Indian Institute of Technology Bhubaneswar

School of Infrastructure

Session: Autumn 2025

Solid Mechanics (CE2L001) Assignment No. 4

Date: November 10, 2025 Total Marks: 100

Instructions:

(1) If two or more answer scripts appear identical, each of them will be awarded ZERO.

(2) Provide neatly drawn figures to explain the concepts behind the problems.

(3) Submit your answer script by November 25, 2025.

1. Derive the formula for all the six stress resultants (axial force, shear forces, bending moments and torsional moment) in terms of the stress components for a one-dimensional (1D) modeling of a beam and a two-dimensional (2D) modeling of a plate. Provide neatly drawn figures mentioning all the steps in your derivation. [10]

2. A reinforced concrete pier is used to support the stringers for a bridge deck. Draw the shear and moment diagrams for the pier when it is subjected to the stringer loads shown. Assume the columns at A and B exert only vertical reactions on the pier. [10]

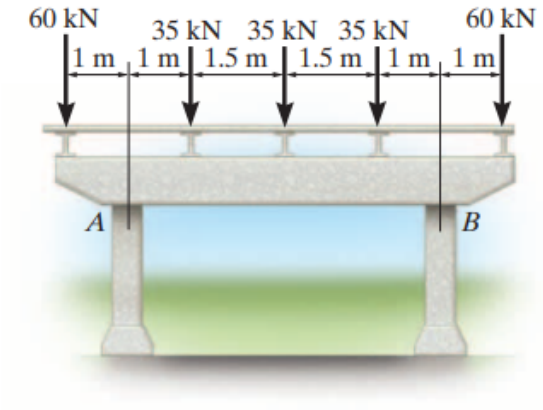


Figure 1

3. Consider the loading condition given in Fig. 2. The load $P = (100\,\boldsymbol{e}_1 + 100\,\boldsymbol{e}_2)$ N.

   (a) Determine the state of stress at points A and B

   (b) Represent the state of stress at points A and B in three-dimensional differential stress elements.

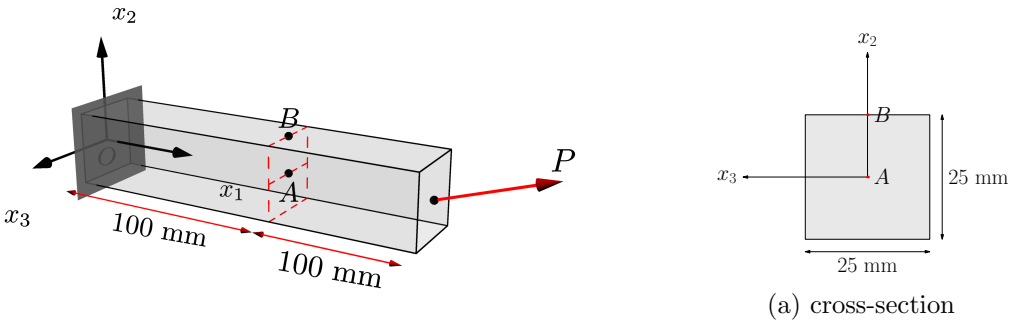
   Using the Mohr's circle, determine:

   (c) The principal stresses and principal angles for the states of stress at A and B.
   Note: identify first which is the plane corresponding to the state of plane stress (namely, $x_1 - x_2$-plane, $x_1 - x_3$-plane or $x_2 - x_3$-plane) for each point and loading condition.

   (d) The maximum in-plane shear stresses at points A and B.

   (e) The absolute maximum shear stress at points A and B.

[15]



(a) cross-section

Figure 2

4. Consider the elastic structure shown in the Fig. 3, where a force equal to $(500\,\boldsymbol{e}_1 - 750\,\boldsymbol{e}_2)\,N$ is applied at the end of the segment CH parallel to the z-axis.

   (a) Determine the internal resultants at cross-section B (i.e., axial force, two shear forces, torque, and two bending moments).

