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THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY

Bachelor of Technology (Engineering) Programme

FINAL EXAMINATION 2010/11

MEX5232 Strength of Materials II

Date: 28 – 02 - 2011

Time: 9.30am – 12.30pm

Duration: 3 hours

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Read the following instructions carefully before answering the questions.

1. This question paper consists of 8 questions. All questions carry equal marks.
2. Answer any 5 questions only.

Q1. A beam is loaded as shown in Figure Q1.

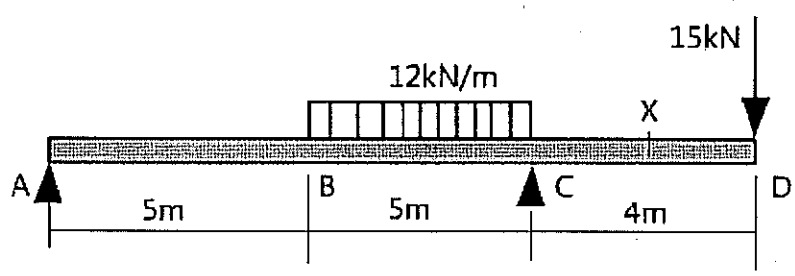


Figure Q1

(i) Write down the bending moment at Point X, using Macaulay's method. (6 marks)

(ii) Determine the equation for the deflection curve in terms of *EI*. (8 marks)

(iii) Find the deflection at point B if the value *EI* is equal to $4 \times 10^5 kNm^2$. (6 marks)

Q2. (a) State the First and Second theorems of Moment-Area method used to determine the deflection of beams. (4 marks)

(b) One end of a built-in beam has been lowered by an amount Δ vertically without rotation as shown in Figure Q2.

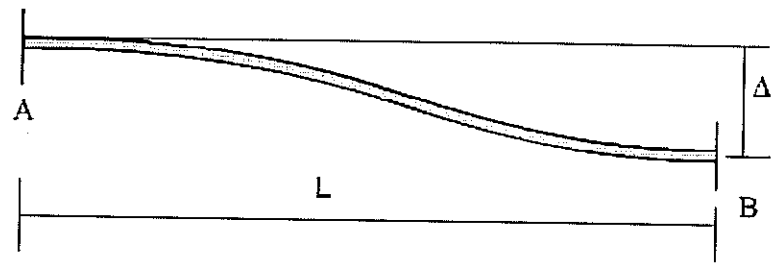


Figure Q2

(i) Considering the beam as a cantilever with appropriate loads at the free end, sketch the bending moment diagram. (6 marks)

(ii) Determine the support reactions at A and B in terms of L, Δ, E and I, using Moment- Area theorems. (10 marks)

Q3. (a) State Lame equations for the hoop and radial stresses in thick cylinders and show how these can be expressed in graphical form. (2 marks)

Show that the hoop stress at the outer surface of a thick cylinder, with internal and external radii R_1 and R_2 respectively, subjected to an internal pressure P is given by the following equation. (4 marks)

$$\sigma_H = \frac{2PR_1^2}{R_2^2 - R_1^2}$$

(b) A steel tube is shrunk on to another steel tube to form a compound cylinder 60mm internal diameter and 180mm external diameter. The initial radial compressive stress at 120mm common diameter is 30MN/m². Taking modulus of elasticity as 200GN/m², calculate the shrinkage allowance. (8 marks)

(c) The above compound cylinder is subjected to an internal pressure of 25MN/m². Calculate the hoop stresses at internal and external surfaces of the compound cylinder. (6 marks)

Q4. A compound cylinder has a bronze inner cylinder and steel outer cylinder. The inner cylinder is of 50mm internal diameter and 60mm external diameter. The external diameter of the steel cylinder is 100mm. When the assembly is at a temperature of 30°C, there is no interface pressure at the common radius. The assembly is heated to 130°C. Calculate,

(i) Interface pressure. (14 marks)

(ii) Thermal hoop stresses inside and outside surfaces of the bronze cylinder. (6 marks)

Modulus of Elasticity (E), Poisson's ratio(ν), and coefficient of linear expansion(α) for bronze and steel are:

For bronze $E = 100\ GN/m^2$, $\nu = 0.33$, $\alpha = 19 \times 10^{-6}\ ^oC^{-1}$
For steel $E = 200\ GN/m^2$, $\nu = 0.30$, $\alpha = 12 \times 10^{-6}\ ^oC^{-1}$

You may use the following formula and the Lame equations.

$$\frac{1}{E_s}[\sigma_{H/s} + \nu_s p\,] - \frac{1}{E_b}[\sigma_{H/b} + \nu_b p] = (T_2 - T_1)(\alpha_b - \alpha_s)$$

E, σ_H, α, ν and p stand for modulus of elasticity, hoop stress at the interface radius, coefficient of linear expansion, Poisson's ratio and interface pressure respectively. Suffixes b and s indicate bronze and steel respectively.

