

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

036



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX5302 Strength of Materials II
Academic Year	: 2022/23
Date	: 06 February 2024
Time	: 9.30 am – 12.30 pm
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **five (5)** questions in **three (3)** pages.
3. Answer all questions. All questions carry equal marks.
4. Answers should be in clear handwriting.
6. Do not use Red color pen

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- Q1 (a) Write down the general equations for radial and hoop stresses for thick cylinders identifying all the notations. (2 marks)
- (b) A thick cylinder is to be designed to hold a pressure of 65 MPa. The internal diameter of the cylinder is 120 mm. Find out the outer diameter if the maximum allowable stress in the cylinder material is 130 MPa. (6 marks)
- (c) The cylinder in (b) is subjected to an external pressure of 15 MPa while the cylinder is subjected to the internal pressure of 65 MPa.
- (i) Sketch the variations of stresses due to internal pressure and external pressure against $1/r^2$ on the same coordinate system. Where 'r' is the radius of the cylinder. (6 marks)
- (ii) Find the hoop stresses at the inner and outer surfaces with the aid of the sketch of variation of stresses in (i). (6 marks)
- Q2 (a) A compound cylinder has been made of the same material, with the inner and outer radii of 0.06 m and 0.1 m respectively. The interface radius is 0.08m. The cylinder is to be subjected to an internal pressure of 80 MPa such that the hoop stress at the outer most surface in the compound cylinder does not exceed 200 MPa.

- (i) Sketch the variations of stresses against $1/r^2$ without and with the applied internal pressure on the same coordinate system. (8 marks)

(Consider the compound cylinder as a single cylinder when sketching stress variation with the applied internal pressure.)

- (ii) Find the initial interface pressure with the aid of the sketch of stress variations in (i) (6 marks)

- (b) Find the internal pressure that will make the hoop stress at the **outer surface** of the **inner cylinder** zero. (6 marks)

- Q3 (a) The stresses for rotating hollow discs with usual notation are given by the following equations.

$$\sigma_r = A - \frac{B}{r^2} - (3 + \nu) \frac{\rho r^2 \omega^2}{8} \quad \sigma_H = A + \frac{B}{r^2} - (1 + 3\nu) \frac{\rho r^2 \omega^2}{8}$$

Show that for a rotating solid disc of radius R, the hoop stress and the radial stress at the center are both equal and given by the following formula. (8 marks)

$$\sigma_H = \sigma_r = (3 + \nu) \frac{\rho \omega^2 R^2}{8}$$

- (b) A steel ring has been fitted to a short solid shaft of diameter 120 mm, which is made of steel. The outer diameter of the ring is 180 mm. When the shaft runs at the speed of 200 rad/s, the radial pressure at the interface is 40 MN/m². Find the hoop stress at outer surface of the shaft considering the shaft as a solid disc. (12 marks)

For steel use the following: Density = 7,000 kg/m³, Poisson's ratio = 0.3

- Q4 (a) Explain what is meant by unsymmetrical bending of beams. (5 marks)
- (b) A cantilever beam having a T - Section with dimensions as shown in Figure Q4 is subjected to a point load of 2 kN acting at an angle of 45° to the vertical at the free end. The length of the cantilever is 1 m.

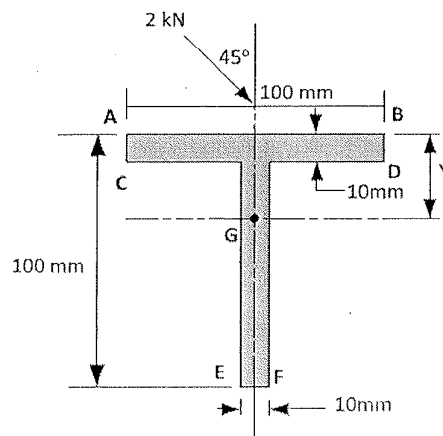


Figure Q4

Find the following

- (i) Distance ($\bar{Y}$) to the center of mass (G) from the top of the "T" section. (5 marks)
- (ii) Second Moment of Area about X and Y axes going through the center of mass (G). (5 marks)
- (iii) Maximum bending stress induced in the cantilever and the location. (5 marks)

- Q5
- (a) Explain the occurrence of deformation beyond elastic limit in beams and its significance in component design. (2 marks)
 - (b) What is meant by "Shape Factor" related to plastic deformation? (3 marks)
 - (c) A Simply supported beam having a rectangular section carries a central load W as shown in Figure Q5. The section having maximum bending moment is has reached yield point at the outer surface.

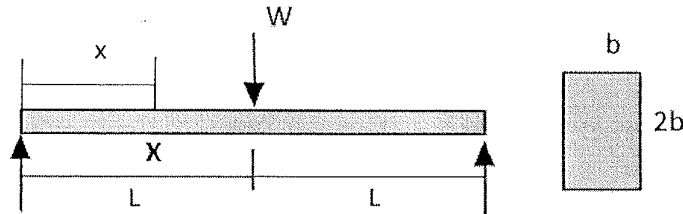


Figure Q5

- (i) Derive an expression for the load W in terms of yield stress (σ_y), b and L (5 marks)
- (ii) If at the section X the plastic yielding has penetrated to a depth of y measured from the neutral axis, derive an expression for the total bending moment carried by the section. (8 marks)
- (iii) Hence obtain plastic penetration depth (y) as a function of x . (2marks)