   (b) Show the stress distribution due to each internal resultant on the appropriate view of the cross B (i.e., side view, front view or top view) (see Fig. 4).

   (c) Determine the state of stress on points a and b on cross-section B.

   (d) Represent the state of stress at points a and b in three-dimensional differential stress elements.

   (e) Determine the principal stresses and the absolute maximum shear stress at point b.

[10]

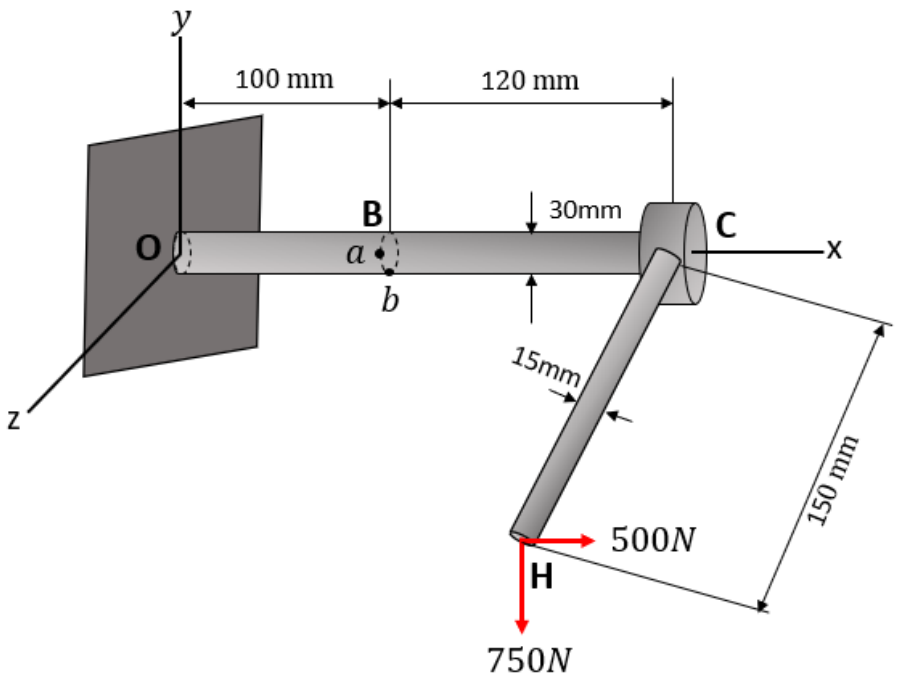


Figure 3

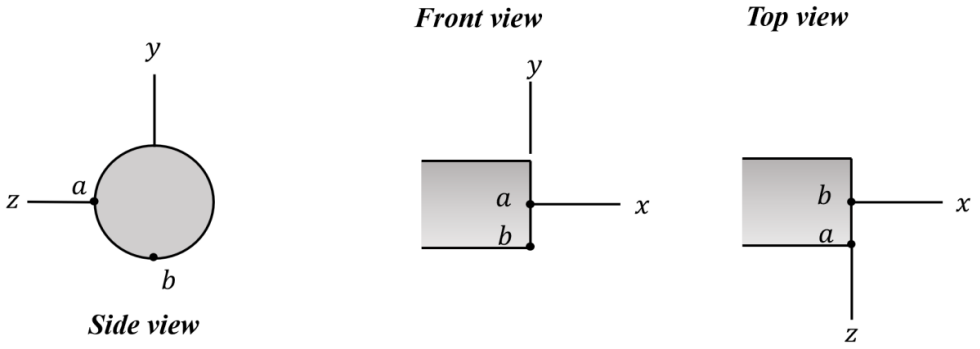


Figure 4

5. A wood beam is supported and loaded as shown in Fig. 5. The weight w of the beam is to be considered, using $\gamma = 50$ lb/ft^3 for the specific weight of the wood. The maximum shear stress in any cross-section (along the y-direction) must not exceed $\tau_{\text{allow}} = 160$ psi.

