Problems of Practices
Of
Mechanics of Solids
8- Deflection in Beams

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1. A simply supported beam carries a uniformly varying load with zero intensity at left support and an intensity of w at the right support.
Calculate the maximum deflection and maximum slope and mention the positions on the beam where these occurs.

2. Use either Macauley's method or the Area-Moment method to show that the deflection of a simply supported beam at point B with an off-centre load at point A, as shown in Fig. 5, is given by

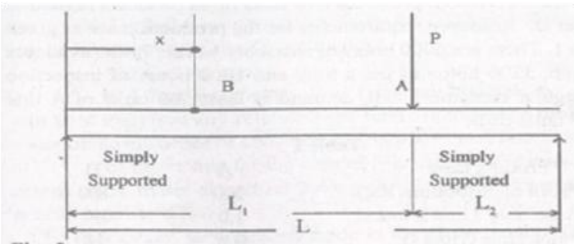


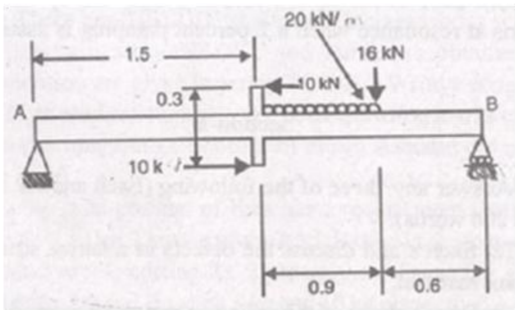
Fig. 5.

3. Compare the elastic deflections at the points of loading produced in a simply supported beam of length l, carrying a concentrated load P at its midpoint to that of a cantilever of length l, carrying a load P at its free end. The moment of inertia of the section for the simply supported beam is J in the left half and 0.5 J in right half. For the cantilever, the moment of inertia of the section is $2J$ upto a distance of $l/2$ from the fixed end and J for the remaining portion. Assume that both the beams are made of same material.

4. A cantilever beam of length l and uniform flexural rigidity EI is subjected to continuously distributed externally supplied moment of intensity m kg-cm per cm of length of the beam. Using the area-moment method, show that the deflection of the free end of the beam is $\delta = ml^3/3EI$, and explain why this is the same deflection as that obtained for the case of a concentrated force $p = m$ applied at the end of the beam.

5. A uniform beam of span L, and flexural rigidity EI is simply supported at its ends. It is carrying a load W at a distance b from the left hand support and subjected to an axial force P (compressive). Derive the expression for the deflection of the beam. What would be the deflection under the lateral load, when $b = L/2$? What is the critical value of P for which the deflection becomes very large?

6. A simply-supported beam is subject to the loading as shown in the figure. Calculate the deflection at a section 2.0 m from the end A. Assume $E = 70$ GN/m² and $I =$ 830 cm⁴.



7. A uniform cantilever beam (EI constant) of length L is carrying a concentrated load P at its free end. What would be its slope at the (i) free end (ii) built-in end.

8. A tube 40 mm outside diameter 5 mm thick and 1.5 m long is simply supported at 125 mm from each end and carries a concentrated load of 1 kN at each extreme end.

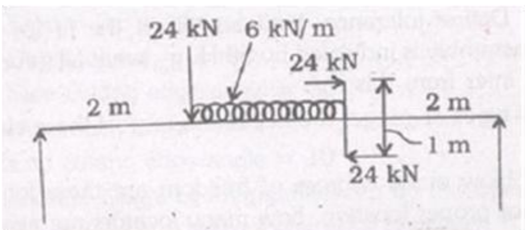
(i) Neglecting the weight of the tube, sketch the shearing force and bending moment diagrams, and

(ii) Calculate the radius of curvature and the deflection of mid-span, take the modulus of elasticity of the material as 208 GN/m².

(iii) Give in example where maximum deflection and maximum stress do not occur at the same point.

(iv) Give an example where they occur at the same point.

9. A beam of flexural rigidity 20 MN/m² is simply supported over a span of 6 m as shown in the figure. It carries a concentrated load of 24 kN, 2m from the left-hand support, and a UDL of 6 kN/m on the central 2 m part. The beam has vertical member welded onto it 2 m from the right-hand support which carry two horizontal loads of 24 kN as shown in the figure. The Distance between these loads is 1 m.



