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Department of CIVIL Engineering
Academic Year: 2019-20 (Odd Semester)

Question Bank

Course Code & Title: CE8301 STRENGTH OF MATERIALS I
Semester & Branch: III Semester B.E. and CIVIL Engineering.

UNIT 1

Part 'A' Two Marks Question:

Q.1 What is Strength of materials?
Ans:

- In mechanics of materials, the strength of a material is its ability to withstand an applied load without failure or plastic deformation.
- The field of strength of materials deals with forces and deformations that result from their acting on a material.
- This concept of strength of materials is applied to solve various problems regarding the properties of a materials and the behaviour of a material under different loading conditions and other parameters.

Q.2 What are the three types of stresses?
Ans: Broadly there are 5 types of stress:

- Axial stresses or longitudinal stress
  a. Tensile stress
  b. Compressive stress
- Bending stress
- Volumetric stress
- Shear stress
- Thermal stress

Q.3 What is the use Mohr's Circle?
Ans:

- Generally Mohr's Circle is a graphical method used to find out the stresses acting on a body in any oblique or inclined plane.
- Mohr's circle can be used conveniently to find the normal and shear stresses on a plane when the magnitude and direction of the principal stresses at a point are known.

Q.4 Define modulus of elasticity and modulus of rigidity.
Ans:

- **Modulus of elasticity** (also known as elastic modulus, the coefficient of elasticity) of a material is a number which is defined by the ratio of the applied stress to the corresponding strain within the elastic limit. Physically it indicates a material's resistance to being deformed when a stress is applied to it.

- **The modulus of rigidity**, also known as **Shear modulus**, is defined as the ratio of shear stress to shear strain of a structural member. This property depends on the material of the member: the more elastic the member, the higher the modulus of rigidity.

Q.5 Explain upper yield point and lower yield point and plastic range in a Stress-Strain curve. For what type of steel we can expect upper and lower yield point?

Ans: Upper yield point is the point at which the material starts its plastic stage and in this point, the cross sectional area of the materials starts decreasing.

After this, the stress decreases with the increase of strain finally the stress decreases to its lower value followed by strain hardening, called as lower yield point.

For Mild steel we can expect the same as mentioned in question.

Q.6 State Hooke's law.

Ans: Hooke's law states that "at constant temperature and at elastic limit, the stress induced in a body for any external applied load, is directly proportional to the strain produced in that body".

Thus mathematically,

Stress α Strain

Or, $\sigma \ \alpha \ e$

Or, $\sigma = k \, . \, e$

Where k is the constant of proportionality known as elastic modulus or Young's modulus.

Q.7. What is meant by limit of proportionality?

Ans:

- Limit of proportionality is a stress up to which Hooke's law is applicable. It is slightly less than the elastic limit.
- It is applicable to find the safe stress in elastic limit.

Q.8. Define principal plane and principal stresses?

Ans:

The planes, which have no shear stress, are known as principal planes. Thus principal stresses are the stresses of zero shear stress. These planes carry only shear stresses.

The normal stresses which are acting on a principal plane, are known as principal stresses.

Q.9. What are the methods used to determine stresses in oblique planes?

Ans: (a) Analytical method and **(b)** Graphical Method

Q.10. Find the stress and strain in a body, which is applied by a force of 2000 N. Take area of the cross section as 200mm^2 and E = 2.1 x 10^{5}N/mm^2.

Ans: Force (P) = 2000 N; Area of cross section = 200 mm^2; E = 2.1 x 10^{5}N/mm^2.

Thus, Stress = P/A = 2000/200 = 10 N/mm^2

Strain = Stress / E = (10 / 2.1 x 10^5) = 0.000047619

Q.11. What is meant by Stiffness?

Ans:

- Stiffness is defined by the property by virtue of which a body resist the deformation in it when any external load is applied.
- It is also referred by the amount of load acting per unit deformation of the body.
- Stiffness is a material property of a body which is used to find out the rigidity and the flexibility of a material and body as well.

Mathematically, Stiffness = Force / Deflection.

Q.12. Write the Principal of Superposition.

Ans: Principal of superposition states that, *"when a number of loads are acting on a body, the resulting strain is equal to the algebraic sum of the all the strains caused by individual forces."*

Q.13. What is Factor of safety?

Ans: Factor safety (FOS) is defined as the ratio of ultimate stress and permissible stress.

Thus, FOS = ultimate stress / permissible stress.

Q.14. Write a note on Lateral strain.

