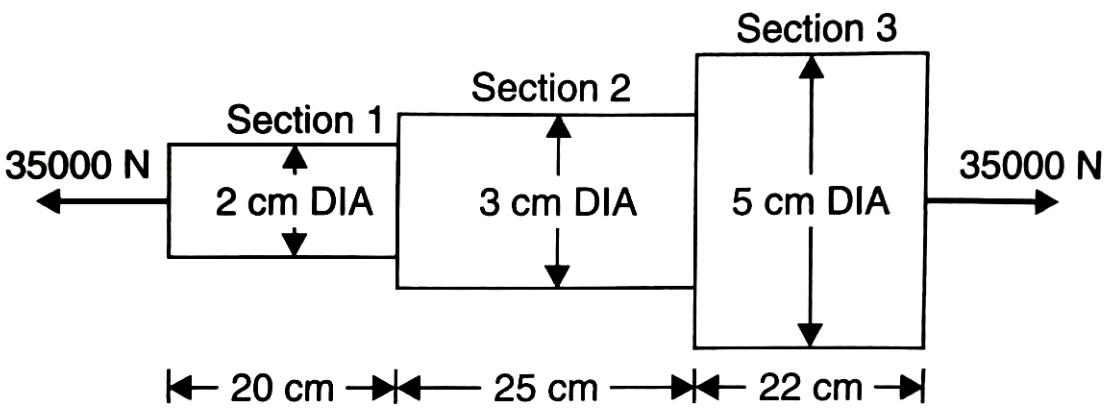
QUESTION BANK

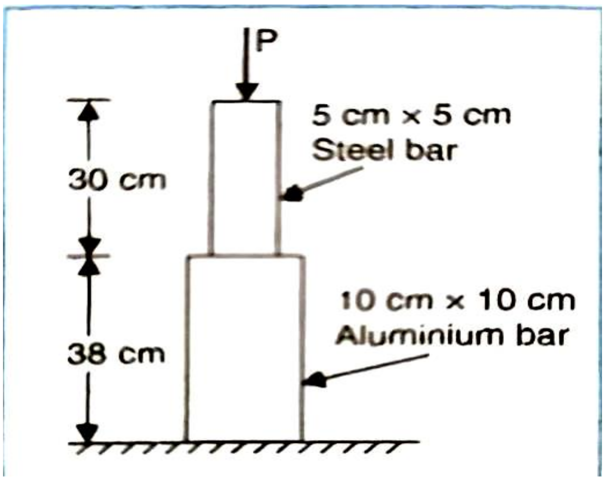
(23A30302) MECHANICS OF SOLIDS

UNIT-1 SIMPLE STRESSES & STRAINS

1. An axial pull of 35000 N is acting on a bar consisting of three lengths as shown in Figure If the Young's modulus = 2.1×10^5 N/mm²,
determine :
(i) stresses in each section and
(ii) total extension of the bar.



2. A member formed by connecting a steel bar to an aluminium bar is shown in Figure Assuming that the bars are prevented from buckling sideways, calculate the magnitude of force P that will cause the total length of the member to decrease 0.25 mm. The values of elastic modulus for steel and aluminium are 2.1×10^5 N/mm² and 7×10^4 N/mm² respectively.

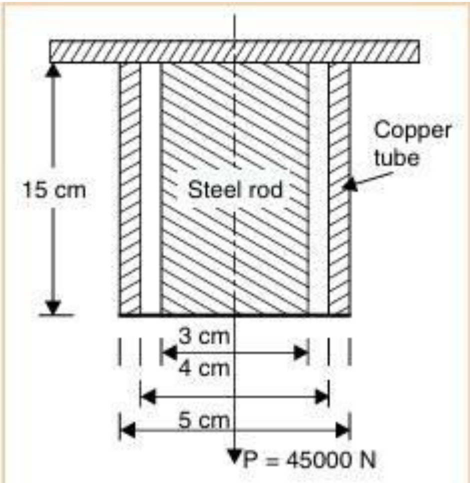


3. A steel rod of 3 cm diameter is enclosed centrally in a hollow copper tube of external diameter 5 cm and internal diameter of 4 cm. The composite bar is then subjected to an axial pull of 45000 N. If the length of each bar is equal to 15 cm, determine :

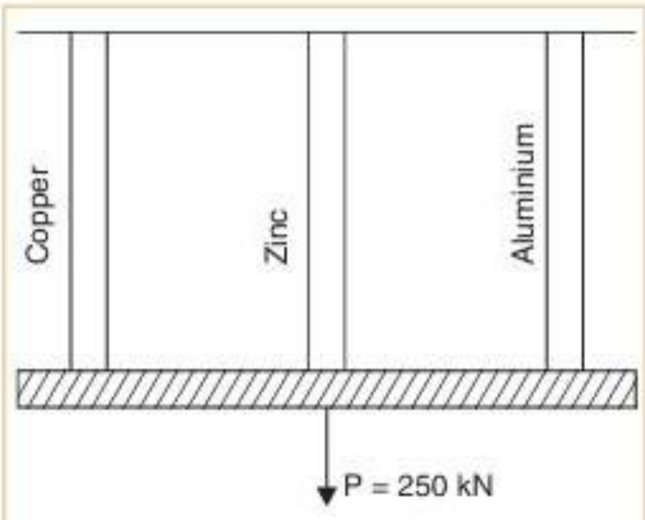
(i) The stresses in the rod and tube, and

(ii) Load carried by each bar. Take E for steel = 2.1 × 10^5 N/mm^2 and for copper = 1.1 × 10^5 $\mathrm{N/mm^2}$

(iii)



4. Three bars made of copper, zinc and aluminium are of equal length and have cross-section 500, 750 and 1000 square mm respectively. They are rigidly connected at their ends. If this compound member is subjected to a longitudinal pull of 250 KN, estimate the proportional of the load carried on each rod and the induced stresses. Take the value of E for copper = 1.3 × 10^5 $\mathrm{N/mm^2}$, for zinc = 1.0 × 10^5 $\mathrm{N/mm^2}$ and for aluminium = 0.8 × 10^5 $\mathrm{N/mm^2}$



5. A rod is 2 m long at a temperature of 10°C. Find the expansion of the rod, when the temperature is raised to 80°C. If this expansion is prevented, find the stress induced in the material of the rod. Take E = 1.0 × 10^5 $\mathrm{MN/mm^2}$ and α = 0.000012 per degree centigrade

6. A steel rod of 3 cm diameter and 5 m long is connected to two grips and the rod is maintained at a temperature of 95°C. Determine the stress and pull exerted when the temperature falls to 30°C, if

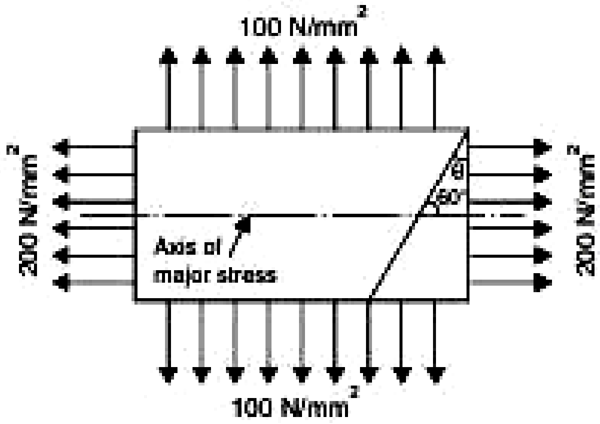
(i) the ends do not yield, and

(ii) the ends yield by 0.12 cm.

