Subject Name: STRENGTH OF MATERIALS

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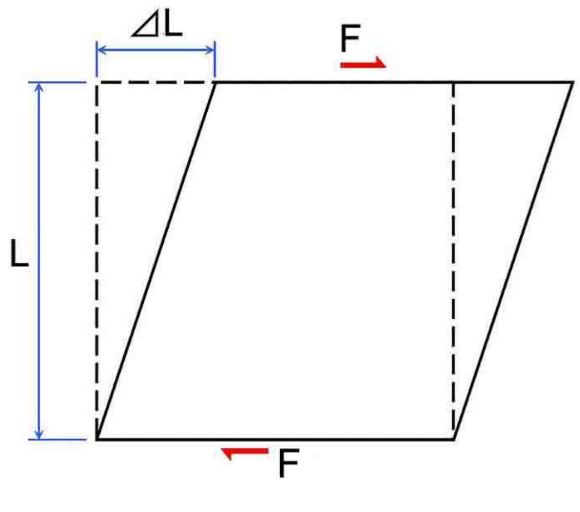
Unit-I: (Simple Stresses And Strains)

Important points / Definitions:

- **Strength:** Strength is the ability of the structure to resist the influence of the external forces acting upon it.
- **Stiffness** is the ability of the structure to resist the strains caused by the external forces acting upon it.
- **Stability** is the property of the structure to keep its initial position of equilibrium.
- **Durability** is the property of the structure to save its strength, stiffness and stability during the exploitation time.
- **Principle of superposition** The final magnitude of a quantity considered (stress, strain, displacement, rotation) caused by the set of external forces can be obtained as an algebraic sum of the quantity magnitudes caused by the particular forces composing the set.
- **Stress** When an external force is applied on a body, it undergoes deformation which is resisted by the body. The magnitude of the resisting force is numerically equal to the applied force. This internal resisting force per unit area of the body is known as stress.
- **Strain** When a body is subjected to an external force, there is some change of dimension in the body. Numerically the strain is equal to the ratio of change in length to the original length of the body.
- **Shear Stress(t) and Shear Strain**The two equal and opposite forces act tangentially on any cross sectional plane of the body tending to slide one part of the body over the other part.The stress induced is called shear stress and the corresponding strain is known as shear strain.



- **Elastic Limit:** The maximum stress that can be applied to a metal without producing permanent deformation is known as Elastic Limit. When stress is applied on a body its dimensions change, these changes can be reversed if the stress applied do not cross a certain limit. This certain limit within which the material when unloaded will re-gain its original dimensions is known as Elastic Limit. Beyond the elastic limit the changes will be permanent and cannot be reversed without an external force. Brittle materials tend to break at or shortly past their elastic limit, while ductile materials deform at stress levels beyond their elastic limit.
- **Hooke's law** This law states that when a material is loaded, within its elastic limit, the stress is directly proportional to the strain.

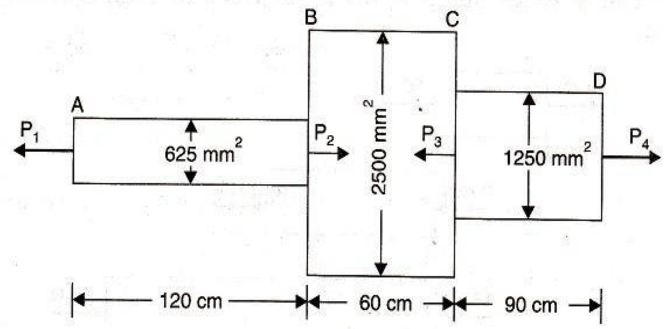
I.SHORT ANSWER QUESTIONS[2M]

1. Define
   a. Stress
   b. Shear stress
   c. Bearing stress
2. Explain simple and complementary shear stesses with neat sketches
3. Draw the stress strain diagram for mild steel and identity the significant points
4. Determine the volumetric strain of a rectangular bar of length l, width b and depth d subjected to an axial load P from first principle.
5. The volume of a hollow cylinder of 800.0mm diameter, 1.4m length and 10.0mm thickness increases by 1245.0mm when subjected to an internal pressure of 4.5Mpa. Determine the poissons ratio of the material, if E=190Gpa
6. Define modular ratio, thermal stresses and thermal strains
7. Define the following terms
   a. Resilience
   b. Proof resilience
   c. Modulus of resilience
8. A steel rod is 2m long and 100mm in diameter. An axial pull of 200kN is suddenly applied to the rod. Calculate the instantaneous stress induced and also the instantaneous elongation produced in the rod. Take E = 100GN/m^2.
9. Obtain a relation for the stress induced in a body if a load P is applied with an impact.
10. Give the relationship between Bulk Modulus and Young's Modulus.

II.LONG ANSWER QUESTIONS [5M]

1.

   a. A member ABCD is subjected to point loads P1, P2, P3 and P4 as shown in figure below. Calculate the force P2 necessary for equilibrium, if P1 = 45kN, P2 = 450kN and P4 = 130kN. Determine the total elongation of the member, assuming the modulus of elasticity to be 2.1x10^5 N/mm^2.



b. A compound tube consists of a steel tube 140mm internal diameter and 160mm external diameter and an outer brass tube 160mm internal diameter and 180mm external diameter. The two tubes are of the same length. The compound tube carries an axial load of 900kN. Find the stresses and the load carried by each tube and the amount it shortens. Length of each tube is 140mm. Take E for steel as $2x10^5$ N/mm^2 and for brass as $1x10^5$ N/mm^2.

2.

a. A steel rod of 3cm diameter and 5m 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 0.12cm. Take E = $2x10^5$ MN/m^2 and $\alpha = 12x10^{-6}$/°C.

b. A metallic block 250mm x 80mm x 30mm is subjected to a tensile force of 20kN, 30kN and 15kN along x, y and z directions respectively. Determine the change in volume of the block. Take E= $2x10^5$ N/mm^2 and Poisson's ratio = 0.30.