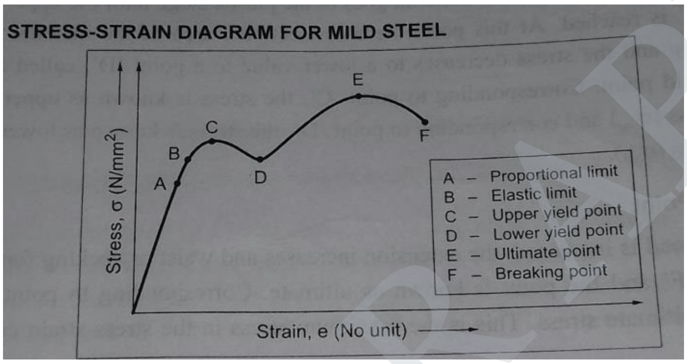
Ans: In continuum mechanics, lateral strain, also known as transverse strain, is defined as the ratio of the change in diameter of a circular bar of a material to its diameter due to deformation in the longitudinal direction.

Q.15. What should be the angle in between the principal plane and plane of max. shear stress and the angles between the principal planes?

Ans: The angle between the principal plane and plane of max. shear stress is 45 degree and the angles between the principal planes is 90 degree.

Q.16. Draw the stress strain diagram for Mild Steel.

Ans:



Q.17. Define shear stress and shear strain.

Ans: When two equal and opposite forces are acting in a tangentially on any of the cross sectional plane of a body tending to slide one part of the body over the other part is called as shear stress and the corresponding strain produced is called as shear stress.

Q.18. Define Bulk modulus.

Ans: When a body is stressed with in the elastic limit, the ratio of direct stress to the corresponding volumetric strain is constant. This ratio is known as bulk modulus. It is denoted by 'K'

Thus, Bulk modulus (K) = (Direct stress / Volumetric strain)

Q.19. What is thermal stress and Thermal strain?

Ans: If the ends of a body are fixed at the supports, so that its expansion is prevented, then compressive stress and strain is set up in the rod. These stresses and strains are known as thermal stresses and thermal strains.

Q.20. Define Modular ratio.

Ans: Modular ratio is the ratio of Young's Moduli of Elasticity of two different materials in construction by composite materials. For example, in a composite bar consisting of two different materials, one having Young's modulus E_1 and other having Young's modulus E_2, then modular ratio is given by $\mathbf{E_1 / E_2}$.

Q.21. What is composite bar?

Ans:

- A composite bar made of two bars of different materials rigidly fixed together so that both bars strain together under external load.
- Since strains in the two bars are same, the stresses in the two bars depend on their Young's modulus of elasticity.
- In other words, a stiffer bar will share major part of external load.

Q.22. What is strain hardening in Stress-Strain curve? Which type of metal will have this property?
Ans:

- When a metal is stressed beyond its elastic limit it enters the plastic region (The region in which residual strain remains upon unloading). When the load is increased further (a kind of rearrangement occurs at atom level and the mobility of the dislocation decreases), dislocation density increases that in turn makes the metal harder and stronger through the resulting plastic deformation.
- It means, it's more difficult to deform the metal as the strain increases and hence it's called "strain hardening". This tends to increase the strength of the metal and decrease its ductility.
- Strain hardening is generally defined as heating at a relatively low temperature after cold-working. During strain hardening the strength of the metal is increased and ductility decreased

Part 'B' Question (13 /15 marks):

Q.1. A tensile test was conducted on a mild steel bar. The following data was obtained from the test:

(i) Diameter of the steel bar = 3 cm
(ii) Gauge length of the bar = 20cm
(iii) Load at elastic limit = 250kN
(iv) Extension at a load of 150kN = 0.21 mm
(v) Maximum load = 380kN
(vi) Total extension = 60 mm
(vii) Diameter of rod at failure = 2.25 cm

Determine:

(1) The Young's modulus
(2) The stress at elastic limit
(3) The percentage of elongation
(4) The percentage decrease in area.

Q.2. Three bars made of copper; zinc and aluminium are of equal length and have cross section 500, 700, and 1000 sq.mm respectively. They are rigidly connected at their ends. If this compound member is subjected to a longitudinal pull of 250kN, 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 N/mm^2, for zinc = 1×105 N/mm^2 and for aluminium = 0.8×105 N/mm^2.

Q.3. A bar 0.3m long is 50mm square in section for 120mm of its length, 25mm diameter for 80mm and of 40mm diameter for its remaining length. If the tensile force of 100kN is applied to the bar calculate the maximum and minimum stresses produced in it, and the total elongation. Take E = 2×105 N/mm^2 and assume uniform distribution of stress over the cross section.

Q.4. A bar of 25mm diameter is subjected to a pull of 40kN. The measured extension on gauge length of 200mm is 0.085mm and the change in diameter is 0.003mm.Calculate the value of Poisson's ratio and the three moduli.

