

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



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: CVX3442 Strength of Materials
Academic Year	: 2024/2025
Date	: Thursday, March 13, 2026
Time	: 09:30-12:30 h
Duration	: 03 hours

Read all the instructions given below carefully before answering the questions.

- Necessary additional information is provided or announced by the examination supervisors.
- Assume reasonable values for any data not given in the examination paper. Clearly state such assumptions made in the answer script.
- In a case where there is more than one interpretation or ambiguity due to the wording of a question, make your own decision but clearly state it in the answer script.
- This is a **Closed Book Test (CBT)**.
- This question paper consists of **EIGHT (08)** questions in **FIVE (05) PAGES**
- Answer any **FIVE (05)** questions.
- Answers should be in clear handwriting.
- Do not use a red colour pen.

Question 1 [Total: 20 marks]**Q1.1**

Sketch the characteristic stress–strain diagram for a mild steel specimen. Clearly label and identify the following regions and points on the curve: elastic region, strain hardening region, necking region, the point representing the yield strength, the point representing the ultimate strength. (10 marks)

Q1.2

In the stress–strain diagram of mild steel, the yield point is distinctly observable. However, many engineering materials do not show a well-defined yield point. For such materials, yield strength is determined using the ‘offset method’. Explain the offset method used to determine the yield strength of materials without a clear yield point, supported by a suitable sketch. (5 marks)

Q1.3

A hollow steel column of circular cross section carries a compressive axial load of 4000 kN. Determine the shortening of the column if its initial height is 6 m. Take $E_{\text{steel}} = 200,000 \text{ N/mm}^2$. The external and internal diameters of the column are 400 and 300 mm respectively. (5 marks)

Question 2 [Total: 20 marks]

Figure 1 illustrates a beam with a cantilever overhang part subjected to a uniformly distributed load of 2 kN/m over the specified length.

Q2.1

Determine the reaction forces at the supports located at A and B. (04 marks)

Q2.2

State clearly the sign convention adopted for evaluating shear forces and bending moments along the length of the beam. (04 marks)

Q2.3

Develop the mathematical expressions for shear force and bending moment along the beam for the segments AB and BC. Clearly specify the reference point chosen as the origin for the x-coordinate. (06 marks)

Q2.4

Using the expressions obtained in **Q2.3**, construct the Shear Force Diagram (SFD) and Bending Moment Diagram (BMD). Indicate all critical points, such as the point of contraflexure, points of maximum / minimum bending moment, and points of zero shear force. (06 marks)

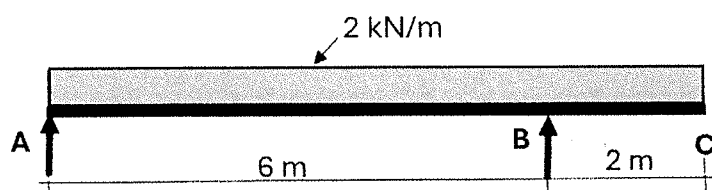


Fig. 1 – A simple Beam with a Cantilever End

Question 3 [Total: 20 marks]

Q3.1

Briefly describe Macaulay's method for evaluating the slope and deflection of beams.

(04 marks)

Q3.2

The **Figure 2** shows a simple beam with a uniformly distributed load and a point load. The uniformly distributed load is 10 kN/m and it is acting over its entire length; the point load is 5 kN and it is acting at 2 m from the **support A**. Determine the maximum deflection in the beam and the location of the maximum deflection. Take $E = 200 \times 10^6 \text{ kN/m}^2$; $I = 80 \times 10^{-4} \text{ m}^4$

(16 marks)

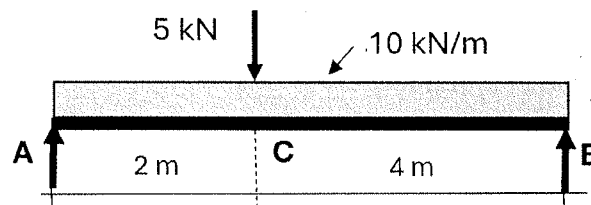


Fig. 2 – A simple Beam with a Uniformly Distributed Load and a Point Load

Question 4 [Total: 20 marks]

A material element is subjected to a two-dimensional state of stress as shown in **Figure 3.1**. Using **Mohr's circle for stress** determine the following quantities for the given stress condition:

Q4.1 Determine the principal stresses.

(05 marks)

Q4.2 Determine the inclination of the principal planes with respect to the plane BC (X-face).

(05 marks)

Q4.3 Calculate the maximum shear stress developed in the element.

(05 marks)

Q4.4 Find the normal and shear stresses acting on a plane inclined at 30° to the X-axis. See **Figure 3.2**.