3.

a. A cast iron hub of 200 mm external diameter and 100 mm thickness is pressed on to a steel shaft of 75 mm diameter. Determine the radial stress required at the interface so that the shaft can transmit 740 MW at 630 rpm. Compute the necessary diametral interference and the stresses in the shaft and the hub. If the shaft is subjected to a compressive force of 180 kN, find the change in the stresses. Assume a frictional coefficient of 0.33, Poisson's ratio of 0.30, and Young's modulii of steel and cast iron to be 210 GPa and 180 GPa, respectively.

b. Write the relations between Modulus of Elasticity and Shear Modulus, Modulus for Elasticity and Bulk Modulus and hence derive the relation among the three elastic constants.

4.

a. A bar of 20mm diameter is tested in tension it is observed that when a lead of 40KN is applied the extension measured over a gauge length of 200mm us 0.12mm&contraction in diameter is 0.0036mm. Find poisson's ratio, young's modulus &bulk modulus & rigidity modulus.

b. The following are the result of a tensile on test on a molested rod is 16 mm gauge length is 50 mm, load at proportionality limit is 48.5 kN. Extension at the proportionally limit is 0.05mm. Load at yield point is 50.3 KN ultimate load is 90KN. Final length between gauge points is 64mm, Diameter of the neck at fracture is 13.7 mm. Determine the young's modules at elastic limit, Yield stress, Ultimate Stress, % of elongation & % of reduction in area.

5.
  a. A solid brass cylinder of 20mm diameter is rigidly attached and surrounded by an aluminium tube of internal diameter 20mm and thickness 6mm. if the assembly is stress free at 30 degrees centigrade. Find the stresses in the two materials when the temperature rises to 100 degrees centigrade. For brass, young's modulus of elasticity is 90GPa and coefficient of linear expansion is 20×10^{-6} per degrees centigrade. For aluminium, young's modulus of elasticity is 75GPa and coefficient of linear expansion is 23×10^{-6} per degree centigrade.
  b. A 12.5 m long steel rope supports a mass of 1000.0 Kg. Design the rope comprising 1.6mm strands with a yield stress of 1500.0MPa and young's modulus of 175.0GPa. assume a safe factor of 3.5, the elongation of the rope should not exceed 12.5mm.

6.
  a. A steel rod of 30mm diameter is enclosed by a copper tube of 45mm external diameter and internal diameter 35mm. the composite bar of length 300mm is subjected to an axial tensile force of 50kn. Find the stresses in each bar and the load carried by each bar. Adopt E for steel is 210GPa and E for copper is 110Gpa.
  b. A steel bar of 30mm diameter was subjected to a tensile load of 12×10^4N. the extension in a length of 250mm was found to be 12mm. Find the young's modulus and modulus of rigidity and also the reduction in diameter. Assume poisson's ratio as 0.30

7.
  a. A steel bar is 900 mm long; its two ends are 40mm and 30 mm in diameter and the length of each rod is 200 mm. The middle portion of the bar is 15 mm in diameter and 500 mm long. If the bar is subjected to an axial tensile load of 15 KN, find its total extension.
     Take $E=200GN/m^2$ (G stand for giga and IG = 10^0).
  b. A steel tie rod 50 mm in diameter and 2.5 m long is subjected to a pull of 100 KN. To what length the rod should be bored centrally so that the total extension will increase by 15 per cent under the same pull, the bore being 25 mm diameter? Take $E = 200GN / m^2$.

8.
  a. A 700 mm length of aluminum alloy bar is suspended from the ceiling so as to provide a clearance of 0.3 mm between in and a 250 mm length of steel bar as show in Fig. $A_{al}=1250$ mm², $E_{al}= 70$ GN/m², $A_s=2500$ mm² $E_s=210$ GN/m². Determine the stress in the aluminum and in the steel due to a 300 KN load applied 500 mm from the ceiling.
  b. Two parallel steel wires 6 m long, 10 mm diameter are hung vertically 70 mm apart and support a horizontal bar at their lower ends. When a load of 9 KN is attached to one of the wires, it is observed that the bar is 2.4^0 to the horizontal. Find 'E' for wire.

9.
   a. A copper sleeve, 21 mm internal and 27 mm external diameter, surround a 20 mm steel bolt, one end of the sleeve being in contact with the shoulder of the bolt. T he sleeve is 60 mm long. After putting a rigid washer on the other end of the sleeve, a nut is screwed on the bolt through 10 degrees. If the pitch of the threads is 2.5 mm, find the stresses induced in the copper sleeve and steel bolt.
   b. A steel rod 15 m long is at a temperature of 15^0C. Find the free expansion of the length when the temperature is raised to 65^0C. Find the temperature stress produced when:

(i) The expansion of the rod is prevented;

(ii) The rod is permitted to expand by 6 mm.

Take: $\propto = 12 \times 10^{-6}$ per^{0}C, And E =200 GN/m^2.