Q.5. A hollow cylinder 2m long has an outside diameter of 50 mm and inside diameter of 30 mm. If the cylinder is carrying a load of 25kN, find the stress in the cylinder. Also find the deformation of the cylinder, if the value of modulus of elasticity for the cylinder material is 100GPa.

Q.6. A short metallic column of $500mm^2$ cross sectional area carries a axial compressive load of 100kN.For a plane inclined at 60^o with the direction of the load.
Calculate:

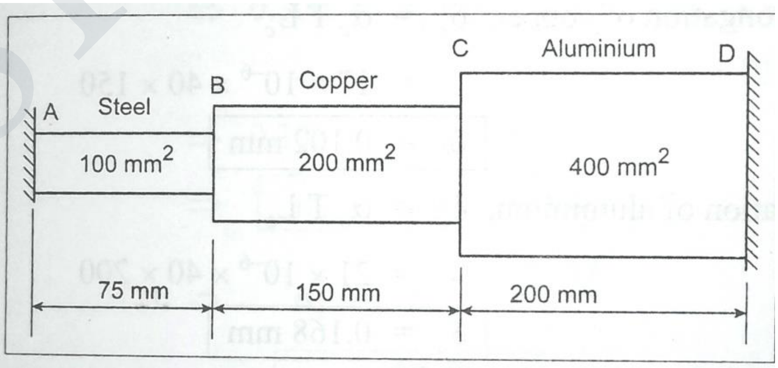
i) Normal stress
ii) Resultant stress
iii) Tangential stress
iv) Maximum shear stress
v) Obliquity of resultant stress.

Q.7. (i) Derive a relation for change in length of a bar hanging freely under its own weight.
(ii) Draw stress - strain curve for a mild steel rod subjected to tension and explain about the salient points on it.

Q.8. (i) Derive the relationship between bulk modulus and young's modulus.
(ii) Derive relations for normal and shear stresses acting on an inclined plane at a point in a stained material subjected to two mutually perpendicular direct stresses.

Q.9. Two vertical rods one of steel and other of copper are rigidly fixed at the top and 80cm apart. Diameter and length of each rod are 3cm and 3.5m respectively. A cross bar fixed to the rods at lower ends carries a load of 6kN such that the cross bar remains horizontal even after loading. Find the stress in each rod and position of load on the bar. Take E for steel as 2×10^5 N/mm^2 and for copper as 1×10^5 N/mm^2.

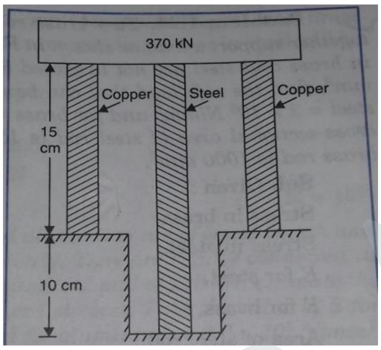
Q.10. A rod is made up of brass, copper and aluminium as shown in the figure, which is held in between two rigid supports A and D. Calculate the stress developed in each of the materials when the temperature of the system is raised by 40 degree centigrade. Take Es = 2.1 x 10^5 N/mm^2, Ec = 1.1 x 10^5 N/mm^2, Ea = 0.7 x 10^5 N/mm^2. The coefficients of thermal expansion for steel, copper and aluminium are 12 x 10^{-6}, 17 x 10^{-6} and 21 x 10^{-6} per degree centigrade respectively.



Q.11. A gun metal rod 25mm diameter screwed at the end passes through a steel tube of 30mm and 35mm internal and external diameters respectively. The temperature of the whole assembly is raised to 125 degree centigrade and the nuts on the rod are then screwed lightly home on the ends of the tube. Calculate the stresses developed in gun metal and steel tube when temperature of the assembly fallen to 20 degree centigrade. Take Eg = 1×10^5 N/mm^2, Es = 2.1×10^5 N/mm^2, $\alpha g = 20 \times 10^{-6}$ /°C and $\alpha s = 12 \times 10^{-6}$ /°C.

Q.12. A tensile load of 40kN is acting on a rod of diameter 40mm and of length 4m. A bore of diameter 20mm is made centrally on the rod. To what length the rod should be bored so that the total extension will 30% under the same tensile load. Take E = 2×10^5 N/mm^2.

Q.13. A steel rod and two copper rods together support a load of 370kN as shown in the figure. The cross sectional area of the steel rod is 2500mm^2 and of each copper rod is 1600mm^2. Find the stresses in the rods. Take Es = 2.1×10^5 N/mm^2 and Ec = 1×10^5 N/mm^2.