Q5. (a) A circular thin walled tube shown in Figure Q5 (a) is used to transmit a toque T, with maximum allowable shear stress being $2MN/m^2$. Find the value of T. (4 marks)

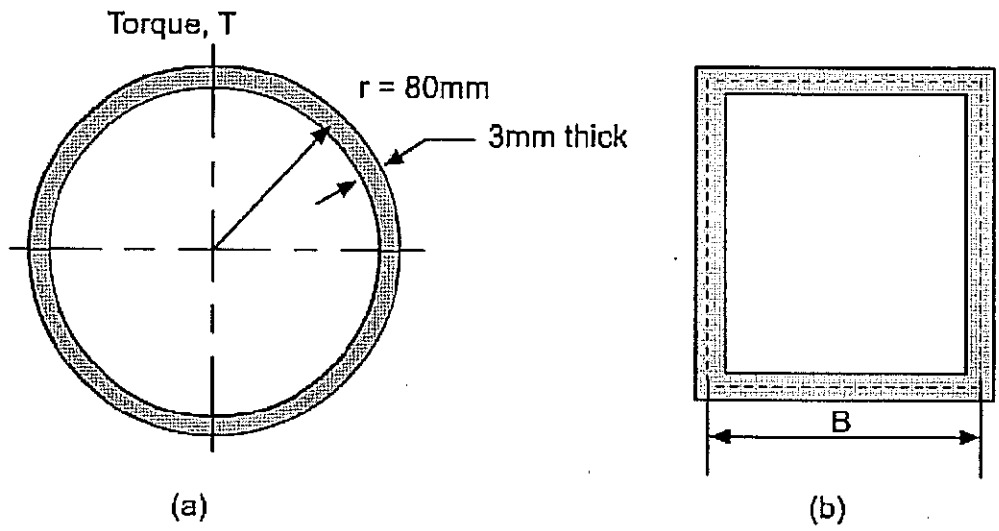


Figure Q5

(b) The circular tube is replaced with a square tube as shown in figure Q5 (b), having the same thickness and the effective area (carrying shear stress) and transmits the same torque. Find,

(i) The dimension (B) of the section. (8 marks)
(ii) Shear stress carried by the section.

(c) Show that circular section has higher torsional stiffness. (8 marks)

You may use the following formulae with usual notation.

$$\tau = \frac{T}{2At} \qquad \frac{\theta}{L} = \frac{TZ}{4A^2tG}$$

Q6. A shaft having two rectangular cells with a uniform thickness all around as shown in figure Q6 is subjected to a torque of 10kNm. (4 marks)

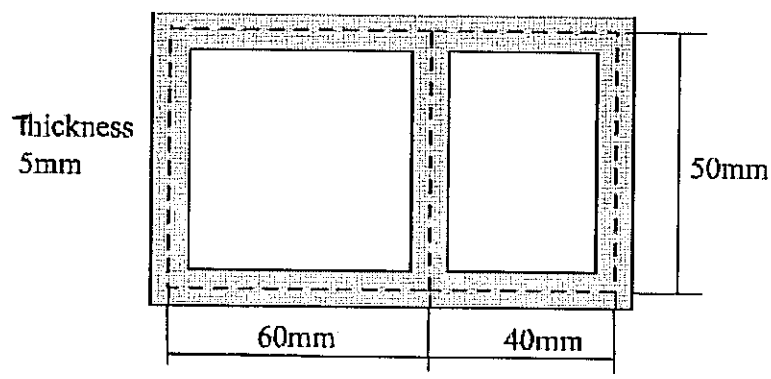


Figure Q6

Determine,

(a) The shear stresses at different portions. (10 mark s)

(b) The angle of twist per unit length if the shaft is made out of structural steel having modulus of rigidity 80GN/m². (6 marks)

You may use the following formulae with usual notation:

$$T = 2\tau tA \qquad \frac{\theta}{L} = \frac{\tau z}{2AG}$$

Q7 (a) Show that bending moment M_{PP} carried by a rectangular beam section having a width B and depth D, when the plastic yielding has taken place to a depth $d/2$, measured from the neutral axis is given by the following equation. (6 marks)

$$M_{PP} = \frac{B(3D^2 - d^2)}{12}\sigma_y$$

(b) A steel beam having a rectangular section, 50mm wide by 20mm deep is simply supported over a length of 1.5m, 20mm side being vertical.

(i) Determine the value of uniformly distributed load that initiate yielding at the outer fibres of the beam. (8 marks)

(ii) If the load is increased by 10%, find the depth of plastic deformation, at the mid span of the beam. (6 marks)

Yield stress of steel is 220MN/m².

Q 8 A turbine has a rotor disc of uniform thickness of 40mm. The radial dimensions of the disc are shown in Figure Q8. On the periphery of the disc, 200 blades have been fixed with uniform spacing. Each blade weighs 150g, and centre of gravity of each blade lies on a circle of radius 320mm.

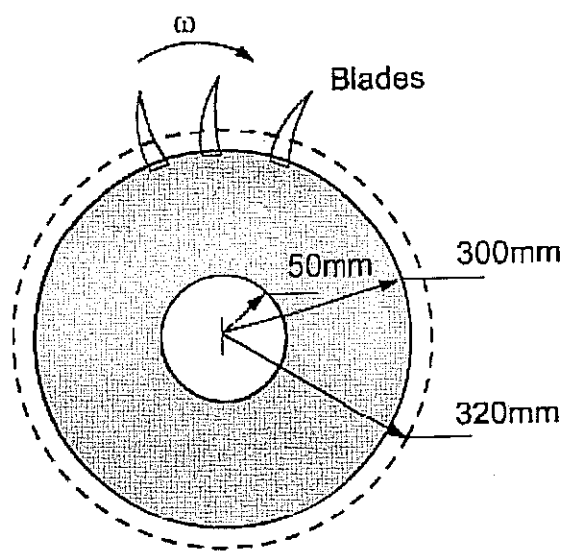


Figure Q8

Calculate,

(i) The radial stress on the outer surface of the disc, when the disc rotates at 6000rpm. (6 marks)