7. (a) Determine the value of Young's modulus and Poisson's ratio of a metallic bar of length 30 cm, breadth 4 cm and depth 4 cm when the bar is subjected to an axial compressive load of 400 kN. The decrease in length is given as 0.075 cm and increase in breadth is 0.003 cm.
(b) Determine the Poisson's ratio and bulk modulus of a material, for which Young's modulus is 1.2×10^5 N/mm^2 and modulus of rigidity is 4.8×10^5 N/mm^2

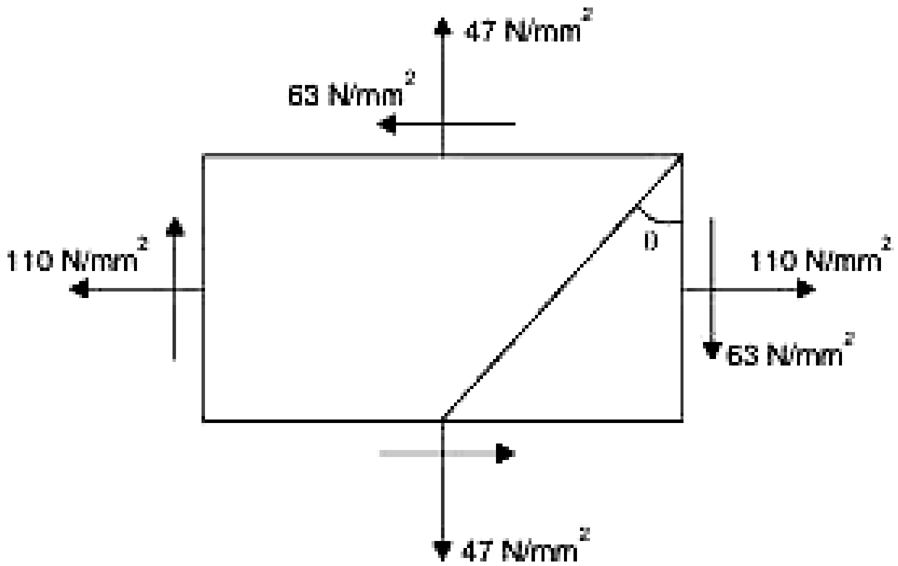
8. (a)A bar is subjected to uniaxial tensile stress of 100 MPa along x-axis.
Find the normal and shear stresses on a plane inclined at 30° to x-axis.
(b) A rectangular element is subjected to stresses: σx = 80 MPa (tensile), σy = 40 MPa (compressive), and τxy = 0. Find normal and shear stress on a plane inclined at 45°.

9.The stresses at a point in a bar are 200 N/mm^2 (tensile) and 100 N/mm^2 (compressive). Determine the resultant stress in magnitude and direction on a plane inclined at 60° to the axis of the major stress. Also determine the maximum intensity of shear stress in the material at the point.

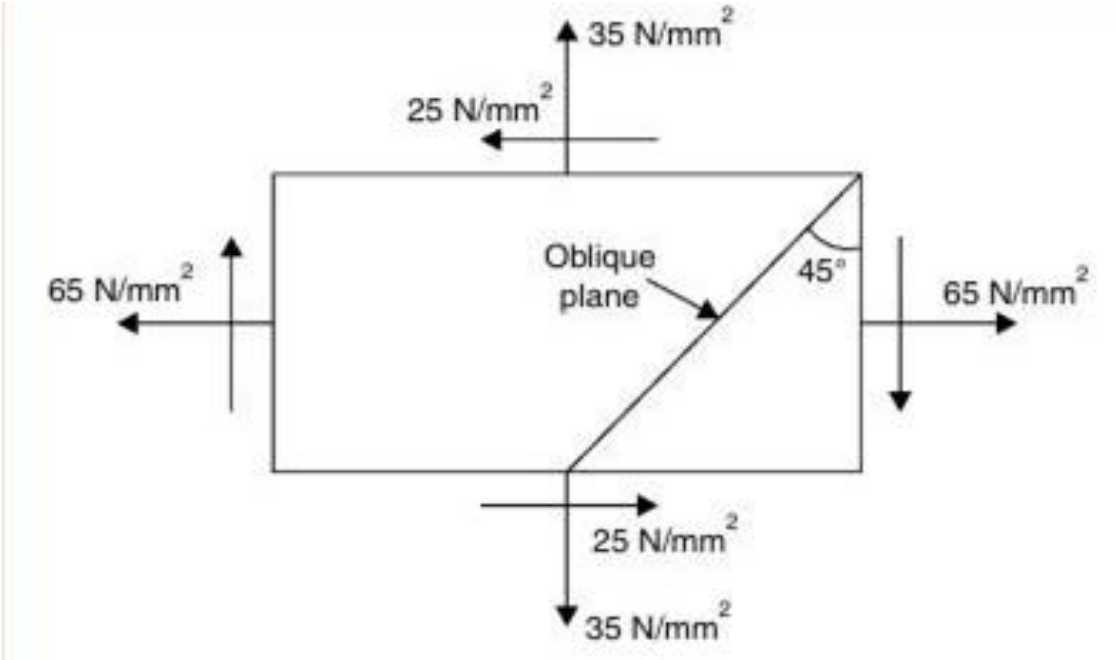


10. A rectangular block of material is subjected to a tensile stress of 110 N/mm^2 on one plane and a tensile stress of 47 N/mm^2 on the plane at right angles to the former. Each of the above stresses is accompanied by a shear stress of 63 N/mm^2 and that associated with the former tensile stress tends to rotate the block anticlockwise.

1. Find : (i)the direction and magnitude of each of the principal stress



11 . A point in a strained material is subjected to stresses shown in Fig. 3.24. Using Mohr's circle method, determine the normal and tangential stresses across the oblique plane. Check the answer analytically.