10.
   a. A circular rod 0.2 m long , tapers from 20 mm diameter at one end to 10 mm diameter at the other. On applying an axial pull of 6 KN, it was found to extend by 0.068 mm. find the Young's modulus of the material of the rod.
   b. A rigid bar is supported by three rods in the same vertical plane and equidistant. The outer rods are of brass and of length 600 mm and diameter 30 mm. The central rod is of steel of 200 mm length and 37.5 mm diameter. Calculate the forces in the bars due to an applied force P, if the bar remains horizontal after the load has been applied. Take E_s/E_b= 2

CHOOSE THE CORRECT ANSWER

1. In a tensile test, when the material is stressed beyond elastic limit, the tensile strain……….as compared to the stress
   a) Decreases slowly
   b) Increases slowly
   c) Decrease more quickly
   d) Increase more quickly
2. Modulud of rigidity is the ratio of
   a) Shear stress to shear strain
   b) Normal stress to normal strain
   c) Poisson's ratio to ultimate
   d) Lateral stress to lateral strain
3. The bulk modulus of materials is less than its young's modulus; the Poisson's ratio of the material is
   a) 0.45
   b) 0.15
   c) 0.35
   d) 0.50
4. Poisson's ratio of aluminum is usually adopted as

a) 0.22
b) 0.14
c) 0.30
d) 0.45

5. A solid cube is subjected to equal compressive stress on all the faces; the ratio of the volumetric strain to linear strain is
   a) 0.30
   b) 0.50
   c) 1.00
   d) 3.0
6. Shear force is usually associated with
   a) External loading
   b) Pure bending
   c) Both a&b
   d) None of the above
7. In plane structure a hinge support the
   a) One reaction
   b) Two reaction
   c) Three reaction
   d) No reaction
8. Between point loads the shear varies
   a) Constant
   b) Linearly
   c) Parabolic
   d) Cubically
9. The bending moment diagram due to uniformly varying load is
   a) Parabolic
   b) Elliptic
   c) Hyperbolic
   d) Cubic
10. The number of points of inflexion in a simply supported beam with U.D.L is
    a) 0
    b) 1
    c) 2
    d) 3

Unit-II: (Shear Force And Bending Moment)

Important points / Definitions:

- **Types of beams**
- **Shear foece**
- **Bending moment**
- **Reaction**
- **Uniform distributed load**
- **Uniform varying load**

SHORT ANSWER QUESTIONS [2M]

1. What do you mean by beam? Explain types of beam
2. Draw shear force and bending moment for a cantilever beam of span 2m carrying a point load 4kN at free end.
3. Define terms
   a. Shear force diameter
   b. Bending moment diagram.
4. Indicate the shape of bending moment diagram for uniform distributed load and varying load.
5. A cantilever beam of length 2m carries a U.d.l of 2kN/m over the whole length and a point load of 3kN at the free end. Draw the S.F and B.M diagrams.
6. A cantilever beam of length 2m carries a U.v.l of 2kN/m over the whole length and a point load of 3kN at the free end. Draw the S.F and B.M diagrams
7. Define point of contraflexure.
8. List any three important points to be kept in mind while drawing SFD and BMD.
9. Draw the SFD, BMD for a cantilever loaded with a clockwise couple of "M" at the free end.
10. Mention the different types of beams and types of supports.

LONG ANSWER QUESTIONS[5M]

1.
   a. A cantilever beam of length 4m carries point loads of 1kN, 2kN and 3kN at 1, 2 and 4m from the fixed end. Draw the S.F and B.M diagrams for the cantilever.
   b. A cantilever of length 4m carries a uniformly distributed load of 2kN/m run over the whole span and a point load of 2kN at a distance of 1m from the free end. Draw the S.F and B.M diagrams for the cantilever.

2.
   a. A cantilever of length 6m carries two point loads 2kN And 3kN at a distance of 1m and 6m from fixed end respectively. In addition to this the beam also carries a uniformly distributed load of 1kN/m over a length of 2m at a distance of 3m from the fixed end. Draw the S.F and B.M diagrams for the cantilever.
   b. A cantilever of length 4m carries a uniformly distributed load of 3kN/m run over a length of 1m from the fixed end. Draw the S.F and B.M diagrams for the

cantilever.

3.

a. A cantilever of length 6m carries a gradually varying load, zero at the free end to 2kN/m at the fixed end. Draw the S.F and B.M diagrams for the cantilever.
b. A simply supported beam of length 8m carries point loads of 4kN and 6kN at a distance of 2m and 4m from the left end. Draw the S.F and B.M diagrams for the beam.

4.

a. A simply supported beam of length 6m is carrying a uniformly distributed load of 2kN/m from the right end. Draw the S.F and B.M diagrams for the beam.
b. A beam of length 10m is simply supported and carries point loads of 5kN each at a distance of 3m and 7m from the left end and also a uniformly distributed load of 1kN/m between the point loads. Draw the S.F and B.M diagrams for the beam.

5.

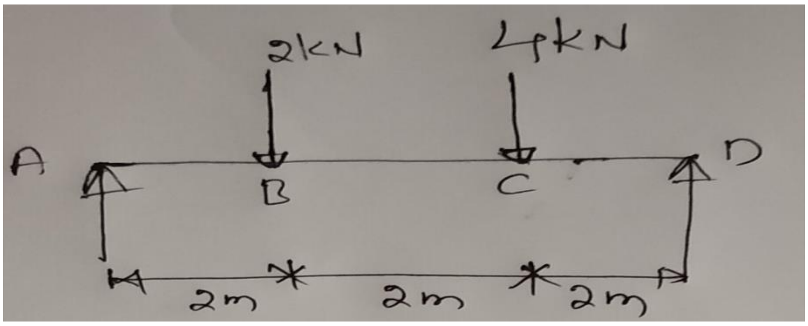
a. A beam of length 6m is simply supported at its ends. It is loaded with gradually varying load of 750N/m from left support to 1500N/m to the right support. Construct the S.F and B.M diagrams and find the position of maximum B.M over the beam.
b. A simply supported beam of length 8m rests on supports 6m apart, the right hand end is overhanging by 2m. The beam carries a uniformly distributed load of 1500N/m over the entire length. Draw S.F and B.M diagrams and find the point of contraflexure, if any.

6.

