Unit 1 SIMPLE STRESS AND STRAIN

Basic

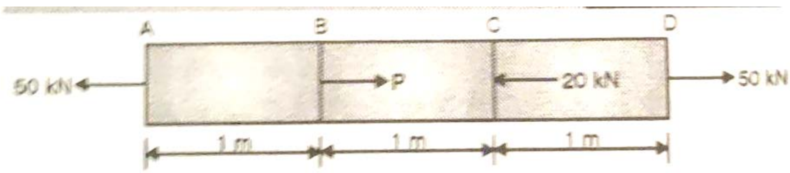
1. Explain
   - Modulus of Rigidity
   - Young modulus
   - Bulk modulus
   - Hooke law
   - Volumetric strain
   - Poisson Ratio

2. 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.
3. Enlist and explain various mechanical properties of materials
4. A steel rod 5 m long and 30 mm in diameter is subjected to an axial tensile load of 50 kN. Determine the change in length, diameter and volume of the rod. Take E = $2x10^3$ N/mm² and Poisson's ratio = 0.25

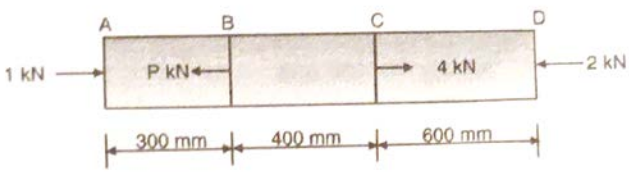
Numerical on Analysis of bar

1. A circular bar having 200 mm area is subjected to the axial loads as shown in Fig. Find the value of 'P' and the total elongation. Take E = 2 x 10^5 N/mm

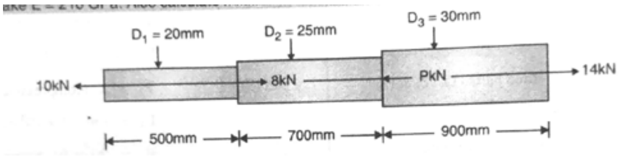
2.



3. A bar of uniform cross-sectional area 100 mm is subjected to axial forces as shown in figure. Calculate the net change in length of the bar. Take E = 2 x 10^4 N/mm²

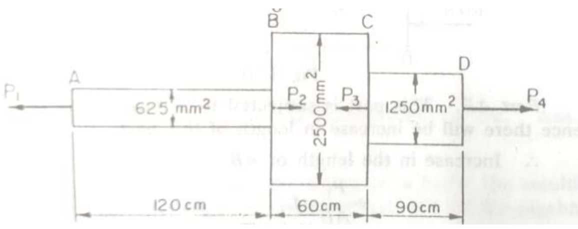


4. Determine the magnitude of P for equilibrium and the total elongation of the bar shown in figure. Take E = 210 GPa.



5. A steel bar 400 mm in length elongated by 10 mm under axial tensile load of 360 kN. Consider Poission ratio= 0.33 and E = 2 x 10^5 N/mm^2. Find the final and original diameter of bar.

6. A member ABCD is subjected to point loads P_1, P_2, P_3, and P_4 as shown in fig. Calculate the P_2 necessary for equilibrium, if P_1=45 KN, P_3=450 KN, P_4=130 KN. Determine the total elongation of a member, assuming the modulus of elasticity to be 2.1 x 10^5 N/mm^2.



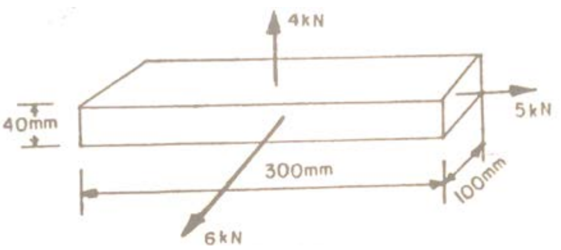
Thermal Stresses and Composite Bar

1. Steel rod of 20 mm diameter passes centrally through a copper tube of 50 mm external diameter and 40 mm internal diameter. The tube is closed at each end by rigid plates of negligible thickness. The nuts are tightened lightly home on the projecting parts of the rod. If the temperature of the assembly is raised by 50°C, calculate the stresses developed in copper and steel. Take E for steel and copper as 200 GN/m² and 100 GN/m² and a for steel and copper as 12×10^{-6} per °C and 18×10^{-6} per °C.