12. A tensile load of 60 kN is gradually applied to a circular bar of 4 cm diameter and 5 m long. If the value of E = 2.0 × 10^5 N/mm^2
determine :

I. stretch in the rod,
II. stress in the rod,
III. strain energy absorbed by the rod

13 . The tensile load of 60 kN is applied suddenly determine:
(i) maximum instantaneous stress induced,
(ii) instantaneous elongation in the rod, and
(iii) strain energy absorbed in the rod.

14. A load of 100 N falls through a height of 2 cm onto a collar rigidly attached to the lower end of a vertical bar 1.5 m long and of 1.5 cm2 cross-sectional area. The upper end of the vertical bar is fixed. Determine :
(i) maximum instantaneous stress induced in the vertical bar, (ii) maximum instantaneous elongation, and
(iii) strain energy stored in the vertical rod.

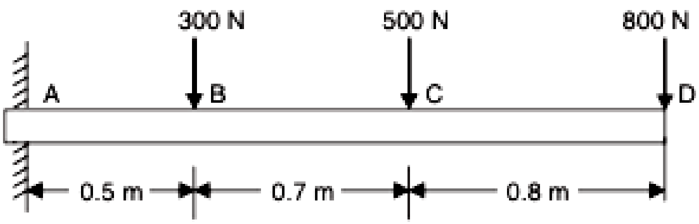
QUESTION BANK

(23A30302) MECHANICS OF SOLIDS

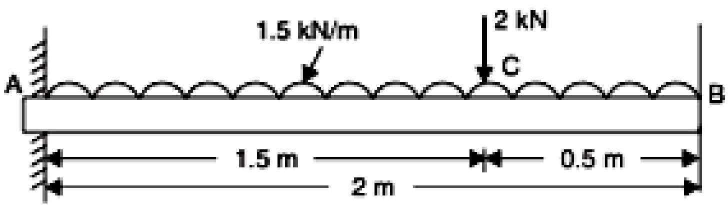
UNIT-2 Shear Force and Bending Moment

1. Explain about types of beams & loads & Concept of Shear Force & bending Moment ?

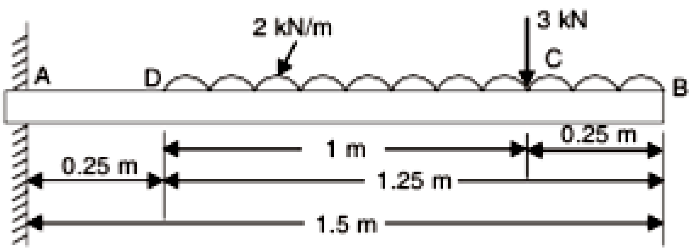
2. A cantilever beam of length 2 m carries the point loads as shown in Fig. 6.15. Draw the shear force and B.M. diagrams for the cantilever beam.



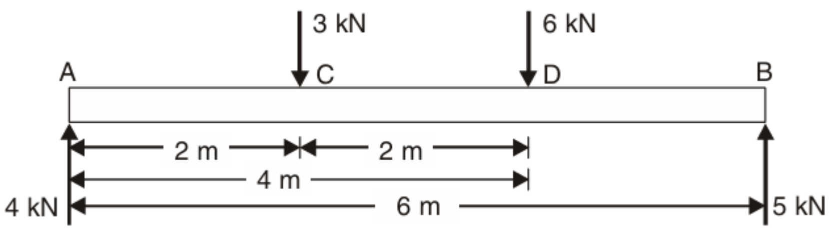
3. A cantilever of length 2 m carries a uniformly distributed load of 1.5 kn/m run over the whole length and a point load of 2 kn at a distance of 0.5 m from the free end. Draw the S.F. and B.M. diagrams for the cantilever.



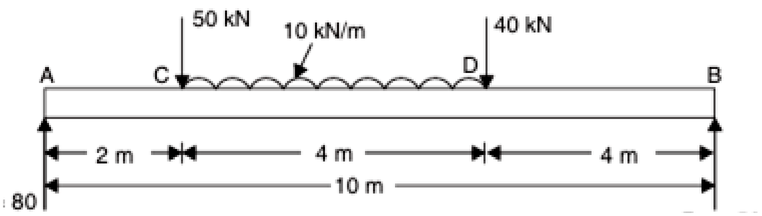
4. A cantilever 1.5 m long is loaded with a uniformly distributed load of 2kN/m run over a length of 1.25 m from the free end. It also carries a point load of 3kN at a distance of 0.25 m from the free end. Draw the shear force and bending moment diagrams of the cantilever.



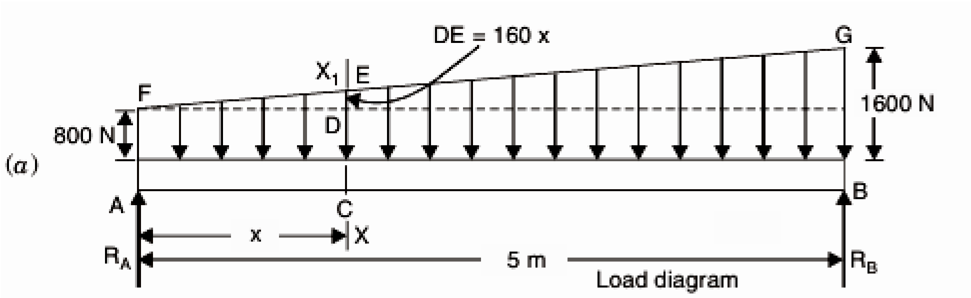
5. A simply supported beam of length 6 m, carries point load of 3kN and 6kN at distances of 2 m and 4 m from the left end. Draw the shear force and bending moment diagrams for the beam.



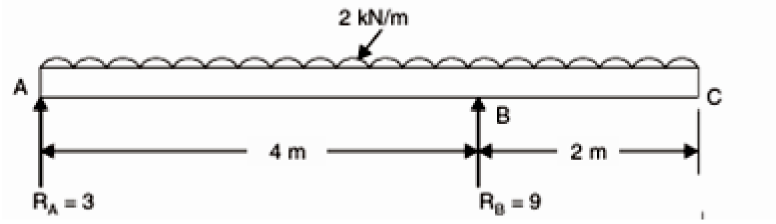
6. A simply supported beam of length 10 m, carries the uniformly distributed load and two point loads as shown in Fig. 6.31. Draw the S.F. and B.M. diagram for the beam. Also calculate the maximum bending moment.