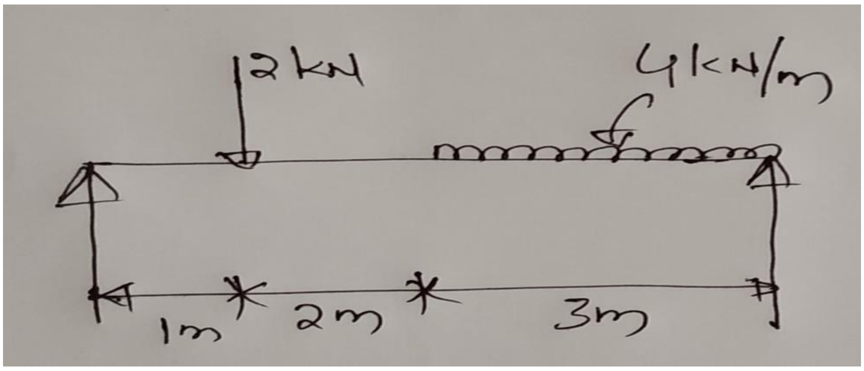
a. A cantilever of length 8m carries a gradually varying load, zero at the free end to 4kN/m at the fixed end. Draw the S.F and B.M diagrams for the cantilever.
b. A simply supported beam of length 6m carries point loads of 4kN and 7kN at a distance of 2m and 4m from the left end. Draw the S.F and B.M diagrams for the beam.

7.

a. Draw the shearing force and bending moment diagrams for the beam in figure and identify salientfeatures.

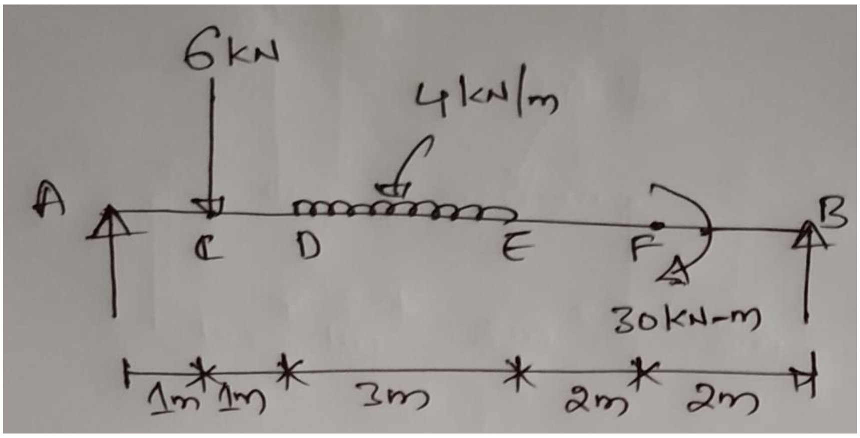


b. Draw the shearing force and bending moment diagrams for the beam in figure and identify salientfeatures.

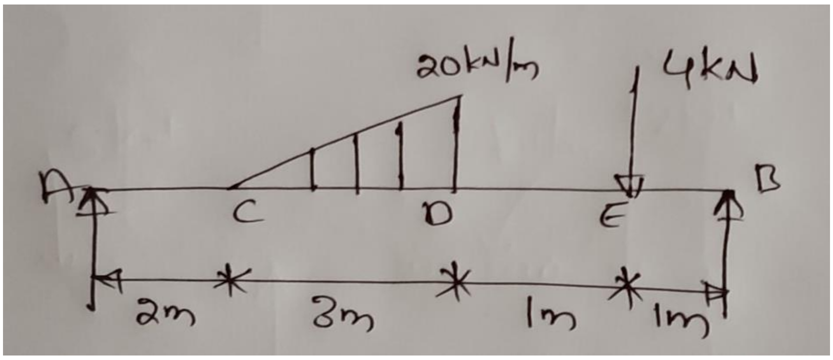


8.

a. Draw the shearing force and bending moment diagrams for the beam in figure and identify salientfeatures.

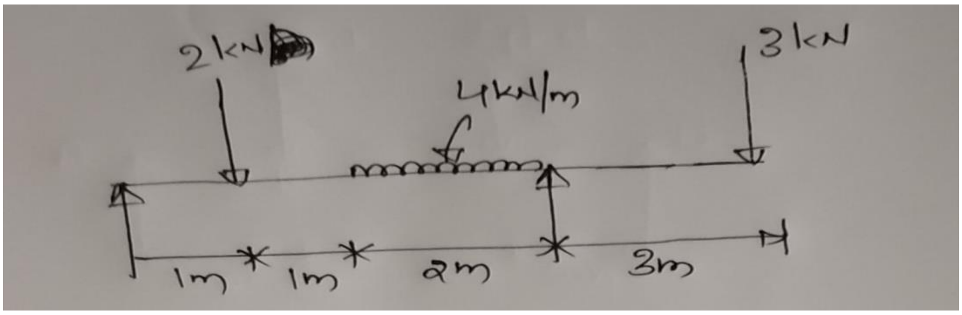


b. Draw the shearing force and bending moment diagrams for the beam in figure and identify salientfeatures.

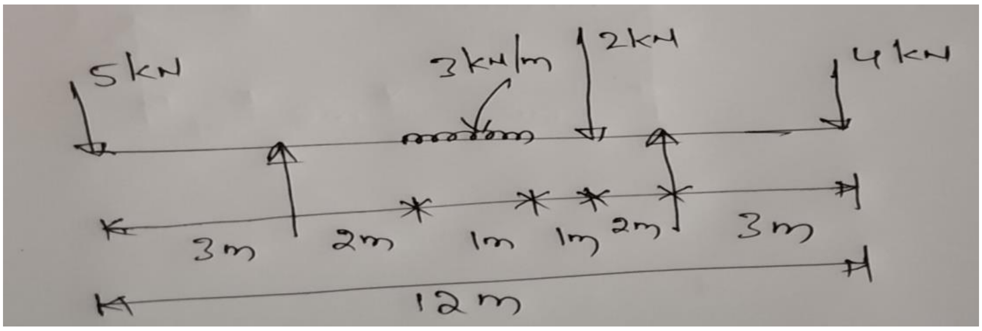


9.

a. Draw the SFD and BMD for a beam supported and located as shown in fig. locate the point of contraflexure.



b. Draw the SFD and BMD for a beam supported and located as shown in fig. locate the point of contraflexure.