2. Steel tube of 30 mm external diameter and 20 mm internal diameter encloses a copper rod of 15 mm diameter to which it is rigidly joined at each end. If, at a temperature of 10°C there is no longitudinal stress, calculate the stresses in the rod and tube when the is raised to 200°C. Take E for steel and copper as 2.1×10^5 N/mm^2 and 1×10^5 N/mm^2 respectively. The value of co-efficient of linear expansion for steel and copper is given as 11×10^{-6} per ^{0}C and 18×10^{-6} per ^{0}C respectively.

Volumetric strain

1. Explain the terms 'volumetric strain' and 'volumetric strain' with the help of a rectangular bar subjected to three forces which are mutually perpendicular. Also represent the same using a proper sketch.
2. Explain the volumetric strain and volumetric strain of a rectangular bar which is subjected to axial load P in the direction of its length with proper diagram
3. Explain the volumetric strain and volumetric strain of cylindrical rod.
4. A metallic bar 300 mm x 100 mm x 40 mm is subjected to a force of 5 kN (tensile), 6 kN (tensile) and 4 kN (tensile) along x, y and z directions respectively. Determine the change in the volume of the block. Take $E = 2 \times 10^5$ N/mm^2 and Poisson's ratio = 0.25.



5. Explain stress-strain curve for ductile material and for brittle materials.
6. Derive expression for Young's modulus in term of bulk modulus

Numerical on Principal plane and stress

1. Explain analytical method for determining stresses on oblique section

    Case 1: member subjected to a direct stress in one plane

    Case 2: member subjected to direct stresses in two mutually perpendicular direction

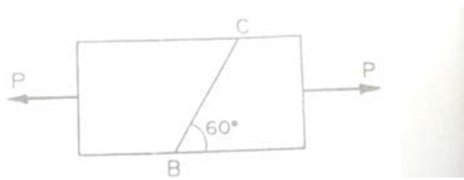
    Case 3: member subjected to direct stresses in two mutually perpendicular by a simple shear stress

2. A rectangular block of material is subjected to a tensile stress of 110 N/mm² on one plane and a tensile stress of 47 N/mm² on the plane at right angles to the former. Each of the above stresses is accompanied by a shear stress of 63 N/mm² and that associated with the former tensile stress tends to rotate the block anticlockwise. Find: (i) The direction and magnitude of each of the principal stress (ii) magnitude of the greatest shear stress.

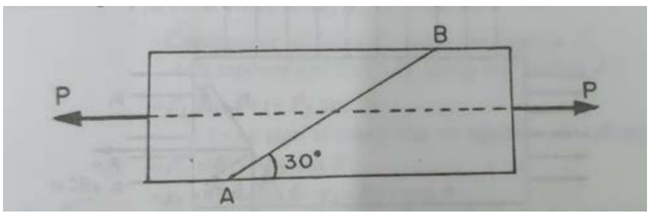
3. A rectangular bar of cross-sectional area 10000 mm is subjected to an axial load of 20 kN. Determine the normal and shear stresses on a section which is inclined at an angle of 30 degrees with normal cross-section of the bar

4. Find the diameter of a circular bar which is subjected to an axial pull of 160 kN, if the maximum allowable shear stress on any section is 65 N/mm².

5. rectangular bar of cross-sectional area of 11000 mm² is subjected to a tensile load P . The permissible normal and shear stresses on the oblique plane BC are given as 7 N/mm^2 and 3.5 N/mm^2 respectively. Determine the safe value of P.



6. Two wooden pieces 10cm x 10 cm in cross-section are glued together along line AB as shown in Fig . What maximum axial force P can be applied if the allowable shearing stress along AB is 1.2N / mm^2



7. The principal tensile stresses at a point across two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2. Determine the normal, tangential and resultant stresses on a plane inclined at 30° to the axis of the minor principal stress.

8. The principal 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 principal stress. Also determine the maximum intensity of shear stress in the material at the point.

9. At a point in a strained material the principal stresses are 100 N/mm^2 (tensile) and 60 N/mm^2 (compressive). Determine the normal stress, shear stress and resultant stress on a plane inclined at 50 degrees to the axis of major principal stress. Also determine the maximum shear stress at the point.

10. At a point within a body subjected to two mutually perpendicular directions, the stresses are 80 N/mm^2 tensile and 40 N/mm^2 tensile. Each of the above stresses, is accompanied by a shear stress of 60 N/mm^2. Determine the normal stress, shear stress and resultant stress on an oblique plane inclined at an angle of 45° with the axis of minor tensile stress.