Q.14. Two brass rods and one steel rod together support a load as shown in figure. If the stresses in brass and steel are not to exceed 60 N/mm^2 and 120 N/mm^2, find the safe load that can be supported. Take Es = 2.1×10^5 N/mm^2 and Eb = 1×10^5 N/mm^2. The cross sectional area of steel rod is 1500 sq.mm and each of the brass rod is 1000 sq.mm.

Unit II

Part 'A' Two mark Questions

Q.1. What is the maximum bending moment for a simply supported beam subjected to uniformly distributed load and where it occurs?

Ans: The maximum bending moment fir a simply supported beam subjected to UDL is $(WL^2)/8$. The maximum moment occurs at the middle portion of the beam.

Q.2. Define shear stress.

Ans: When two equal and opposite forces are acting in a tangentially on any of the cross sectional plane of a body tending to slide one part of the body over the other part is called as shear stress.

Q.3. What is shear force in a beam?

Ans:

- Shear force in a beam is the force in the beam acting perpendicular to its longitudinal (x) axis.
- For design purposes, the beam's ability to resist shear force is more important than its ability to resist an axial force.
- The shear forces at the ends of the beam are equal to the vertical forces of the support reactions.

Q.4. What is bending moment in a beam?

Ans:

- A bending moment is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend.
- The most common or simplest structural element subjected to bending moments is the beam.

Q.5. List the types of supports.

Ans: The types of supports are:

- Simply support
- Hinged support
- Fixed support
- Roller support

Q.6. Write the relation between bending moment and shear force.

Ans:

- A force that tends to bend the beam downward is said to produce a positive bending moment.
- A force that tends to shear the left portion of the beam upward with respect to the right portion is said to produce a positive shearing force.

Q.7. What is meant by section modulus?

Ans:

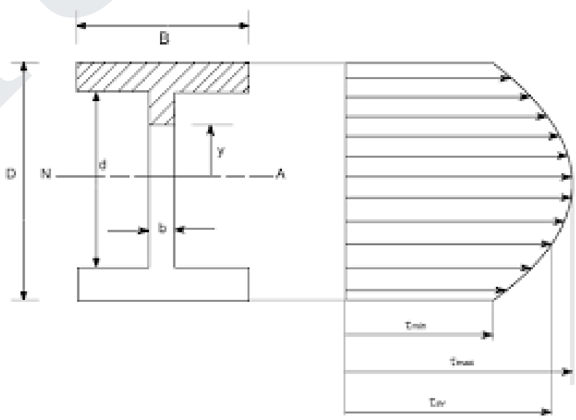
- Section Modulus. It is termed as the ratio of second moment of area and distance from N.A (Neutral axis) to the extreme fibre.
- Also it is the measure of strength of given member. The stress in the outermost section of beam is computed with the help of section modulus.

Q.8. What is the differential relation between bending moment, shear force and the applied load?

Ans: Relationship between Load, Shear, and Moment. Thus, the rate of change of the bending moment with respect to x is equal to the shearing force, or the slope of the moment diagram at the given point is the shear at that point.

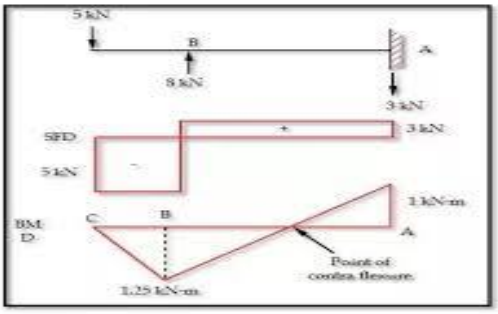
Q.9. Sketch the shear stress variation for symmetrical I section

Ans:



Q.10. What do you meant by point of contraflexure?

Ans: In a bending beam, a point is known as a point of contraflexure if it is a location where bending moment is zero (changes its sign). In a bending moment diagram, it is the point at which the bending moment curve intersects with the zero line.



Distance of point of contra flexure from A is $\frac{1}{3} = 0.333$ m

Q.11. What is meant by moment of resistance of a beam?

Ans: Moment of resistance, usually denoted as (W) is a term in structural engineering. It is found from the moment of inertia (I) and the distance from the outside of the object concerned to its major axis. Simply, moment of resistance means couple produce when a beam subjected to bending under the action of loads.

Q.12. Write any four assumptions in the theory of simple bending.

