

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	: 2023/24
Date	: 03 March 2025
Time	: 1.30 pm – 4.30 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

- Q1 (a) Derive the equations for hoop stress and longitudinal stress experienced in thin-walled cylinders subjected to internal pressure. (6 marks)
- (b) A pressure vessel is designed to withstand a pressure of 1.5 MPa. The vessel material has a tensile strength of 200 MPa, and the vessel's diameter is 50 cm. Determine the minimum thickness required for the vessel if the safety factor is set at 2. (8 marks)
- (c) Calculate the longitudinal strain experienced by the cylinder, using the following data. The modulus of Elasticity is 200 GPa and Poisson's ratio is 0.3. (6 marks)
- Q2 (a) (i) Write down the **Lame equations** for stresses in thick-walled cylinders. (4 marks)
- (ii) Explain how stresses vary across the wall thickness of a thick-walled cylindrical vessel under internal pressure.
- (b) A thick-walled cylinder with an inner radius of 40 mm is subjected to an internal pressure of 8 MPa. Determine the outer radius of the cylinder so that the maximum stress anywhere in the cylinder does not exceed 22 MPa. (6 marks)
- (c) The cylinder mentioned in part (b) is further subjected to an external pressure such that the maximum stress is reduced to 11 MPa. Sketch the variation of stresses against $1/r^2$ for both cases: (1) internal pressure and (2) external pressure. (6marks)
- (b) Determine the value of the applied external pressure mentioned in part (c) using the sketch of stress variations. (4marks)

Q3 (a) Explain the benefits of compound cylinders used for various applications. (6 marks)

(b) A compound cylinder made of the same material has inner and outer radii of 0.06 m and 0.1 m, respectively. The interface radius is 0.08 m. The pressure at the interface is 20 MPa.

(i) Sketch the variations of stresses against $1/r^2$ (8 marks)

(ii) Determine the maximum stress within the compound cylinder and identify its location.

(b) Determine the internal pressure required to make the hoop stress at the outer surface of the inner cylinder equal to zero. (6 marks)

Q4 (a) Explain what is meant by the unsymmetrical bending of beams. (5 marks)

(b) A cantilever beam with the specified cross-section in Figure Q4 is subjected to a point load, W , of 2 kN. This load acts at an angle of 30 degrees to the vertical at the free end of the beam. The length of the cantilever is 1 meter.

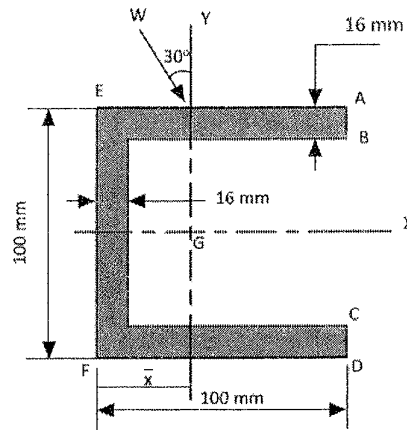


Figure Q4

Find the following:

(i) The distance ($\bar{x}$) to the center of mass (G) from the side EF. (5 marks)

(ii) The second moment of area about the X-axis. (5 marks)

(iii) The maximum bending stress experienced in the cantilever and its specific location. (5 marks)

Take the second-moment area about the Y axis as $7.0346 \times 10^{-6} \text{ m}^4$.

Q5 (a) Define the following concerning deformation beyond the elastic limit in the bending of beams. (4 marks)

- i. Elastic moment,
- ii. Partially plastic moment,
- iii. Fully plastic moment, and
- iv. Shape factor

- (b) A beam with a rectangular cross-section measuring 120 mm by 60 mm and a length of 3 meters is designed to support a point load at its mid-span. The beam has simple supports at both ends, with the 120 mm side oriented vertically. (8 marks)

Determine the point load that would initiate plastic yielding and the load that would create a plastic hinge. The tensile yield stress of the material is 200 MPa.

- (c) (i) Write the equation for shear stress induced in thin-walled tubes and describe its variables. (2 marks)

- (ii) A tube of 2 mm wall thickness and 150 mm mean diameter is subjected to a torque of 150 Nm. Calculate the shear stress induced in a cross-section and the angle of twist per unit length. The Modulus of rigidity of the material is 70 GPa. (3 marks)

The following expression with the usual notation denotes the angle of twist.

$$\theta = \frac{TL}{4GA^2} \frac{z}{t}$$

- (iii) If a square section is used instead of the circular tube mentioned in (ii), maintaining the same wall thickness, shear stress, and applied torque, what should the dimensions of the square section be? (3 marks)