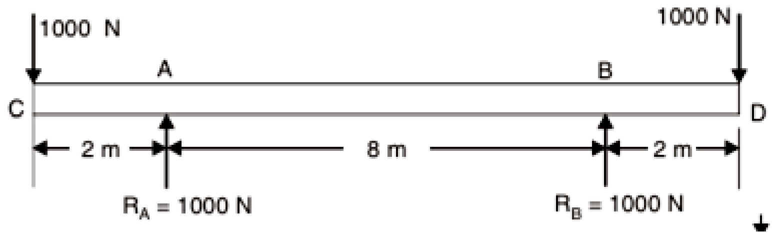
7. A simply supported beam of length 5 m carries a uniformly increasing load of 800 N/m run at one end to 1600 N/m run at the other end. Draw the S.F. and B.M. diagrams for the beam. Also calculate the position and magnitude of maximum bending moment.



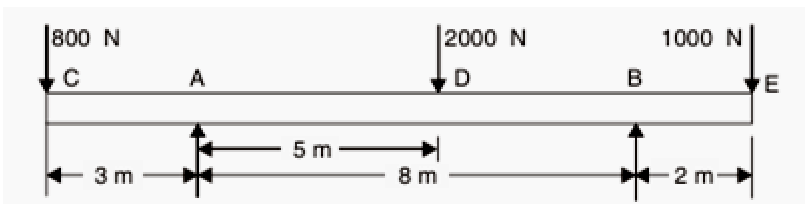
8. Draw the shear force and bending moment diagrams for the over-hanging beam carrying uniformly distributed load of 2 kN/m over the entire length as shown in Fig.6.35. Also locate the point of contra flexure.



9. A beam of length 12 m is simply supported at two supports which are 8 m apart, with an overhang of 2 m on each side as shown in Fig. 6.37. The beam carries a concentrated load of 1000 N at each end. Draw S.F. and B.M. diagrams.



10. Draw the S.F. and B.M. diagrams for the beam which is loaded as shown in Fig. 6.38. Determine the points of contra flexure within the span AB.



<u>QUESTION BANK</u>

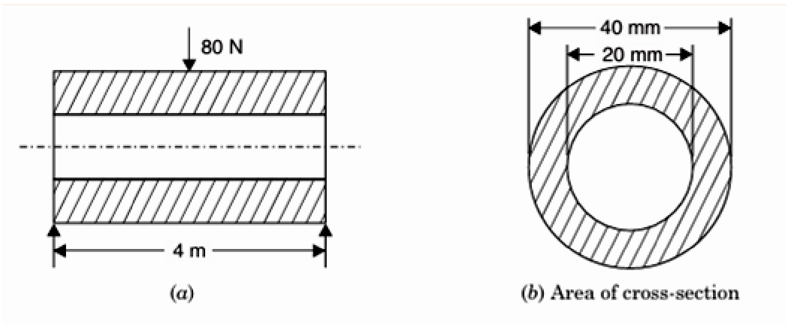
<u>(23A30302) MECHANICS OF SOLIDS</u>

<u>UNIT-3 (PART-A) Flexural Stresses</u>

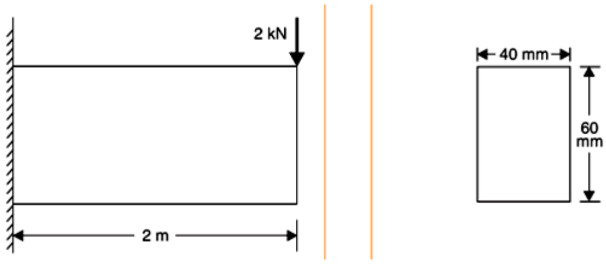
1. Derive an Expression of Simple Bending Equation & What are the assumptions made in the theory of simple bending ?

2. A steel plate of width 120 mm and of thickness 20 mm is bent into a circular arc of radius 10 m. Determine the maximum stress induced and the bending moment which will produce the maximum stress. Take $E = 2 \times 10^5\ N/mm^2$.

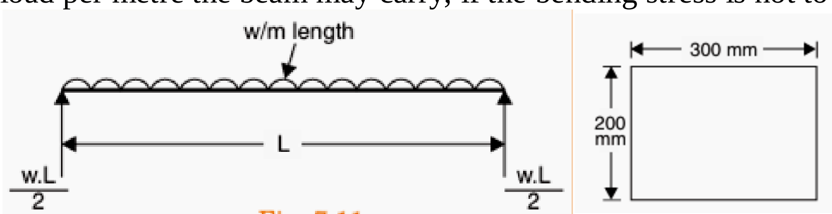
3. Calculate the maximum stress induced in a cast iron pipe of external diameter 40 mm, of internal diameter 20 mm and of length 4 metre when the pipe is supported at its ends and carries a point load of 80 N at its centre.



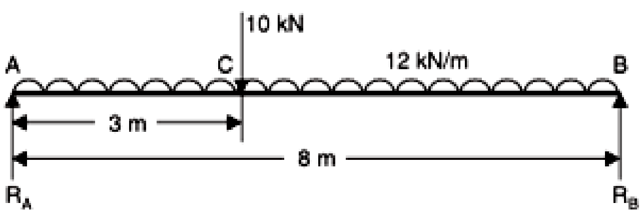
4 (a). A cantilever of length 2 metre fails when a load of 2 kN is applied at the free end. If the section of the beam is 40 mm × 60 mm, find the stress at the failure.



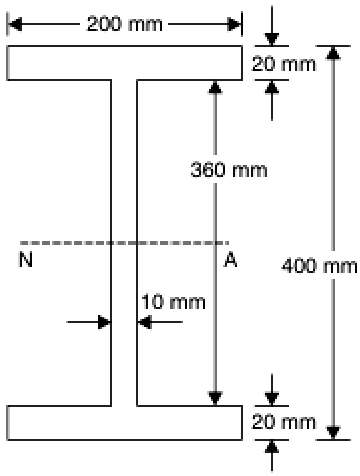
(b). A rectangular beam 200 mm deep and 300 mm wide is simply supported over a span of 8 m. What uniformly distributed load per metre the beam may carry, if the bending stress is not to exceed 120 N/mm^2.