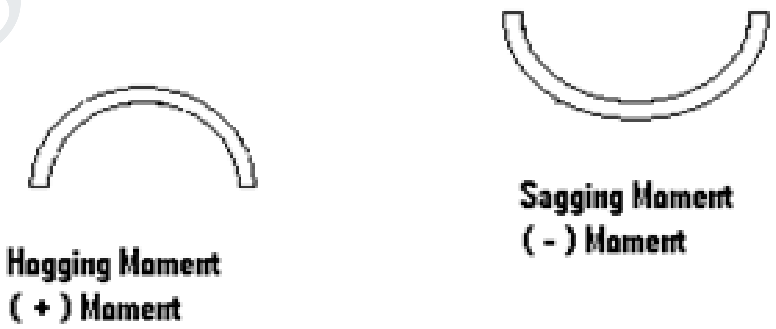
Ans:

- The material of the beam is homogeneous and isotropic.
- The value of Young's Modulus of Elasticity is same in tension and compression.
- The transverse sections which were plane before bending, remain plane after bending also.
- The material should obey Hooke's law.

Q.13. Differentiate between hogging and sagging bending moment.

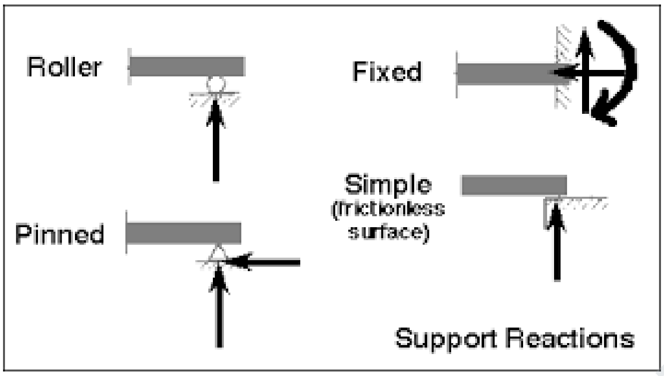
Ans:

- Sagging and Hogging are the terms used to define the sign of a bending moment.
- The bending moment which causes a beam to bend with the concave side upwards, is called a **Sagging Bending Moment**. This kind of bending moment is treated as a positive bending moment.
- The bending moment which causes a beam to bend with the concave side downwards, is called a **Hogging Bending Moment**. This kind of bending moment is treated as a negative bending moment.



Q.14. Sketch any 2 types of supports used for a beam indicating the reactions in each case.

Ans:



Q.15. How would you find the bending stress in unsymmetrical sections?

Ans: When a section of a beam is not symmetrical about the plane of bending, an unsymmetrical bending takes place, i.e., in addition to bending, due to applied loads twisting is observed in the beam. Then there are principal axes of the section where the product of inertia is zero.

Q.16. How do you locate the point of maximum bending moment?

Ans:

- The maximum bending moment occurs in a beam, when the shear force at that section is zero or changes the sign because at point of contra flexure the bending moment is zero.
- Thus the point at which the shear force diagram is touching the x axis or the point at which the shear force is zero is the point of maximum bending moment.

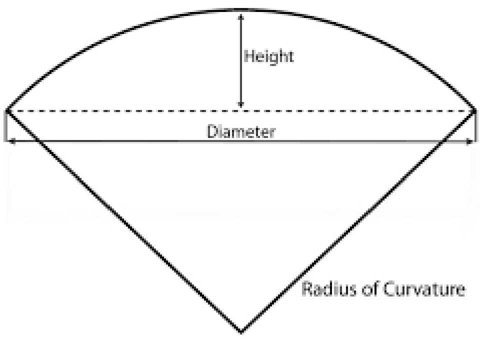
Q.17. What do you understand by neutral axis ? How do you locate Neutral axis?

Ans:

- A line or plane through a beam or plate connecting points at which no extension or compression occurs when it is bent is called as neutral axis.
- Using the force and Moment equilibrium, you can find the location of neutral axis. The natural axis is the axis where there is no stress. Generally this could be calculated by dividing the section of the beam into differential elements.

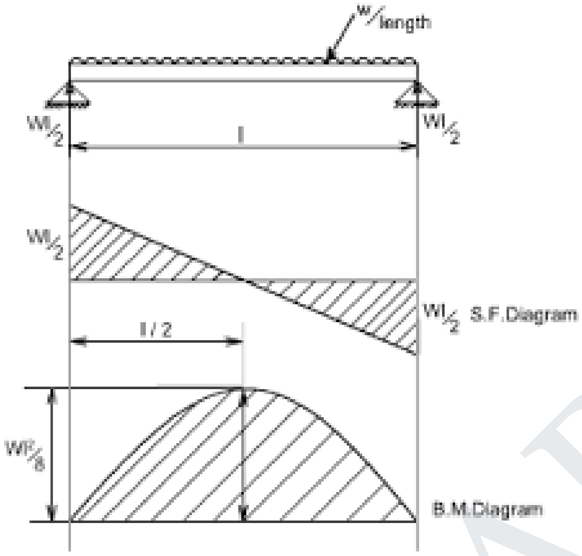
Q.18. What is radius of Curvature?