11. The normal stress in two mutually perpendicular directions are 600 N /mm^2 and 300 N/mm^2 both tensile. The complimentary shear stresses in these directions are of intensity 450 N/mm^2. Find the normal and tangential stresses on the two planes which are equally inclined to the planes carrying the normal stresses mentioned above.

Graphical Method

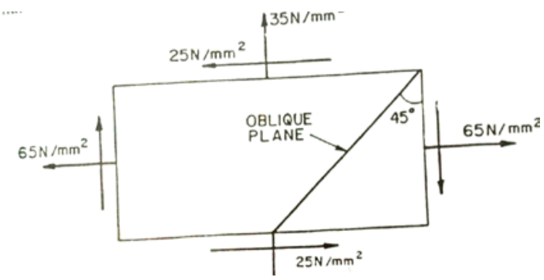
12. The principal tensile stresses at a point across two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2. Determine the normal, tangential and resultant stresses on a plane inclined at 30° to the axis of the minor principal stress. (solve by Graphical Method)

Mohr's circle

1. The principal tensile stresses at a point across two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2. Determine the normal, tangential and resultant stresses on a plane inclined at 30° to the axis of the minor principal stress. (solve by Mohr's Circle Method)

2. At a point in a strained material the principal stresses are 100 N/mm² (tensile) and 60 N/mm² (compressive). Determine the normal stress, shear stress and resultant stress on a plane inclined at 50 to the axis of major principal stress. Also determine the maximum shear stress at the point.(solve by Mohr's Circle Method)

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



Strain Energy

1. Explain Resilience, Proof Resilience, Modulus of Resilience
2. Expression for strain energy stored in body when load is applied gradually.
3. Expression for strain energy stored in body when load is applied suddenly.
4. Expression for strain energy stored in body when load is applied with impact.

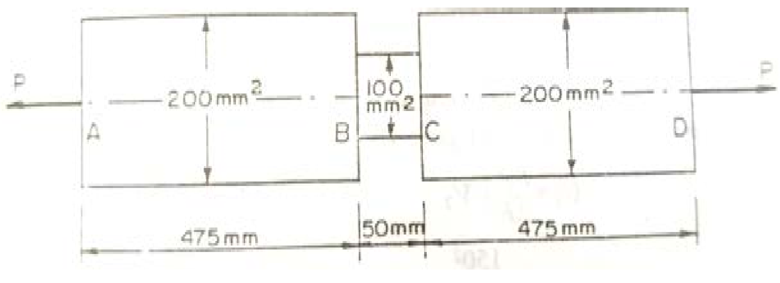
Numerical on strain energy

1. A tensile load of 60 KN is gradually applied to circular bar of 4 cm diameter and 5 m long. If the value of F = 20 * 10^5 N/mm², determine:
   (i) stretch in the rod,
   (ii) stress in the rod,
   (iii) strain energy absorbed by the rod.

2. Calculate instantaneous stress produced in a bar 10 cm^2 in area and 3 m long by the sudden application of a tensile load of unknown magnitude, if the extension of the bar due to suddenly applied load is 1.5 mm. "Also determine the suddenly applied load. Take E = 2 * 10^3 N/mm^2.

3. A steel rod is 2 m long and 50 mm in diameter. An axial pull of 100 KN is suddenly applied to the rod. Calculate the instantaneous stress induced and also the instantaneous elongation produced in the rod. Take E = 200GN /m^2

4. The maximum stress produced by a pull in a bar of length 1 m is 150 N/mm². The area of cross-sections and length . Calculate the strain energy stored in the bar if E=2x10 N/mm².



5. A weight of 10 KN falls by 30 mm on a collar rigidly attached to a vertical bar 4 m long and 1000 mm in section. Find the instantaneous expansion of the bar. Take E=210 GPA. Derive the formula you use.

6. A load of 100 N falls through a height of 2 cm or to a collar rigidly attached to the lower end of a vertical bar 1.5 m long and of 1.5 cm^2 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. Take $E = 2 * 10^5 *$ N/mm^2.

7. A bar 12 mm diameter gets stretched by 3 mm under a steady load of 8000 N. What stress would be produced in the same bar by a weight of 800 N, which falls vertically through a distance of 8 cm on to a rigid collar attached at its end? The bar is initially unstressed. Take $E=2.0*10^5$ N/mm^2.