   (a) Calculate the maximum allowable value of the loading P for the solid rectangular cross-section (A), with dimensions $b = 2.5$ in and $h = 6$ in.

   (b) Calculate the maximum allowable value of the loading P for the solid circular cross-section (B), with diameter $d = 6$ in.

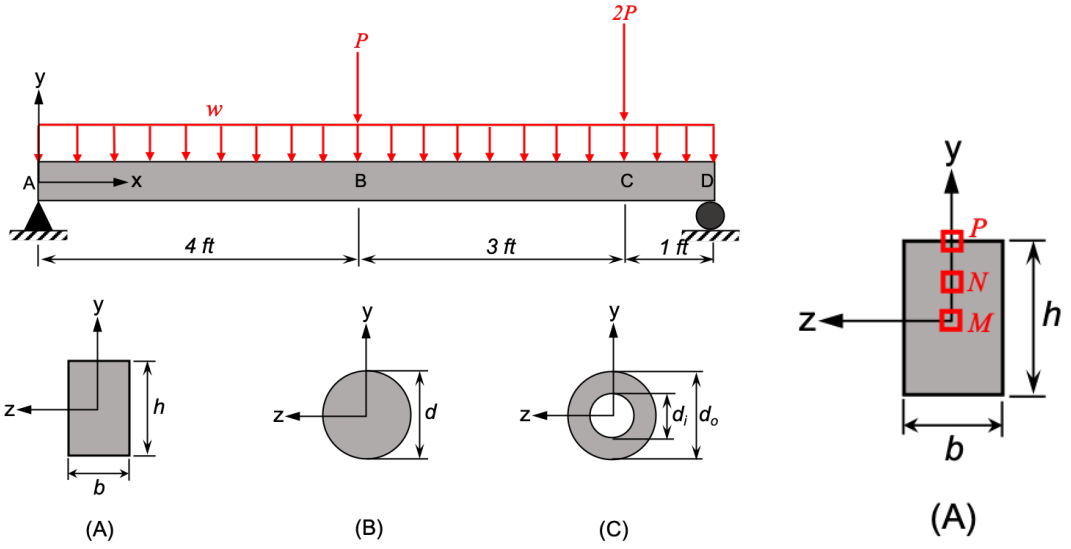
(c) Calculate the maximum allowable value of the loading P for the hollow circular cross-section (C), with outer diameter diameter $d_o = 6$ in and inner diameter $d_i = 3$ in.

(d) Show the state of stress at three places (M, N, P) on the cross-section (A) as shown in Fig. 5(b) . The co-ordinates for these points are:

Points	Coordinates (x, y, z)
M	(6ft, 0in, 0in)
N	(6ft, 1.5in, 0in)
P	(6ft, 3in, 0in)

Table 1

[15]



(a) (b)

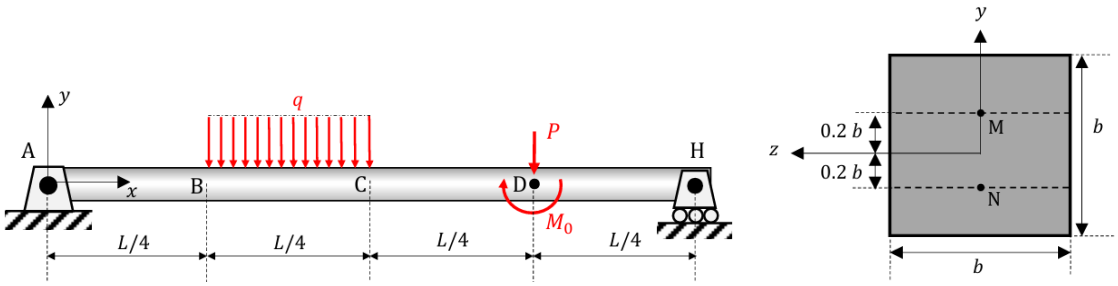
Figure 5

6. A simply supported beam AH is subjected to a constant distributed load q over the section BC, a moment M_0 and a concentrated force P at D. The cross section of the beam is shown below (See Fig. 6). The parameters are following: L=8 ft., q=10 lb/ft, $M_0 = 40$ lb-ft, P=10 lb, b= 2 in.