(i) Draw the Bending Moment Diagram for this beam.

(ii) Calculate the vertical deflection of the central point of the beam.

10. A beam of rectangular cross-section 50 mm wide and 100 mm deep is simply supported over a span of 1500 mm. It carries a concentrated load of 50 kN, 500 mm from the left support. Calculate –

(i) the maximum tensile stress in the beam and indicate where it occurs;

(ii) the vertical deflection of the beam at a point 500 mm from the right support.

E for the material of the beam = 2×10^5 MPa.

11. A simply supported beam of length L carries a concentrated load W at a distance 'a' from one and 'b' from the other ($a > b$). Find the position and magnitude of the maximum deflection and show that the position is always within $L/13$ approximately from the centre of the beam.

12. A cantilever of length 1.2 m carries a udl of 4 kN/m run and a concentrated load of 10 kN at the free end. The cross-section of the cantilever is rectangular and having a Width of 40 mm and a depth of 100 mm.

(i) Draw S.F. and B.M. diagrams for the cantilever and obtain the value of S.F. and B.M. at a section 1 m from the free end.

(ii) Obtain normal stress and shear stress distribution on a section 1 m from the free end, and

(iii) Calculate the maximum deflection of the cantilever and indicate the location where it occurs.

13. A beam $ABCD$, 5 m long, is supported at A and C as shown in Fig. 8. It carries a point load of 2 kN at end D, and a moment of 2 kN-m (cw) at B. What is the flexural rigidity (EI) of the beam, if deflection at D is not to exceed 1 mm?

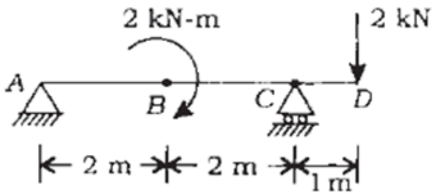


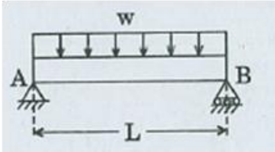
Fig. 8

14. A cantilever beam of length L is subjected to two concentrated loads of $2P$ and P at its mid-length and free end respectively. If deflection at its free end is limited to $L/500$, what should be the value of P? Take flexural rigidity of the beam as EI.

15. A cantilever, 3 m long, and of symmetrical section 250 mm deep carries a uniformly distributed load of 30 kN per m run throughout, together with a point load of 80 kN at a section 12 m from the fixed end. Find the deflection at the free end. Take, E = 200 GPa and I = 54,000 cm^4.

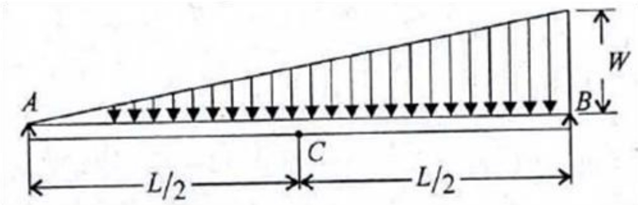
16. A steel beam of rectangular section has a span of 8 m and is simply supported at its ends. It is required to carry a total load of 60 kN uniformly distributed over the whole span. Find the minimum values of breadth and depth if the maximum bending stress is not to exceed 50 MPa, and the maximum deflection is limited to 10 mm. E = 210 GPa.

17. The simply supported beam AB carries a uniformly distributed load 'w' per unit length (figure). Determine the equation of the elastic curve and the maximum deflection of the beam.



18. A simple beam supports a concentrated downward force P at a distance a from the left support. The flexural rigidity EI is constant. Find the equation of the elastic curve by successive integration.

19. A simply supported beam AB of span L carries a distributed load of varying intensity as shown in figure below. Establish the equation for deflection curve for the beam at a distance x from the origin A of the beam. Determine the deflection of the beam at the mid-section C in terms of W, L, E and I, where EI is the flexural rigidity of the beam.