Ans: The radius of a circle which touches a curve at a given point and has the same tangent and curvature at that point.



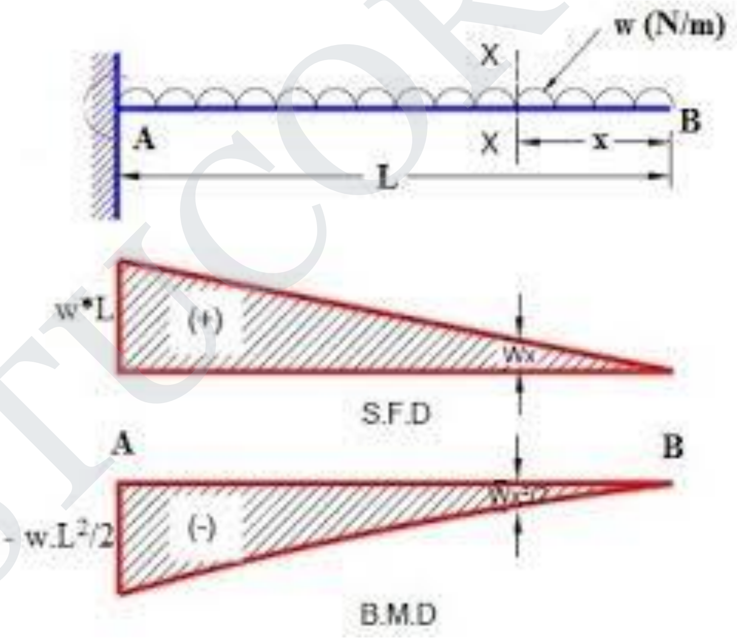
Q.19. Draw the shear force and bending moment diagram of a simply supported beam with UDL throughout the span of the beam.

Ans:



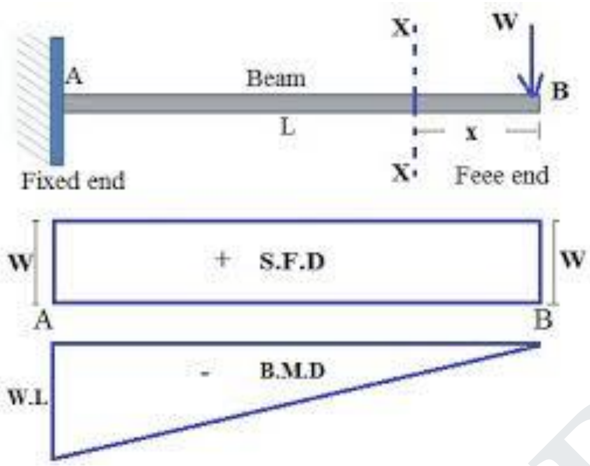
Q.20. Draw the shear force and bending moment diagram for a cantilever beam with UDL throughout the span of the beam.

Ans:



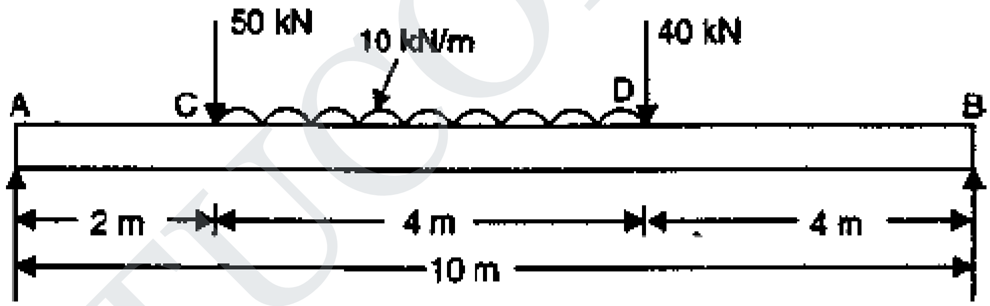
Q.21. Draw the shear force and bending moment diagram for a cantilever beam with point load at the free end point of the beam.

Ans:



Part 'B' Question (13 / 15 marks):

Q.1. A simply supported beam of length 10m carries the uniformly distributed load and two point loads as shown in Fig. Draw the S.F and B.M diagram for the beam and also calculate the maximum bending moment.