10.

a. A cantilever of length 8m carries a gradually varying load, zero at the free end to 4kN/m at the fixed end. Draw the S.F and B.M diagrams for the cantilever.

b. A simply supported beam of length 8m carries point loads of 11kN and 9kN at a distance of 2m and 4m from the left end. Draw the S.F and B.M diagrams for the beam

CHOOSE THE CORRECT ANSWER

1. A cantilever of length 6m Is carrying a uniform distributed load of w per unit run for a distance 4m from the free end. The value of maximum bending moment is [ ]
   (a) 16w
   (b) 18.5w
   (c) 22w
   (d) 21w
2. Which of the following is giving correct relation between Load(w), shear force(F) and bending moment(M)
   (a) F=dM/dx
   (b) M=dF/dx

(c) W=dM/dx
(d) M=dw/dx

3. Bending stress on a beam section is zero at
(a) Depends on the shape of the beam
(b) Top fibre
(c) Bottom fibre
(d) Centroid of the section
4. Which of the following are the most efficient in carrying bending moments?
(a) Rectangular sections
(b) Circular sections
(c) I- sections
(d) T- sections
5. The ratio of the polar moment of inertia of a circular section to that of its second moment of area about a diagonal is
(a) 1.0
(b) 2.0
(c) Route of 2
(d) 0.50
6. The variation of shear stress over the cross section of a beam of T- section is
(a) Rectangular
(b) Parabolic
(c) Parabolic with a step
(d) Parabolic with two steps
7. Shear stress in a beam with rectangular cross section is maximum at
(a) Extreme top fibre
(b) Neutral axis
(c) Extreme bottom fibre
(d) Mid depth
8. The most efficient section to resist bending stress is
(a) Rectangular sections
(b) I-section
(c) T-section
(d) Circular section
9. In a beam of rectangular cross section, the ratio of the maximum shear stress to the average shear stress is
(a) 2.50
(b) 2.00
(c) 1.50
(d) 1.33
10. Which of the following end conditions permits the displacement in any direction and also rotation?
(a) Fixed end

(b) Hinged end
(c) Free end
(d) Roller end

Unit-III: (FLEXURAL STRESSES AND SHEAR STRESSES)

Important points / Definitions:

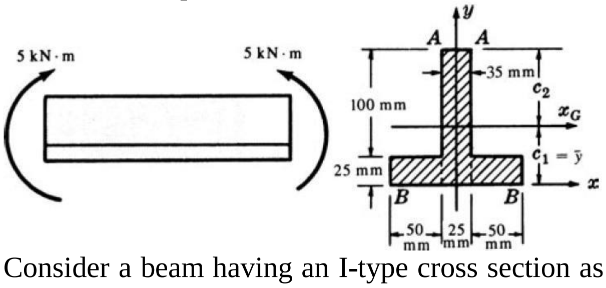
1. Capacity is defined as “the ability of individuals, organizations, organizational units and / or systems to perform functions effectively and in a sustainable manner.
2. Structural measures are any physical construction to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems.
3. Non-structural measures are measures not involving physical construction which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education.
4. Capacity assessment is a term for the process by which the capacity of a group is reviewed against desired goals, and the capacity gaps are identified for further action.
5. Counter disaster management is about trying to prevent disasters by being aware of the risks to collections and acting to minimize them.
6. Mainstreaming disaster risk reduction into sectoral programmes – environment, social and economic development practices, infrastructure, physical and technical measures e.g. land-use planning, urban and regional development.
7. Preparedness planning, contingency planning, early warning systems and vulnerability assessments.
8. Hazard analysis, risk assessment, impact assessment, early warning systems, risk mapping capacity and vulnerability analysis.
9. UNDP (United Nations Development Programme) defines capacity development as “the process through which individuals, organizations and societies obtain, strengthen and maintain the capabilities.
10. To design a project for capacity development for disaster risk reduction, it is important to first analyze and understand the local context, including general political, social, cultural, economic, physical and environ- mental factors.

SHORT ANSWER QUESTIONS [2M]

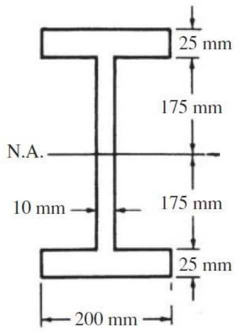
1. Define bending stress in a beam with a diagram.
2. Define pure bending and show an example by a figure.
3. Define neutral axis and where is it located in a beam.
4. What are the assumptions made in theory of simple bending?
5. Write the bending equation, defining all the terms in the equation.
6. Explain the terms: moment of resistance and section modulus
7. Explain the role of section modulus in defining the strength of a section.
8. Write the section modulus for a solid rectangular section.
9. Write the section modulus for a hollow rectangular section.
10. Write the section modulus for a solid circular section.