Direct and Bending Stresses

1. Explain

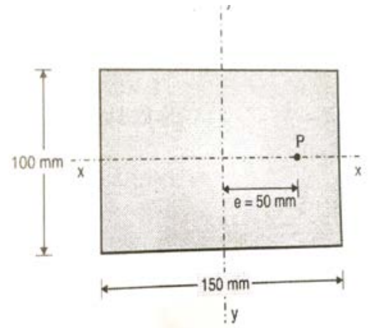
- Axial load or direct load
- Eccentric load
- No tension or zero stress condition

2. Explain middle third rule for rectangular section

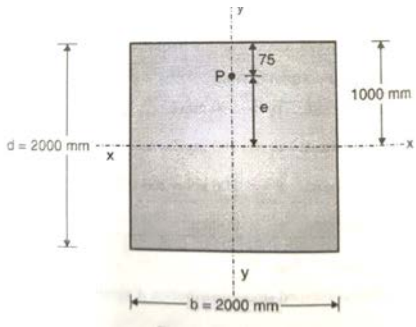
Numerical on direct and bending stresses

1. A square pillar is 600 mm x 600 mm in section. At what eccentricity a point load of 6000 KN be placed on one of the centroidal axis of the section so as to produce no tension in the section
2. Draw core section for a rectangular section having dimensions 600 mm x 450 mm. Show the dimensions of core section in it.
3. Calculate the limit of eccentricity for a circular section having diameter 80 mm. (Not by using direct formula but from basic principle)
4. Calculate maximum eccentricity for a hollow circular section having external diameter and internal diameter equal to 250 mm and 120 respectively, so that stress distribution is of same nature.
5. A rectangular column 150 mm wide and 100 mm thick carries a load of 150 KN at an eccentricity of 50 mm in the plane bisecting the thickness.

Find σ max and σ min



6. A pier of 2m * 2 m in section and having its weight 385 KN and carries a compressive load P which is acting at 75 mm from its edge bisecting one of its axis. What is the value of P for no tension conditions?


y
75
P
e
1000 mm
d = 2000 mm
x
x
y
b = 2000 mm

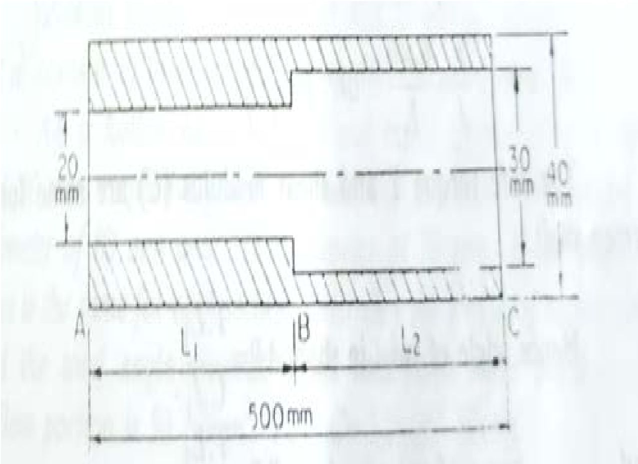
TORSION AND COLUMN

TORSION

1. Derive the formula of shear stress produced in the circular shaft subjected to torsion
2. Derive the maximum torque transmitted by a circular shaft
3. Derive the maximum torque transmitted by a hollow shaft

Numerical on torsion

1. solid circular shaft and a hollow circular shaft whose inside diameter is (3/4) of the outside diameter, are of the same material, of equal lengths and are required to transmit a given torque. Compare the weights of these two shafts if the maximum shear stress developed in the two shafts are equal.
2. Two shafts of the same materials and of same length are subjected to same torque, if the first is of a solid circular section and second shaft is of hollow circular section, whose internal diameter 2/3 of the outside diameter and the maximum shear stress developed in each shaft is the same, compare the weights of the shafts
3. A hollow shaft of external diameter 120 mm transmits 300KW power at 200 rpm. Determine the maximum internal diameter if the maximum stress in the shaft is not to exceed 60 N/mm^2.
4. A hollow shaft is to transmit 300 KW power at 80 rpm. If shear stress is not to exceed 60 N/mm2 and the internal diameter is 0.6 of the external diameters, find the external and internal diameter assuming that the maximum torque is 1.4 times the mean.
5. solid circular shaft and a hollow circular shaft whose inside diameter is (3/4) of the outside diameter, are of the same material, of equal lengths and are required to transmit a given torque. Compare the weights of these two shafts.
6. A shaft ABC of 500 mm length and 40 mm external diameter is bored, for a part of its length AB, to a 20 mm diameter and for the remaining length BC to a 30 mm diameter bore. If the shear stress is not to exceed 80 N/mm^2, find the maximum power, the shaft can transmit at a speed of 200 r.p.m. If the angle of twist in the length of 20 mm diameter bore is equal to that in the 30 mm diameter bore, find the length of the shaft that has been bored to 20 mm and 30 mm diameter