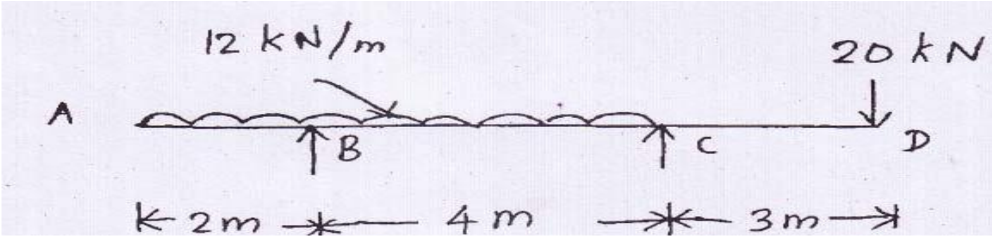
Q.2. (i) Derive an expression for bending moment equation.

(ii) A rectangular beam 300 mm deep is simply supported over the span of 4 m. Determine the uniformly distributed load per metre which the beam may carry, if the bending stress should not exceed 120N/mm2. Take I=8×106 mm^4.

Q.3. A cantilever beam of 2 m long carries a uniformly distributed load of 1.5 kN/m over a length of 1.6 m from the free end. Draws shear force and bending moment diagrams for the beam.

Q.4. A simply supported beam 6 m long is carrying a uniformly distributed load of 5 kN/m over a length of 3 m from the right end. Draw shear force and bending moment diagrams for the beam and also calculate the maximum bending moment on the beam.

Q.5. Draw shear force and bending moment diagram for the beam given in Fig.



Q.6. State the assumptions made in the theory of simple bending and derive the bending formula.

Q.7. A 100mm X 200mm rolled steel I section has the flanges 12mm thick and web 10mm thick.
Find:

(i) The safe udl the section can carry over a span of 6m if the permissible stress is limited to 150 N/mm^2

(ii) The maximum bending stress when the beam carries a central point load of 20kN.

Q.8. The cross section of T beam is as follows: Flange thickness = 10mm; width of the flange = 100mm; thickness of the web = 10mm; depth of the web = 120mm; If a shear force of 2kN is acting at a particular section of the beam draw the shear stress distribution across the section.

Q.9. An overhanging beam ABC is simply supported at A & B over a span of 6m and BC overhangs by 3m. If the supported span AB carries a central concentrated load of 8kNand overhang span BC carries 2kN/m draw the shear force and bending moment diagram.

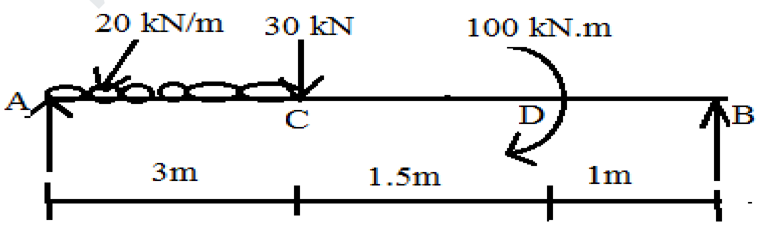
Q.10. A simply supported beam of span 4m carries a udl of 6kN/m over the entire span. If the maximum allowable stress due to bending is restricted to 150 N/mm^2, determine the cross sectional dimensions if the section is;

(i) Rectangular with depth twice the breadth

(ii) Solid circular section

(iii) Hollow circular section having a diameter ratio of 0.6

Q.11. Draw shear force and bending moment diagram for the beam shown in Fig.



Q.12. A flitched beam consists of two timber joist 100mm wide and 240mm deep with a steel plate 180mm deep and 10mm thick placed symmetrically between the timber joists and well clamped. Determine

i) The maximum fibre stress when the maximum fibre stress in wood is 80 kg/cm^2.

ii) The combined moment of resistance if the modular ratio is 18.

Unit III

Part 'A' Two mark Questions

Q.1. What are the methods for finding out the slope and deflection at a section?
Ans: Following are the important methods which are used for finding out the slope and deflection at a section in a loaded beam:

- Double integration method.
- Moment–area method.
- Mecaulay's method.

Q.2. Why moment method is more useful when compared with double integration?

Ans: Moment area method is more useful, as compared with double integration method because many problems which do not have a simple mathematical solution can be simplified by the ending moment area method

Q.3. What is conjugate beam method?
Ans:

- 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; however, this method relies only on the principles of statics, so its application will be more familiar.

Q.4. State the two theorems in moment area method.
Ans:

1. The first moment area theorem is that *the change in the slope of a beam between two points is equal to the area under the curvature diagram between those two points*. Recall that the curvature is just equal to M/EI, so the curvature diagram often looks similar to the moment diagram; however, be careful, because it is possible for EI to change along the length of a beam, which may cause 'steps' in the curvature diagram, which don't exist in the moment diagram.
2. The second moment area theorem is that *the vertical distance between a reference tangent line that is tangent to one point of the beam and the deflected shape of the beam at another*

point is equal to the moment of the area under the curvature diagram between the two points with the moments of the areas calculated relative to the point on the deflected shape.