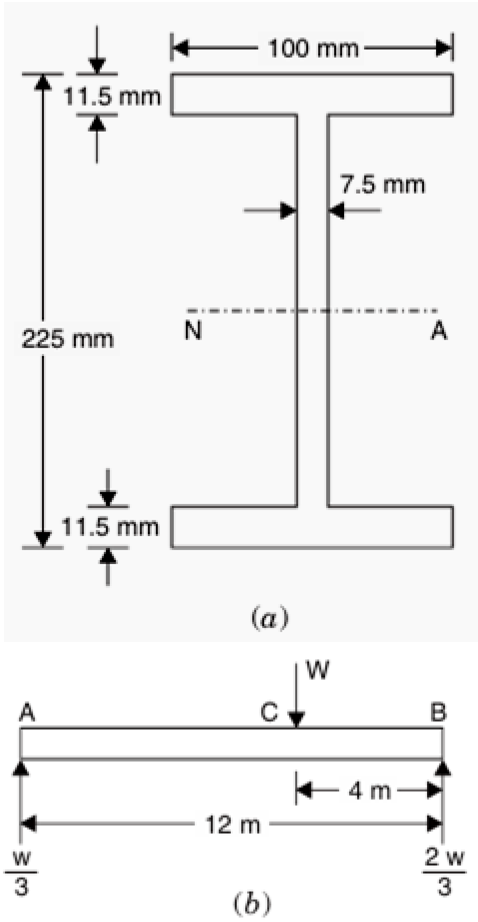
5 . A timber beam of rectangular section of length 8 m is simply supported. The beam carries a U.D.L. of 12 kN/m run over the entire length and a point load of 10 kN at 3 metre from the left support. If the depth is two times the width and the stress in the timber is not to exceed 8 N/mm2, find the suitable dimensions of the section



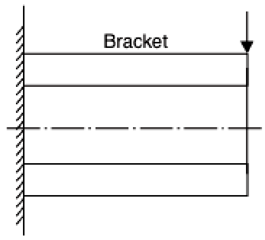
6. A rolled steel joist of I section has the dimensions as shown in Figure. This beam of I-section carries a u.d.l. of 40 kN/m run on a span of 10 m, calculate the maximum stress produced due to bending.

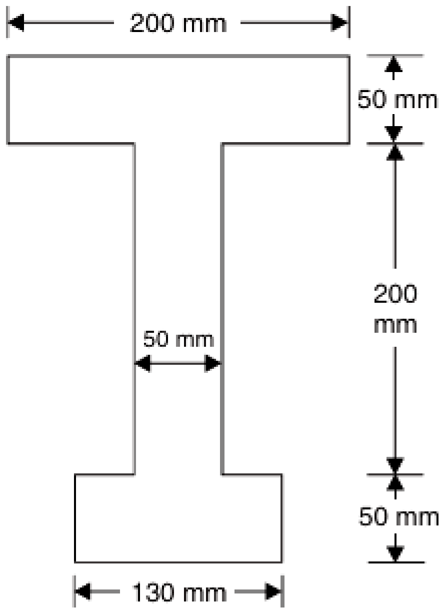


7. An I-section shown in Figure, is simply supported over a span of 12 m. If the maximum permissible bending stress is 80 N/mm^2, what concentrated load can be carried at a distance of 4 m from one support ?

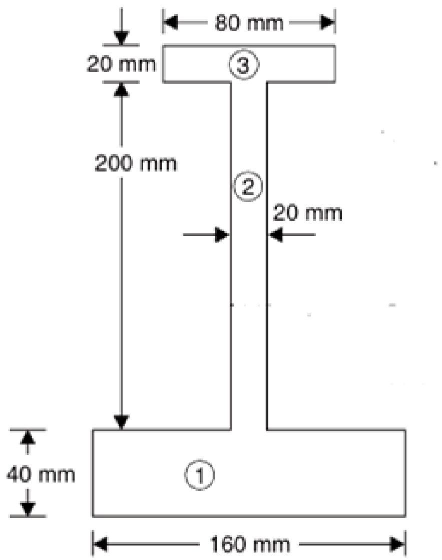


8. A cast iron bracket subject to bending has the cross-section of I-form with unequal flanges. The dimensions of the section are shown in Figure. Find the position of the neutral axis and moment of inertia of the section about the neutral axis. If the maximum bending moment on the section is 40 MN mm, determine the maximum bending stress. What is the nature of the stress ?

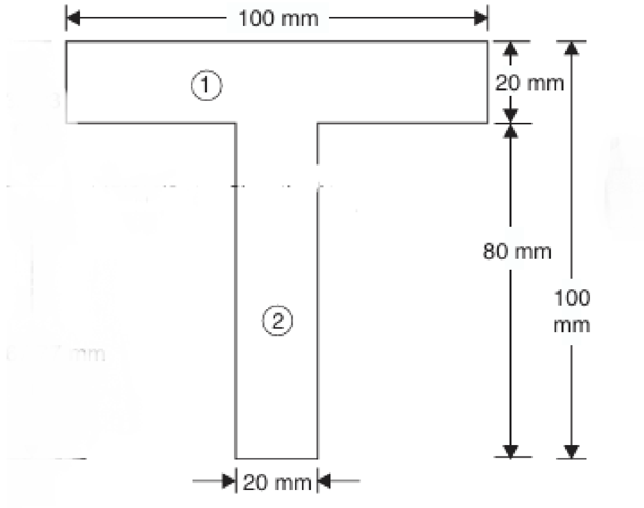




9. A cast iron beam is of I-section as shown in Figure The beam is simply supported on a span of 5 metres. If the tensile stress is not to exceed 20 N/mm^2, find the safe uniformly load which the beam can carry. Find also the maximum compressive stress.



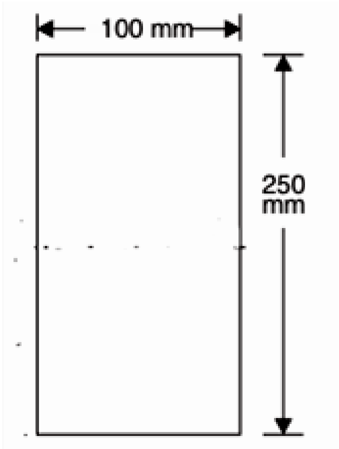
10. A cast iron beam is of T-section as shown in Figure The beam is simply supported on a span of 8 m. The beam carries a uniformly distributed load of 1.5 kN/m length on the entire span. Determine the maximum tensile and maximum compressive stresses.