7. A steel shaft ABCD having a total length of 2.4 m consists of three lengths having different sections as follows: AB is hollow having outside and inside diameters of 80 mm and 50 mm respectively and BC and CD are solid, BC having a diameter of 80 mm and CD a diameter of 70 mm. If the angle of twist is the same for each section, determine the length of each section and the total angle of twist if the maximum shear stress in the hollow portion is 50 N/mm². Take $C=8.2x10^4$ N/mm²
8. A composite shaft consists of a steel rod 60 mm diameter surrounded by a closely fitting tube of brass. Find the out-side diameter of the tube so that when a torque of 1000 Nm is applied to the composite shaft, it will be shared equally by the two materials. Take C for steel t = $8.4 * 10^4 * N / mm^2$ and C for brass $=4.2*10^4 N / mm^2$ Find also the maximum shear stress in each material and common angle of twist in a length of 4 m

9. solid shaft of diameter 80 mm is subjected to a twisting moment of 8 MN mm and a bending moment of 5 MN mm at a point. Determine:

   (i) Principal stresses and

   (ii) Position of the plane on which they act.

Column

1.derive the equation for column when both ends are hinged

2.derive the equation for column when one end is fixed and other is free

3.derive the equation for column when both ends are fixed

4.derive the equation for column when one is fixed and other is pinned

numerical

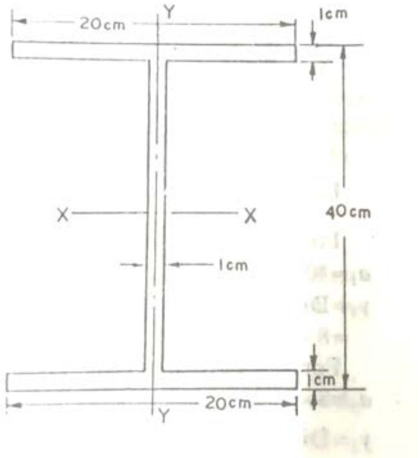
1.A solid round bar 3 m long and 5 cm in diameter is used as a strut with both ends hinged. Determine the crippling (or collapsing) load. Take $E = 2.0 * 10^5 * N / mm^2$

2. Use above problem determine the crippling load, when the given strut is used with the following conditions: (i) One end of the strut is fixed and the other end is free

(ii) Both the ends of strut are fixed. (iii) One end is fixed and other is hinged.

A column of timber section 15 cmx20 cm 6 meter long both ends being fixed. If the Young's modulus for timber=17.5 kN/mm², determine: (i) Crippling load and (ii) Safe load for the column if factor of safety=3.

1. Determine Euler's crippling load for an I-section joist 40 cmx20 cm x1 cm and 5 m long which is used as a strut with both ends fixed. Take Young's modulus for the joist as $2.1x10^4$ N/mm.



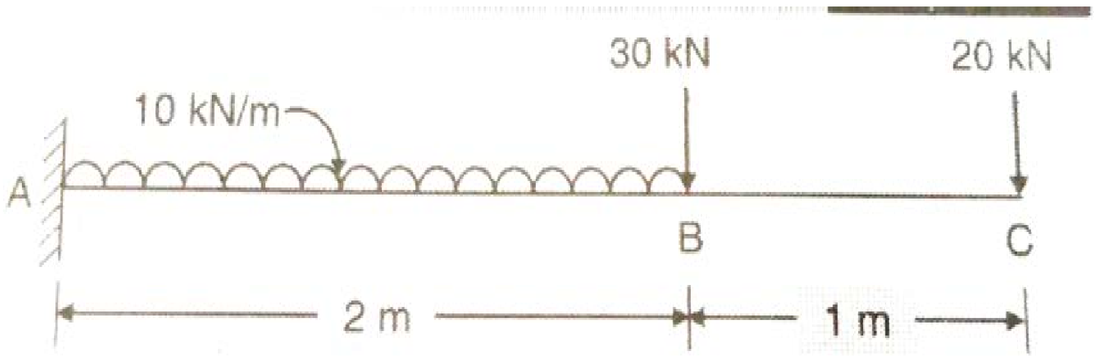
2. Hollow cylindrical cast iron column is 4 m long with both ends fixed. Determine the minimum diameter of the column if it has to carry a safe load of 250 KN with a factor of safety of 5. Take the internal diameter as 0.8 times the external diameter. Take f=550 N/mm² and a = 1/1600 in Rankine's formula.