20. A uniform beam ($I = 7{,}800\ cm^4$) is 6 m long and carries a central concentrated load of 60 kN. Taking $E = 210$ GPa, calculate the deflection under the load if the beam is built-in at one end and simply supported at the other end.

21. A beam of uniform section and length ($L + 2a$) is simply supported over a span L with two equal overhanging lengths 'a'. Compute the deflection at mid span due to a uniformly distributed load w/unit length when covering the length L between the supports and when covering only two overhanging lengths. EI is the flexural rigidity of the beam.

22. Determine the deflection at points C and D for the beam loaded as shown in figure 3. The beam is of rectangular cross-section 150 mm × 300 mm (depth) and $E = 200$ GPa.

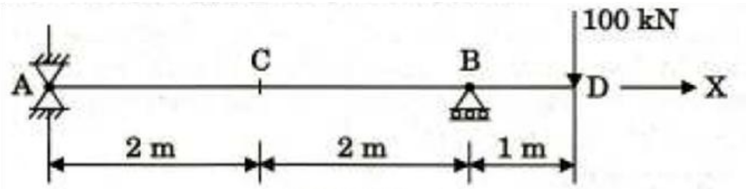


Figure 3

23. A simply supported beam of length L is loaded with load $w = w_0 \sin\frac{\pi x}{L}$, with x measured from the left support.

Determine:

(i) Equation representing the deflection of the beam,

(ii) Slope at the ends,

(iii) Maximum deflection.

24. For the beam as shown in Figure 3(a) given below, if $P = 1$ kN and $L = 1$ m, determine the deflection at overhanging end C. The beam is of rectangular cross-section 120 mm x 240 mm (depth) and coefficient of elasticity, $E = 200$ GPa.

Given: $q \times 2L = 3P$.

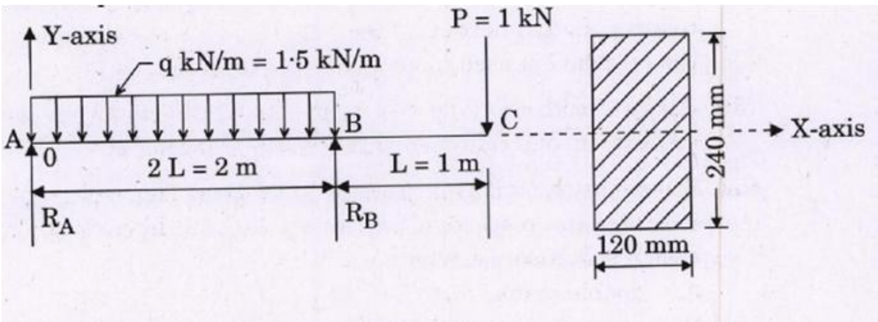
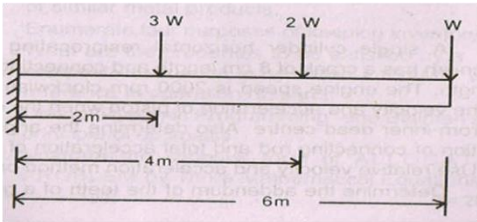


Figure 3(a)

25. A steel cantilever of length 2 m of circular cross-section, 50 mm in diameter, carries uniformly distributed load of intensity w. What is the maximum value of w so that deflection at free end is not to exceed 1 mm? Find out the slope at free end. Take $E = 200$ GPa.

26. A cantilever of length L is loaded by a uniformly increasing load, starting from zero at the free end to a maximum of w_0 at the fixed end. The free end is propped to the level of fixed end. Determine the reaction at the prop and equation to the elastic curve along with the slope at the propped end. EI is assumed constant.

27. Find the slope and deflection at the free end of a cantilever beam of length 6 m as loaded shown in figure below, using method of superposition. Evaluate their numerical values using $E = 200$ GPa, $I = 1 \times 10^{-4}$ m^4 and $W = 1$ kN.



28. A cantilever of length L carries a uniformly distributed load w/unit length over the entire length. The free end is supported from bottom by a rigid prop. Determine the reaction of the prop.

29. A two-span continuous beam is clamped at one end and simply supported at two other points. Determine the reactions caused by the application of a uniformly distributed load W_a; EI for the beam is constant.