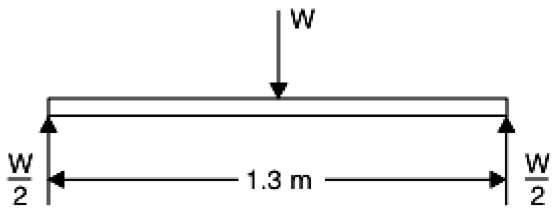
(23A30302) MECHANICS OF SOLIDS

UNIT-3 (PART-B) Shear Stresses

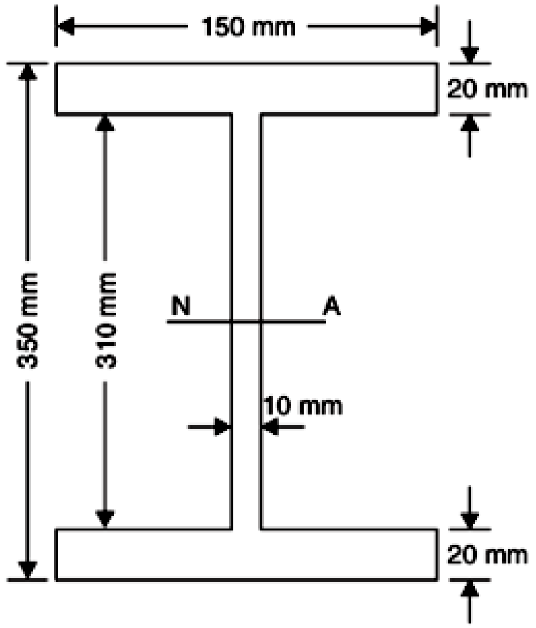
1. A rectangular beam 100 mm wide and 250 mm deep is subjected to a maximum shear force of 50 kN. Determine : (i)Average shear stress, (ii)Maximum shear stress, and (iii) Shear stress at a distance of 25 mm above the neutral axis.



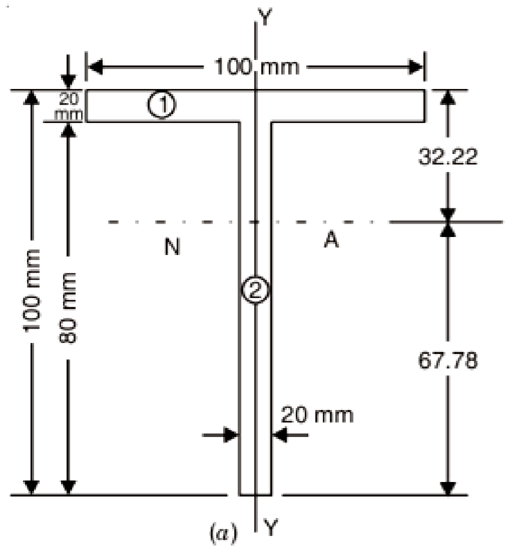
2. A simply supported wooden beam of span 1.3 m having a cross-section 150mm wide by 250 mm deep carries a point load W at the centre. The permissible stress are 7N/mm^2 in bending and 1 N/mm^2 in shearing. Calculate the safe load W.



3. An I-section beam 350 mm × 150 mm has a web thickness of 10 mm and a flange thickness of 20 mm. If the shear force acting on the section is 40 kN, find the maximum shear stress developed in the I-section & sketch the shear stress distribution across the section. Also calculate the total shear force carried by the web

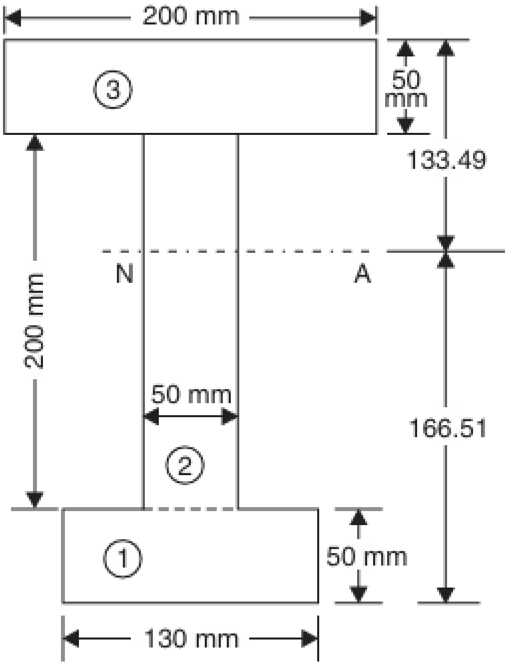


4. The shear force acting on a section of a beam is 50 kN. The section of the beam is of T-shaped of dimensions 100 mm × 100 mm × 20 mm as shown in Figure. The moment of inertia about the horizontal neutral axis is 314.221×10^4. mm^4 Calculate the shear stress at the neutral axis and at the junction of the web and the flange.

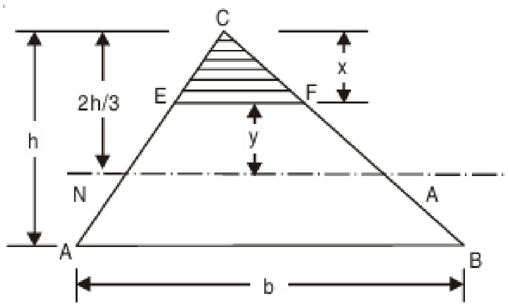


(a)

5. The shear force acting on a beam at an I-section with unequal flanges is 50 kN. The section is shown in Figure. The moment of inertia of the section about N.A. is 2.849×10^4. Calculate the shear stress at the N.A. and also draw the shear stress distribution over the depth of the section.

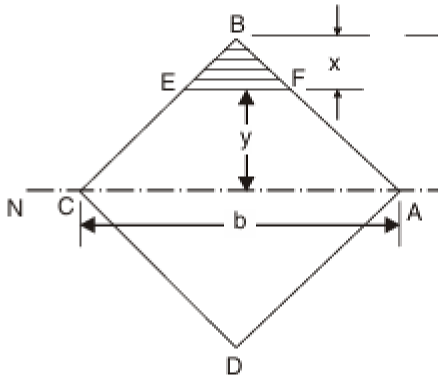


6. The shear force acting on a beam at a section is F. The section of the beam is triangular base b and of an altitude h. The beam is placed with its base horizontal. Find the maximum shear stress and the shear stress at the N.A.



(a)

7. A beam of square section is used as a beam with one diagonal horizontal. The beam is subjected to a shear force F, at a section. Find the maximum shear in the cross section of the beam and draw the shear distribution diagram for the section.



(23A30302) MECHANICS OF SOLIDS

UNIT-4 (PART-A) Deflection of Beams

1. A beam 6 m long, simply supported at its ends, is carrying a point load of 50 kN at its centre. The moment of inertia of the beam (i.e. I) is given as equal to $78 \times 10^5 \text{mm}^4$. If E for the material of the beam = 2.1×10^5 N/mm^2, calculate : (i) deflection at the centre of the beam and (ii) slope at the supports.