(a) Draw the shear force and bending moment diagrams. Mark the values at the cross sections A, B, C, D, and H, and the maximum and minimum values along the beam.

(b) Determine the stress state at the points M and N which are located at the cross section C. Sketch their stress state on the given stress elements.

[10]



(a) (b) cross-section

Figure 6

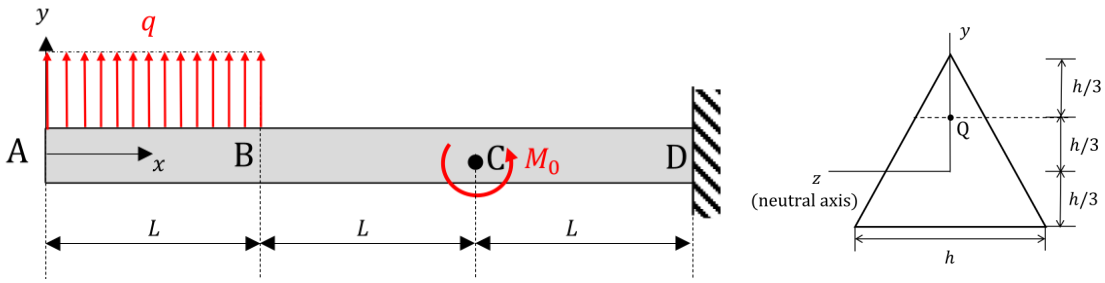
7. A cantilever beam ABCD of the length $3L$ is fixed to the end at D. The beam is subject to a constant distributed load q (N/m) over the section AB, and a moment M_0 of the magnitude $4qL^2$ (N-m) at C. The cross-section of the beam has a triangular shape, as shown below. The second area moment for a triangle is $I_z = \frac{1}{36}h^4$.

   (a) Draw the shear force and bending moment diagrams. Mark the values in sections A, B, C, and D.

   (b) Determine the maximum compressive flexural stress (largest magnitude) and the maximum tensile flexural stress along the beam.

   (c) Determine the stress state at point Q which is located on the cross-section B. Sketch the stress state on the given stress element.

[10]



(a) (b) cross-section

Figure 7

8. Consider the following loading condition of a simply supported beam as shown in Fig. 8. Draw the elastic curve for the given problem and determine the maximum deflection and slope. [10]

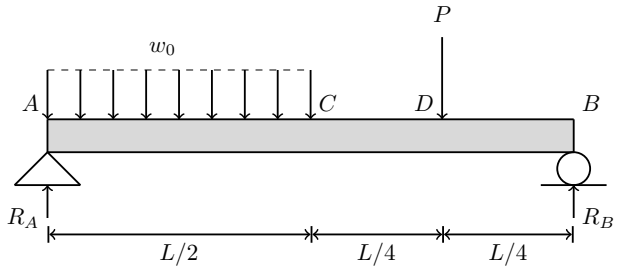


Figure 8

9. Consider the following loading condition on a simply supported beam as shown in Fig. 9. Draw the elastic curve for the given problem and determine the maximum deflection and slope. [10]

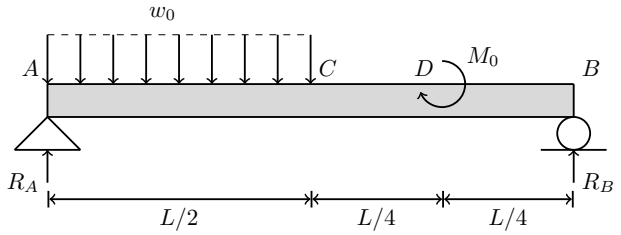


Figure 9