LONG ANSWER QUESTIONS [5M]

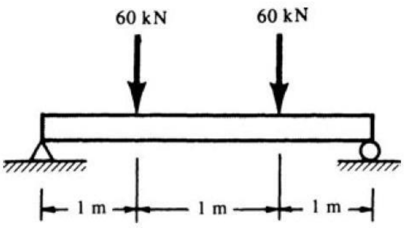
1. Derive the bending equation for a beam.
2. For a given stress, compare the moments of resistance of a beam of a square section, when placed (i) with its two sides horizontal and (ii) with its diagonal horizontal. Which is more suitable?
3. Three beams have the same length, the same allowable stress and the same bending moment. The cross-section of the beams are a square, a rectangle with depth twice the width and a circle. If all the three beams have the same flexural resistance capacity, then find the ratio of the weights of the beams. Which beam is most economical?
4. A rectangular beam 60 mm wide and 150 mm deep is simply supported over a span of 6 m. If the beam is subjected to central point load of 12 kN, find the maximum bending stress induced in the beam section.
5. A rectangular beam 300 mm deep is simply supported over a span of 4 m. What uniformly distributed load the beam may carry, if the bending stress is not to exceed 120 MPa. Take I = 225 x 10^6 mm^4.
6. A cantilever beam is rectangular in section having 80 mm width and 120 mm depth. If the cantilever is subjected to a point load of 6 kN at the free end and the bending stress is not to exceed 40 MPa, find the span of the cantilever beam?
7. A hollow square section with outer and inner dimensions of 50 mm and 40 mm respectively, is used as a cantilever of span 1 m. How much concentrated load can applied at the free end, if the maximum bending stress is not exceed 35 MPa?
8. A beam is loaded by one couple at each of its ends, the magnitude of each couple being 5 kN-m. The beam is of steel and has a T-type cross section with the dimensions indicated in Figure. Determine the maximum tensile stress in the beam and its location, and the maximum compressive stress and its location.



9. Consider a beam having an I-type cross section as shown in Fig. A shearing force *V* of 150 kN acts over the section. Determine the maximum and minimum values of the shearing stress in the vertical web of the section.



10. The beam shown in Fig. is simply supported at the ends and carries the two symmetrically placed loads of 60 kN each. If the working stress in either tension or compression is 125 MPa, what is the required moment ofinertia of area required for a 250-mm-deep beam?



CHOOSE THE CORRECT ANSWER

1. In a cantilever carrying a uniformly varying load starting from zero at the free end and reaching a maximum at fixed end, the shear force variation _________
2. The bending moment and displacement are related as___________________
3. Maximum deflection of a cantilever beam subjected to a concentrated load at free end is________________
4. Maximum deflection of a simply supported beam subjected to uniformly distributed load over entire span is_______________________
5. A cantilever of span 1 subjected to uniform distributed gravity loading w/m is subjected to an upward force P at a distance ½ from the free end. If the deflection at the free end of the beam is zero, (wl/p) is______________________
6. A point of contra-flexure is a point where ___________________
7. A circular section of 200mm diameter is subjected to a bending moment of 10kN-m. the maximum tensile stress caused in the section is____________________
8. A T-section with 300mm depth has 200x100mm flanges and 100x200mm web projection. It is subjected to a bending moment of 100kN-m. The approximately bending stress at top fibre is (in Mpa)__________________________
9. In case of a circular section, the maximum shear stress is _________________ percent more than the mean shear stress.
10. Section modulus of a circular section about an axis through its centre of gravity__________________

Unit-IV: (DEFLECTION OF BEAMS AND CONJUGATE BEAM METHOD)
Important points / Definitions:

- **Conjugate beam** is defined as the imaginary beam with the same dimensions (length) as that of the original beam but load at any point on the conjugate beam is equal to the bending moment at that point divided by EI.
- The **conjugate-beam method** is an engineering method to derive the slope and displacement of a beam.
- The conjugate-beam method was developed by H. Müller-Breslau in 1865. Essentially, it requires the same amount of computation as the moment-area theorems to determine a beam's slope or deflection.
- The basis for the method comes from the similarity of Eq. 1 and Eq 2 to Eq 3 and Eq 4. To show this similarity, these equations are shown below.

$Eq.1 \ \frac{dV}{dx} = w$	$Eq.3 \ \frac{d^2M}{dx^2} = w$
$Eq.2 \ \frac{d\theta}{dx} = \frac{M}{EI}$	$Eq.4 \ \frac{d^2v}{dx^2} = \frac{M}{EI}$

- Here the shear V compares with the slope θ, the moment M compares with the displacement v, and the external load w compares with the M/EI diagram. Below is a shear, moment, and deflection diagram. A M/EI diagram is a moment diagram divided by the beam's Young's modulus and moment of inertia.
- Theorem 1: The slope at a point in the real beam is numerically equal to the shear at the corresponding point in the conjugate beam.
- Theorem 2: The displacement of a point in the real beam is numerically equal to the moment at the corresponding point in the conjugate beam

Conjugate beam

- Draw the conjugate beam for the real beam. This beam has the same length as the real beam and has corresponding supports as listed above.
- In general, if the real support allows a slope, the conjugate support must develop shear; and if the real support allows a displacement, the conjugate support must develop a moment.
- The conjugate beam is loaded with the real beam's M/EI diagram. This loading is assumed to be distributed over the conjugate beam and is directed upward when M/EI is positive and downward when M/EI is negative. In other words, the loading always acts away from the beam

SHORT ANSWER QUESTIONS [2M]

1. Define column and effective length of a column.
2. Distinguish between a column and a strut.
3. Distinguish between short column and long column
4. Define slenderness ratio, crippling load.
5. Explain the Limitations of Euler‘s Formula?

6. What are the assumptions made in Euler's theory to arrive at buckling load on column.
7. Calculate the slenderness ratio of a strut made from a hollow tube of 20mm outside diameter, 16mm inside diameter and 1.2m long.
8. State the secant formula and explain each of the terms in it.
9. Why is it necessary to use the minimum radius of gyration of a section to calculate the crippling load?
10. What is the slenderness ratios of the column of square section of 30 mm side and length 2 m.
11. Explain the parameters influencing buckling load of a long column.