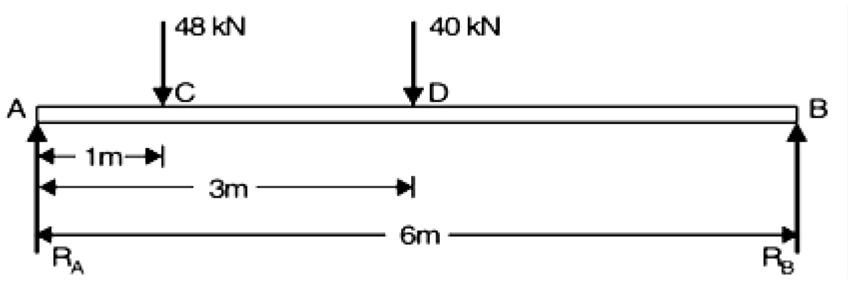
2. Determine : (i) slope at the left support, (ii) deflection under the load and (iii) maximum deflection of a simply supported beam of length 5 m, which is carrying a point load of 5 kN at a distance of 3 m from the left end. Take E = 2×10^5 N/mm^2 and I = 1×10^8 mm^4

3. A beam of uniform rectangular section 200 mm wide and 300 mm deep is simply supported at its ends. It carries a uniformly distributed load of 9 kN/m run over the entire span of 5 m. If the value of E for the beam material is 1×10^4 N/mm^2, find : (i)the slope at the supports and (ii) maximum deflection.

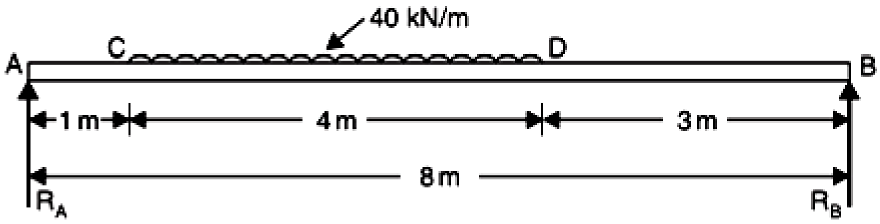
4. A beam of length 5 m and of uniform rectangular section is supported at its ends and carries uniformly distributed load over the entire length. Calculate the depth of the section if the maximum permissible bending stress is 8 N/mm^2 and central deflection is not to exceed 10 mm. Take the value of E = 1.2×10^4 N/mm^2

MACAULAY'S METHOD.

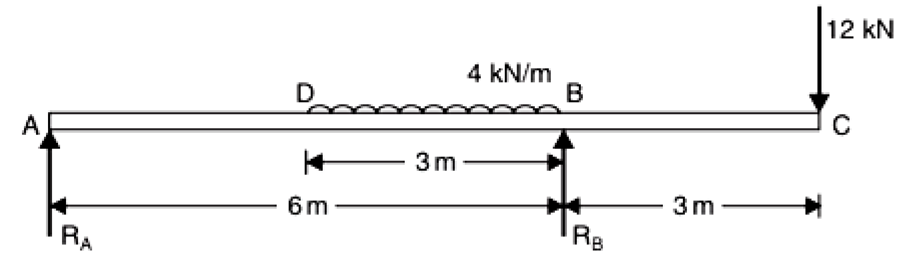
5. A beam of length 6 m is simply supported at its ends and carries two point loads of 48 kN and 40 kN at a distance of 1 m and 3 m respectively from the left support. Find : (i)deflection under each load, (ii)maximum deflection, and (iii)the point at which maximum deflection occurs. Given E = 2×10^5 N/mm^2 and I = 85×10^6 mm^4



6. A beam of length 8 m is simply supported at its ends. It carries a uniformly distributed load of 40 kN/m as shown in Figure Determine the deflection of the beam at its mid-point and also the position of maximum deflection and maximum deflection. Take E = 2×10^5 N/mm^2 and I = 4.3×10^8 mm^4



7. A beam ABC of length 9 m has one support of the left end and the other support at a distance of 6 m from the left end. The beam carries a point load of 1 kN at right end and also carries a uniformly distributed load of 4 kN/m over a length of 3 m as shown in Figure Determine the slope and deflection at point C. Take E = 2×10^5 N/mm^2 and I = 5×10^8 mm^4.



8. What is a Macaulay's method ? Where is it used ? Find an expression for deflection at any section of a simply supported beam with an eccentric point load, using Macaulay's method.

9. What is moment-area method ? Where is it conveniently used ? Find the slope and deflection of a simply supported beam carrying a (i) point load at the centre and (ii) uniformly distributed load over the entire length using moment-area method.

DOUBLE INTEGRATION METHOD

10. A cantilever of length 3 m is carrying a point load of 50 kN at a distance of 2 m from the fixed end. If I = 10^8 mm^4 and E = 2×10^5 N/mm^2, find (i) slope at the free end and (ii) deflection at the free end.

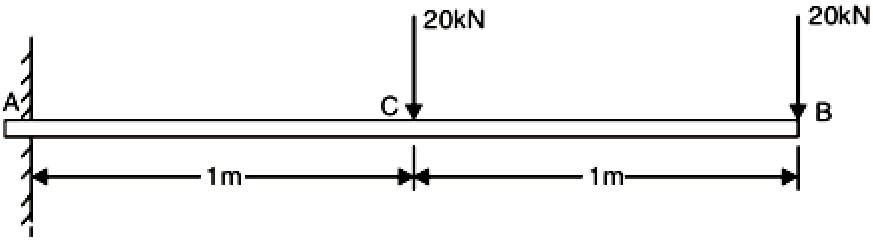
11.(A) A cantilever of length 2.5 m carries a uniformly distributed load of 16.4 kN per metre length over the entire length. If the moment of inertia of the beam = 7.95×10^5 N/mm^4 and value of E = 2×10^5 N/mm^2, determine the deflection at the free end

(B) A cantilever of length 3 m carries a uniformly distributed load over the entire length. If the deflection at the free end is 40 mm, find the slope at the free end

12.A cantilever of length 2 m carries a uniformly distributed load 2 kN/m over a length of 1 m from the free end, and a point load of 1 kN at the free end. Find the slope and deflection at the free end if $E = 2.1 \times 10^5\ \mathrm{N/mm^4}$ and $I = 6.667 \times 10^5\ \mathrm{N/mm^4}$

13.A cantilever of length 2 m carries a uniformly varying load of 25 kN/m at the free end to 75 kN/m at the fixed end. If $E = 1 \times 10^5\ \mathrm{N/mm^4}$ and $I = 10^8$ mm4, determine the slope and deflection of the cantilever at the free end.

14. A cantilever of length 2 m carries a point load of 20 kN at the free end and another load of 20 kN at its centre. If $E = 10^5\ \mathrm{N/mm^4}$ and $I = 10^8$ mm4 for the cantilever then determine by moment area method, the slope and deflection of the cantilever at the free end.



PART-B TORSION

1. **Define the terms:** Torsion, torsional rigidity and polar moment of inertia.

2. **Derive an expression** for the shear stress produced in a circular shaft which is subjected to torsion.What are the assumptions made in the derivation?