(05 marks)

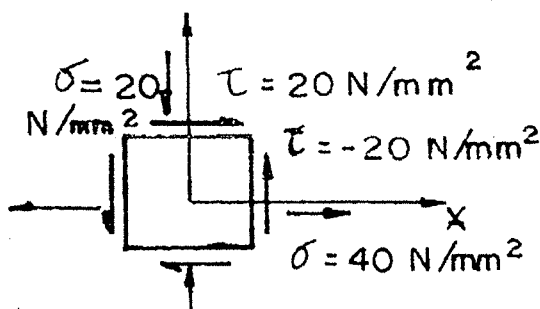


Fig. 3.1

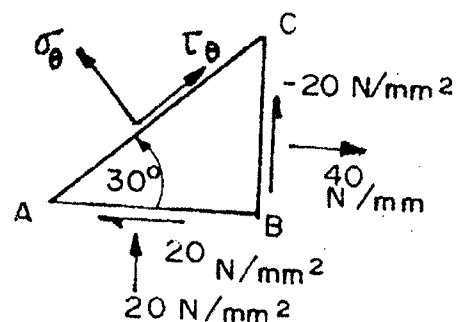


Fig. 3.2

Fig. 3 An element subjected to a two-dimensional state of stress

Question 5 [Total: 20 marks]**Q5.1**

Define the terms *radius of gyration* and *slenderness ratio* as used in column analysis.

(05 marks)

Q5.2

Buckling load, P_e , of a column is given by $P_e = \pi^2 EI/L_e^2$.

Where, 'E' is the modulus of elasticity, 'I' is the second moment of inertia and L_e is the 'Equivalent Length' of a column.

A column of 3.0 m with both ends pinned has a buckling load (P_e) of 3.0 kN. Three other columns made of the same material and having identical cross-sectional dimensions and length are provided with the following end conditions. For each case, determine the equivalent length (L_e) and the corresponding buckling load (P_e).

Q5.2.1 One end fixed and the other end free.

(05 marks)

Q5.2.2 Both ends fixed.

(05 marks)

Q5.2.3 One end fixed and the other end pinned.

(05 marks)

Question 6 [Total: 20 marks]

Q6.1 List the assumptions made in deriving the flexure (bending) formula for beams.

(07 marks)

Q6.2 Describe the term *flexural rigidity*.

(03 marks)

Q6.3

A simply supported beam of span 4.0 m is subjected to a uniformly distributed load of intensity 'w' kN/m. An I-section of dimensions 310 mm × 165 mm, as shown in **Figure 4**, is used for the beam. If the permissible stress is 110 N/mm², determine the maximum value of the uniformly distributed load that the beam can safely carry.

The second moment of area of section, I, is $85.1 \times 10^6 \text{ mm}^4$.

(10 marks)

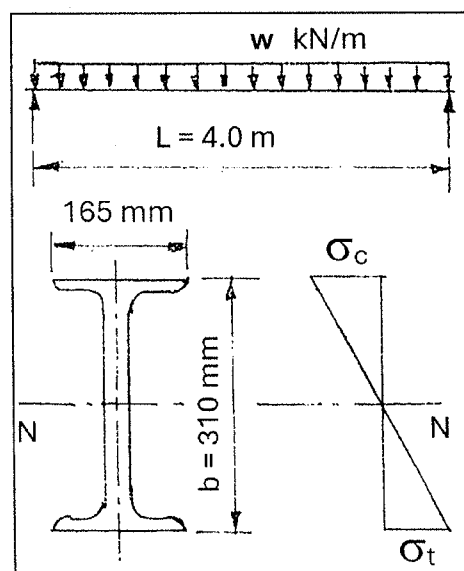


Fig. 4 An I section of 310 x 165 mm

Question 7 [Total: 20 marks]

Q7.1 Explain the concept of *torsional rigidity* of a shaft.

(05 marks)

Q7.2

A solid circular shaft transmits a torque of 1500 Nm. The maximum allowable shear stress in the shaft is $40 \times 10^6 \text{ N/m}^2$ and allowable twist is 2° per meter length. Determine the required diameter of the shaft. Assume the modulus of rigidity $G = 83 \times 10^9 \text{ N.m}^2$.

(15 marks)

Question 8 [Total: 20 marks]

Q8.1

State the mathematical relationships that exist between the uniformly distributed load intensity (w), the shear force (V), and the bending moment (M) at any cross-section of a beam located at a distance (x) from one end (Refer **Figure 5**).

(05 marks)

Q8.2

Write down the relationships linking the bending moment (M), the slope (θ), and the deflection (y) of a beam at a section situated at a distance (x) from one end.

(05 marks)

Q8.3

A simply supported beam of span (L), as shown in **Figure 5**, is subjected to a uniformly distributed load of intensity (w) over the entire length. Using the **double integration method**, determine the deflection at the mid-span of the beam.

(10 marks)

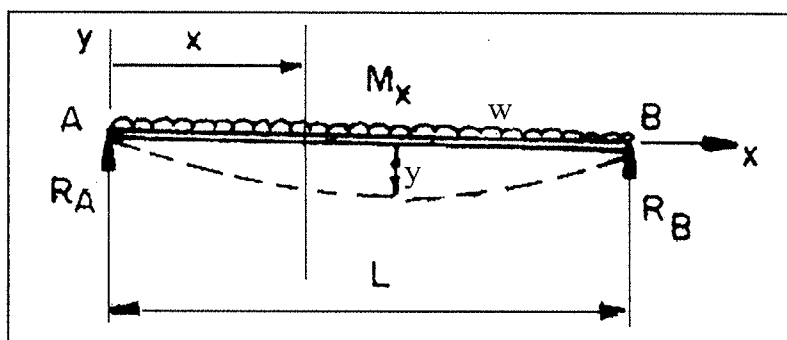


Fig. 5 A simply supported beam of length L