LONG ANSWER QUESTIONS [5M]

1. Calculate the maximum stress in a propeller shaft with a 400mm external and 200mm internal diameter, when subjected to a twisting moment of 4650Nm. If the modulus of rigidity, C=82GN/m^2, how much is the twist in a length 20 times the diameter?
2. The stiffness of a closely coiled helical spring is 1.5 N/mm of compression under a maximum load of 100N. The maximum shearing stress produced in the wire of the spring is 130 N/mm2. The solid length of the spring (when the coils are touching) is given as 5cm. Find (i) Diameter of the wire (ii) Mean diameter of the coils and (iii) No. of coils required. Take C=4.5X10^4 N/mm^2
3. Determine the diameter of a solid steel shaft which will transmit 112.5kW at 200rpm. Also determine the length of the shaft if the twist must not exceed 1.50 over the entire length. The maximum shear stress is limited to 55 N/mm2. Take G = 8x10^4 N/mm^2
4. The internal diameter of a hollow shaft is 2/3^{rd} of its external diameter.Compare its resistance to torsion with that of solid shaft of the same weight and material.
5. A hollow shaft of diameter ratio 3/5 is required to transmit 800kW at 110rpm. The maximum torque being 20% greater than the mean. The shear stress is not to exceed 63MPa and the twist in a length of 3m is not to exceed 1.40. Calculate the minimum external diameter satisfying these conditions.
6. A propeller shaft 280mm in diameter transmits 2.5mW at 250rpm. The propeller weighs 50kN and overhangs its support by 400mm. If the propeller thrust is of 123kN weights. Calculate the maximum principal stress induced in the cross-section and indicates its position. C=80MPa
7. A hollow circular shaft, of outside diameter 50 mm and inside diameter36 mm, is made of steel, for which the permissible stress in shear is 90 MPa and G = 85 GPa. Find the maximum torque that such a shaft can carry and the angle of twist per metre length.

CHOOSE THE CORRECT ANSWER

1. Conjugate-Beam method was developed by:-
   a) Hooke
   b) Otto mohr
   c) Charles E.greene
   d) H.muller-Breslau

2. In this method, shear compare with:-
   a) **Slope**
   b) Moment
   c) Displacement
   d) External load

3. In this method, moment compare with:-
   a) Slope
   b) Shear
   c) **Displacement**
   d) External load

4. If L is length of conjugate beam and l is length of real beam then:
   a) L > l
   b) L < l
   c) **L = l**
   d) Can't say

5. While converting a beam into its conjugate one, end supports remain same. This statement is:-
   a) Always true
   b) Always false
   c) **Can't say**
   d) Depends upon type of load

6. Pin joint is replaced by __________ in conjugate beam.
   a) Roller
   b) **Pin**
   c) Fixed support
   d) Link

7. Roller is replaced by fixed joint in conjugate beam.
   State whether the above statement is true or false.
   a) True
   b**) False**

8. Fixed joint is replaced by ___________ in conjugate beam.
   a) Roller
   b) Pin
   c**) Free end**
   d) Link

9. Free end is replaced by __________ in conjugate beam.
   a) Roller
   b) Pin
   c) **Fixed support**
   d) Link

10. Internal pin is replaced by ___________ in conjugate beam.
    a) Roller
    b) Pin
    c) Fixed support
    d) **Hinge**

Unit-V: (Principal Stresses and Strains and Theories of Failure)

Important points / Definitions:

Maximum principal stress theory- Good for brittle materials

- According to this theory when the maximum principal stress induced in a material under complex load condition exceeds the maximum normal strength in a simple tension test the material fails. So the failure condition can be expressed as

$$\sigma_1 \geq \sigma_{ult}$$

- ***Maximum shear stress theory – Good for ductile materials***

According to this theory when the maximum shear strength in actual case exceeds maximum allowable shear stress in simple tension test the material case. Maximum shear stress in actual case in represented as

$$\tau_{max,act} = \frac{\sigma_1 - \sigma_3}{2}$$

- Maximum shear stress in simple tension case occurs at angle 45 with load, so maximum shear strength in a simple tension case can be represented as

$$\tau_{45} = \tau_{max,simp} = \frac{\sigma_y}{2}$$

- Comparing these 2 quantities one can write the failure condition as

$$\frac{1}{2}(\sigma_1 - \sigma_3) \geq \frac{1}{2}\sigma_y$$

Maximum normal strain theory – Not recommended

- This theory states that, when the maximum normal strain in actual case is more than maximum normal strain occurred in simple tension test case the material fails. The maximum normal strain in actual case is given by

$$strain_{max,act} = \frac{\sigma_1}{E} - v\frac{\sigma_2}{E} - v\frac{\sigma_3}{E}$$

- Maximum strain in simple tension test case is given by

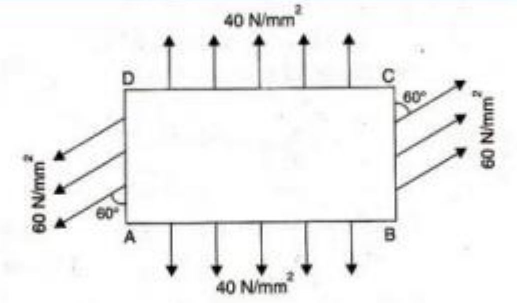
$$strain_{max} = \frac{\sigma_y}{E}$$

SHORT ANSWER QUESTIONS [2M]

1. Define deflection and slope.
2. List out the different methods for finding slope and deflection of a beam.
3. What is Macaulay's method? Where is it used?
4. Define Principal plane.
5. Define principal stress. What are the methods used
6. What are the methods used to determine the stresses on oblique section?

