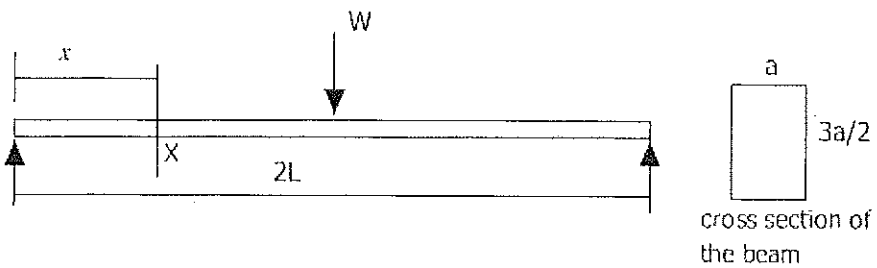

Figure Q6

(a) Derive an expression for the load W in terms of yield stress (σy), a and L (5 marks)

(b) Derive an expression for the bending moment carried by the section X, if the plastic yielding at this section has penetrated to a depth of y measured from the neutral axis. (12 marks)

(c) Hence obtain plastic penetration depth (y) as a function of x. (3 marks)

Q7 (a) A thin walled circular tube is transmitting a torque of 3 kNm. Find the mean diameter of the tube if the wall thickness of the tube is 5 mm and the allowable shear stress is 60 MPa. (6 marks)

(b) If a thin walled square section with the same perimeter and the wall thickness as of the circular tube mentioned in (a) is used, what is the maximum torque that can be transmitted with the same allowable shear stress? (6 marks)

(c) Show that the angle of twist (θ) of a thin walled tube subjected to an axial moment (T) are given by the following equation. (8 marks)

$$\frac{\theta}{L} = \frac{TZ}{4A^2tG}$$

L - Axial length of the tube

Z -Circumferential length of the tube section

A - Cross sectional area of the tube section

t - Thickness of the tube

G - Modulus of rigidity

You may use the following information.

Strain energy stored in the tube per unit volume is given by the following equation.

$$u = \frac{1}{2}\tau\gamma = \frac{\tau^2}{2G}$$

τ = shear stress, γ = shear strain