3. 1.5 m long column has a circular cross section of 5 cm diameter. One of the ends of the column is fixed in direction and position and other end is free. Taking factor of safety as 3, calculate the safe load using: Rankine's formula, take yield stress, f_{c} = 560N / mm^2 and 1600 for pinned ends. a=1/1600

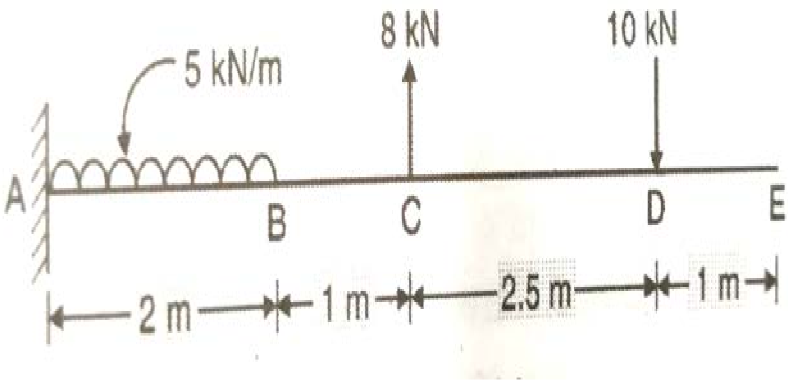
(b) Euler's formula, Young's modulus for =1.2*10^{5} N/mm^2

Unit 5. SFD BMD

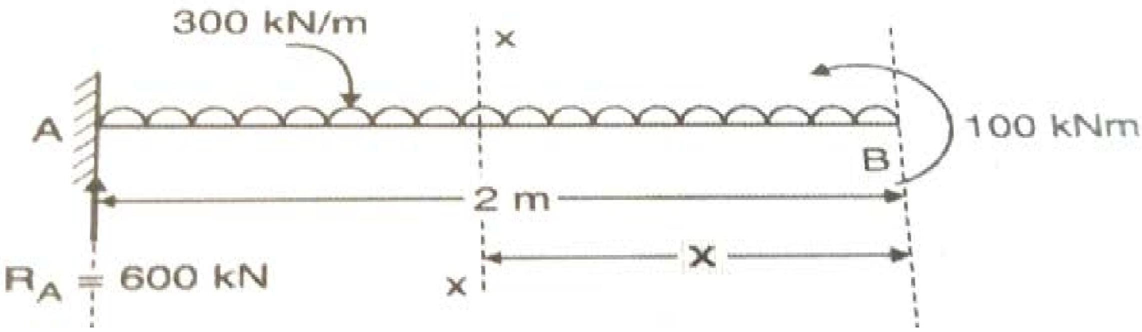
1. Cantilever beam of length 2 m carries the point load as shown in fig. Draw the shear force and bending moment diagram for cantilever beam.
2. Draw shear force and bending moment diagrams for a simply supported beam of length of 8 m and carrying a uniformly distributed load of 10 KN/m for a distance of 4 m.
3. A simply supported beam of length of 5 m carries a uniformly distributed load of 800 N/m run at one end to 1600 N/m run at other end. Draw the S.F and B.M diagram for beam. Also calculating the position and magnitude of maximum bending moment.
4. A horizontal beam AB of length 4 m is hinged at A and supported on rollers at B. The beam carries inclined loads of 100N, 200N, 300N inclined loads 60,45,30 degree to horizontal as shown in fig. draw the S.F, B.M.
5. A cantilever beam AB of span 3 m is fixed at A. it carries a point load 10 KN and 5 KN at 1.5 m and 3 m from fixed support. Draw S.F and B.M.
6. Draw SF and BM diagram for cantilever loaded as shown in fig