LONG ANSWER QUESTIONS[5M]

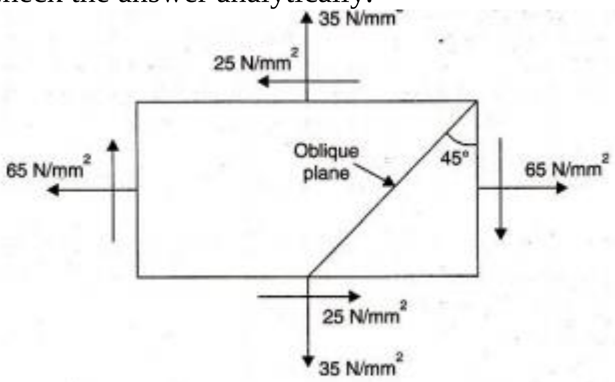
1. The stresses at a point in a bar are 200 N/mm2 (tensile) and 100 N/mm2 (compressive). Determine the resultant stress in magnitude and direction on a plane inclined at 60o to the axis of major stress. Also determine the maximum intensity of shear stress in the material at that point?
2. A point in a strained material is subjected to the stresses as shown in figure. Locate the principal planes, and evaluate the principal stresses.



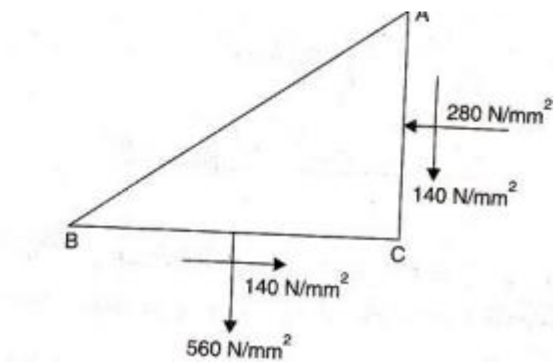
3. The normal stress in two mutually perpendicular directions are 600 N/mm2 and 300 N/mm2 both tensile. The complimentary shear stress in these directions is of

intensities 450 N/mm2 . Find the normal and tangential stresses on the two planes which are equally inclined to the plane carrying the normal stress mentioned above.

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



5. At a point in a strained material, on plane BC there are normal and shear stresses of 560 N/mm2 and 140 N/mm2 respectively. On plane AC, perpendicular to plane BC, there are normal and shear stresses of 280 N/mm2 and 140 N/mm2 respectively as shown in the figure. Determine the following: (i) principal stresses and location on which they act; (ii) maximum shear stress and the plane on which it acts.



6. The principal stresses at a point in a elastic material are 22 N/mm2 (tensile), 110N/mm2 (tensile) and 55 N/mm2 (compressive). If the elastic limit in simpletension is 220 N/mm2 and μ = 0.3, then determine whether the failure of material will occur or not according to (i) Maximum principal stress theory (ii) Maximum principal strain theory (iii) Maximum shear stress theory (iv) Maximum strain energy theorem (v) Maximum shear strain energy theory

7. Determine the diameter of a bolt which is subjected to an axial pull of 12 kN together with a transverse shear force of 6kN, when the elastic limit in tension is 300 N/mm2 , factor of safety = 3 and μ = 0.3 using (i) Maximum principal stress theory (ii) Maximum principal strain theory (iii) Maximum shear stress theory (iv) Maximum strain energy theorem (v) Maximum shear strain energy theory

8. In a two dimensional stress system, the direct stresses on two mutually perpendicular planes are 120MN/mm2 . These planes also carry a shear stress of 40MN/mm2 . If the factor of safety on elastic limit is 3, then find: (i) the value of stress when shear strain energy is minimum; (ii) elastic limit of material in simple tension.

CHOOSE THE CORRECT ANSWER

1. The normal stress is perpendicular to the area under considerations, while the shear stress acts over the area.
   a**) True**
   b) False

2. If a body is subjected to stresses in xy plane with stresses of 60N/mm² and 80N/mm² acting along x and y axes respectively. Also the shear stress acting is 20N/mm²Find the maximum amount of shear stress to which the body is subjected.
   a**) 22.4mm**
   b) 25mm
   c) 26.3mm
   d) 27.2mm

3. If a body is subjected to stresses in xy plane with stresses of 60N/mm² and 80N/mm² acting along x and y axes respectively. Also the shear stress acting is 10N/mm². Find the inclination of the plane in which shear stress is maximal.
   a) **45'**
   b) 30'
   c) 60'
   d) 15'

4. If a body is subjected to stresses in xy plane with stresses of 60N/mm² and 80N/mm² acting along x and y axes respectively. Also the shear stress acting is 20N/mm². Find the maximum normal stress.
   a) 90
   b**) 92.4**
   c) 94.2
   d) 96

5. If a body is subjected to stresses in xy plane with stresses of 60N/mm² and 80N/mm² acting along x and y axes respectively. Also the shear stress acting is 20N/mm². Find the minimum normal stress.
   a) 45.4
   b) **47.6**
   c) 48.2
   d) 50.6

6. If compressive yield stress and tensile yield stress are equivalent, then region of safety from maximum principal stress theory is of which shape?
   a) Rectangle
   b) **Square**
   c) Circle
   d) Ellipse

7. Maximum Principal Stress Theory is not good for brittle materials.

a) True
b) **False**

8. The region of safety in maximum shear stress theory contains which of the given shape
a) **Hexagon**
b) Rectangle
c) Square
d) None of the mentioned

9. The total strain energy for a unit cube subjected to three principal stresses is given by?
a) U= $[(\sigma\acute{\varepsilon})_1 + (\sigma\acute{\varepsilon})_2 + (\sigma\acute{\varepsilon})_3]/3$
b) **U= $[(\sigma_1^2+\sigma_2^2+\sigma_3^2)/2E] - (\sigma_1\sigma_2+\sigma_2\sigma_3+\sigma_3\sigma_1)2\mu$**
c) U= $[(\sigma\acute{\varepsilon})_1 + (\sigma\acute{\varepsilon})_2 + (\sigma\acute{\varepsilon})_3]/4$
d) None of the mentioned

10. Distortion energy theory is slightly liberal as compared to maximum shear stress theory.
a) **True**
b) False