3. A) A solid shaft of 150 mm diameter is used to transmit torque.
   Find the maximum torque transmitted by the shaft if the maximum shear stress induced in the shaft is **45 N/mm²**.
   b)The shearing stress of a solid shaft is not to exceed **40 N/mm²** when the torque transmitted is **20 000 N-m**.Determine the minimum diameter of the shaft.

4. In a hollow circular shaft of outer and inner diameters of **20 cm** and **10 cm** respectively, the shear stress is not to exceed **40 N/mm²**.Find the maximum torque which the shaft can safely transmit.

5. Two shafts of the same material and of same lengths are subjected to the same torque.
   If the first shaft is of a solid circular section and the second shaft is of hollow circular sectionwhose internal diameter is **2/3** of the outside diameter and the maximum shear stress developed in each shaft is the same,compare the weights of the shafts.

6. A hollow shaft of external diameter **120 mm** transmits **300 kW** power at **200 r.p.m.** Determine the maximum internal diameter if the maximum stress in the shaft is not to exceed **60 N/mm^2**.

7. A hollow shaft is to transmit **300 kW** power at **80 r.p.m.**If the shear stress is not to exceed **60 N/mm^2** and the internal diameter is **0.6** of the external diameter,find the external and internal diameters assuming that the maximum torque is **1.4 times** the mean.

8. A solid steel shaft has to transmit 75 kW at 200 r.p.m.Taking allowable shear stress as 70 N/mm^2, find suitable diameter for the shaft if the maximum torque transmitted at each revolution exceeds the mean by 30%.

(23A30302) MECHANICS OF SOLIDS

UNIT-5 (PART-A) — THIN & THICK CYLINDERS (PART-B) COLUMNS

1) A thin cylinder of internal diameter 1.25 m contains a fluid at an internal pressure of 2 N/mm^2.
Determine the maximum thickness of the cylinder if:
(i) The longitudinal stress is not to exceed 30 N/mm^2.
(ii) The circumferential stress is not to exceed 45 N/mm^2.

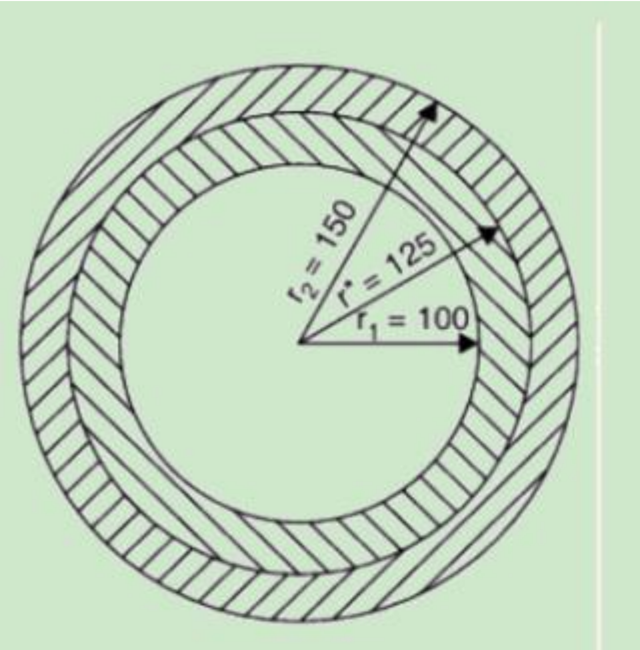
2) Calculate:
(i) The change in diameter,
(ii) Change in length, and
(iii) Change in volume of a thin cylindrical shell 100 cm diameter, 1 cm thick, and 5 m long when subjected to internal pressure of 3 N/mm^2.
Take $E = 2 \times 10^5$ N/mm^2 and Poisson's ratio (μ) = 0.3.

3) A closed cylindrical vessel made of steel plates 4 mm thick with plane ends carries fluid under a pressure of 3 N/mm^2.
The diameter of cylinder is 25 cm and length is 75 cm.
Calculate the longitudinal and hoop stresses in the cylinder wall and determine the change in diameter, length, and volume of the cylinder.

Take E = 2.1 × 10^5 N/mm² and μ = 0.286.

4) Find the thickness of metal necessary for a cylindrical shell of internal diameter 160 mm to withstand an internal pressure of 8 N/mm².
The maximum hoop stress in the section is not to exceed 35 N/mm².

5) A compound cylinder is made by shrinking a cylinder of external diameter 300 mm and internal diameter 250 mm over another cylinder of external diameter 250 mm and internal diameter 200 mm.
The radial pressure at the junction after shrinking is 8 N/mm².
Find the final stresses set up across the section when the compound cylinder is subjected to an internal fluid pressure of 84.5 N/mm².



6) A steel tube of 200 mm external diameter is to be shrunk onto another steel tube of 60 mm internal diameter.
The diameter at the junction after shrinking is 120 mm.
Before shrinking on, the difference of diameters at the junction is 0.08 mm.
Calculate the radial pressure at the junction and the hoop stresses developed in the two tubes after shrinking.
Take E = 2 × 10^5 N/mm².

7) A thick spherical shell of 200 mm internal diameter is subjected to an internal fluid pressure of 7 N/mm².
If the permissible tensile stress in the shell material is 8 N/mm²,
find the thickness of the shell.

UNIT-5 (PART-B) — COLUMNS

1. Explain the assumptions made in Euler's column theory.
How far are the assumptions valid in practice?

2. Derive an expression for Euler's crippling load for a long column with the following end conditions:
(a) Both ends hinged
(b) Both ends fixed

3. Explain how Rankine-Gordon formula is used to calculate the intensity of stress in short, intermediate, and long columns.
What is a Rankine's constant?
What is the approximate value of Rankine's constant for a cast iron column?

4. Determine the external diameter and internal diameter of a hollow circular cast iron column,which carries a load of 1000 kN.The length of the column is 6 metres.The internal diameter is to be one-half that of the outer diameter.Use Rankine's formula withOne end is fixed and the other end is free.

$$f = 560\,\mathrm{N/mm}^2,\ a = \frac{1}{1600},$$ and **factor of safety = 4**.

5. A mild steel tube is 7.5 cm in diameter and 0.25 cm thick.A short length of this tube is tested in compression and is found to yield at 500 N/mm^2.The modulus of elasticity of the material of the tube is 2×10^5 N/mm^2.A length of 2 m when tested as a strut with free ends failed with a load of 180 kN.Assuming the failing stress in Rankine's formula to be the yield stress of the material,find the value of Rankine's constant (a).Also find the crushing load as per Euler's formula.

6. Calculate the safe compressive load on a hollow cast iron column (one end rigidly fixed and other hinged) of 10 cm external diameter, 7 cm internal diameter, and 8 m in length.
Use Euler's formula with a factor of safety of 4 and E = 95 kN/mm^2.