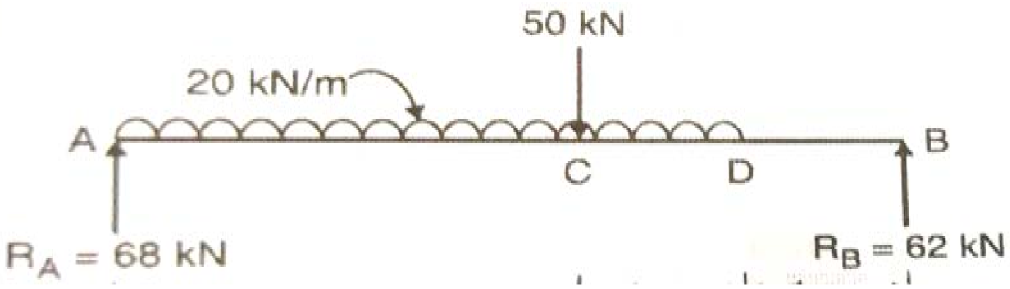
7. Draw SF and BM diagram



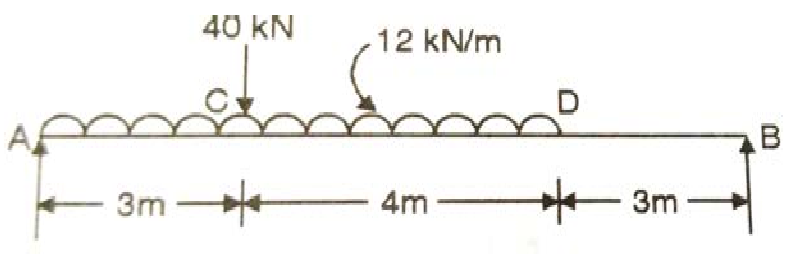
8. A cantilever beam of length 2 m subjected to UDL of 300 kN/m over entire length and anticlockwise couple of 100 kN-m at free end . Draw force and bending moment diagram



9. A simply supported beam of span 5 m carries a UDL of 20 kN/m over 4 m length from the left support and a point load of 50 kN at 2 m from right side support. Draw SF AND BM

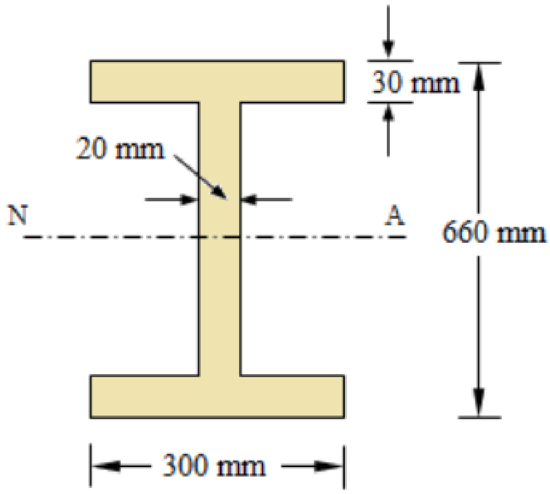


10. Draw SF and BM



BENDING STRESSES

1. A rectangular beam of breadth 100 mm and depth 200 mm is simply supported over a span of 4 m. The beam is loaded with an uniformly distributed load of 5 kN/m over the entire span. Find the maximum bending stresses.
2. A beam of I-section shown inlis simply supported over a span of 10 m. It carries a uniform load of 4 kN/m over the entire span. Evaluate the maximum bending stresses.



3. A rectangular beam of size 60 mm x 100 mm has a central rectangular hole of size 15 mm x 20 mm. The beam is subjected to bending and the maximum bending stress is limited to 100 N/mm^2 . Find the moment of resistance of the hollow beam section.
4. A cantilever of 2 m length and square section 200 mm x 200 mm, just fails in bending when a point load of 12 KN is placed at its free end. A beam of rectangular cross section of same material, 150 mm wide and 300 mm deep, is simply supported over a span of 3 m. Calculate the maximum concentrated load that the beam can carry at its centre without failure.
5. A beam of symmetric I-section has flange size 100 mm x 15 mm, overall depth 250 mm. Thickness of web is 8 mm. Compare the flexural strength of this section with that of a beam of rectangular section of same material and area. The width of rectangular section is two?third of its depth
6. Two wooden planks 60 mm x 160 mm each are connected together to form a cross section of a beam as shown in the Fig. If a sagging bending moment of 3500 Nm is applied about the

horizontal axis, find the stresses at the extreme fibre of the cross-section. Also calculate the total tensile force on the cross-section