Q.5. What are the boundary conditions for a simply supported end?

Ans:

A simply-supported beam (or a simple beam , for short), has the following boundary conditions: W(0)=0 . Because the beam is pinned to its support, the beam cannot experience deflection at the left-hand support.

Q.6. When Macaulay's method is preferred?

Ans: Macaulay's method. Macaulay's method (the double integration method) is a technique used in structural analysis to determine the deflection of Euler-Bernoulli beams. Use of Macaulay's technique is very convenient for cases of discontinuous and/or discrete loading.

Q.7. What is meant by double integration method?

Ans: The double integration method is a powerful tool in solving deflection and slope of a beam at any point because we will be able to get the equation of the elastic curve.

In calculus, the radius of curvature of a curve y = f(x) is given by,

$P = [1 + (dy/dx)^2]^{3/2} \;/\; (d^2y/dx^2)]$

Q.8. What is meant by determinate and indeterminate beams?

Ans:

Statically determinate structures are those in which reactions and internal forces can be determined with the help of statics (equilibrium equations) only.

For eg - simply supported beam, cantilever beam, three hinged arch, etc..

But in case of indeterminate structures, there are extra constraints by supports or members (redundancies) than required to obtain statically determinate and stable structures. So statics as well as compatibility conditions are required to analyse indeterminate structures.

For eg - propped cantilever, two hinged arch, both end fixed beam.

Indeterminate structures are more applicable because of following reasons:

- The maximum stresses in statically indeterminate structures are generally lower than those in comparable determinate structures.
- Indeterminate structures have more members or support reactions than required for static stability,
- So if a part (or member or support) of such a structure fails, the entire structure will not necessarily collapse, and the loads will be redistributed to the adjacent portions of the structure.
- Statically indeterminate structures generally have higher stiffnesses (i.e., smaller deformations), than those of comparable determinate structures.

Q.9. Explain the Theorem for conjugate beam method?

Ans:

Theorem I : "The slope at any section of a loaded beam, relative to the original axis of the beam is equal to the shear in the conjugate beam at the corresponding section"

Theorem II: "The deflection at any given section of a loaded beam, relative to the original position is equal to the Bending moment at the corresponding section of the conjugate beam"

Q.10. What is slope of a beam?

Ans:

Deflection of a Beam: The deflection at any point on the axis of the beam is the distance between its position before and after loading.

Slope of a Beam: Slope at any section in a deflected beam is defined as the angle in radians which the tangent at the section makes with the original axis of the beam.

Q.11. Write the maximum value of deflection for a simply supported beam of constant EI, span Lcarrying central concentration loud W.

Ans: The deflection at the centre of a simply supported beam carrying a point load at the centreis given by: $yc = -(WL^3/ 48EI)$

Q.12. Where the maximum deflection will occur in a simply supported beam loaded with UDL of w kN/m run?

Ans: The deflection at the centre of a simply supportedbeam carrying a point load at the centreis given by: $yc = -(WL^3/ 48EI)$

Q.13. What are the advantages of Macaulay's method over double integration method for beam deflection analysis?

Ans: Macaulay's method is used in finding slope and deflection at anypoint of a beam. The points used in this method are:

a) Brackets are to be integrated as a whole.

b) Constants are written after the first term.

c) The section, for which BM is to be found, should be taken in the last part.

Q.14. What is meant by propped cantilever?

Ans: A cantilever which has an additional support at the free end is termed as propped cantilever.

Q.15. What are the methods for finding out the slope and deflection at a section?

Ans: The important methods used for finding out the slope and deflection at a section in a loaded beam are:

a) Double integration method

b) Moment area method

c) Macaulay's methodThe first two methods are suitable for a single load, whereas the last one is suitable for several loads.

Q.16. What is a conjugate beam?

Ans: Conjugate beam is an imaginary beam of length equal to that of original beam but for which load diagram is M/EI diagram.

Q.17. A cantilever of length 4 m carriesa uniformly varying load of zero at the free end and 50 kN at the fixed end. If I = 108mm4and E = 2.1 x 10^5N/mm^2, find the deflection at the free end.

Ans: The deflection at the free end is given by:

y_B= WL^4/ 30EI

y_B= (50 x 4000^4) / (30 x 2 x 10^5x 10^3)

y_B= 21.33 mm

Q.18. Write an expression for deflection by moment area method.

Ans: The shear stress at a fibre in a section of a beam is given by:

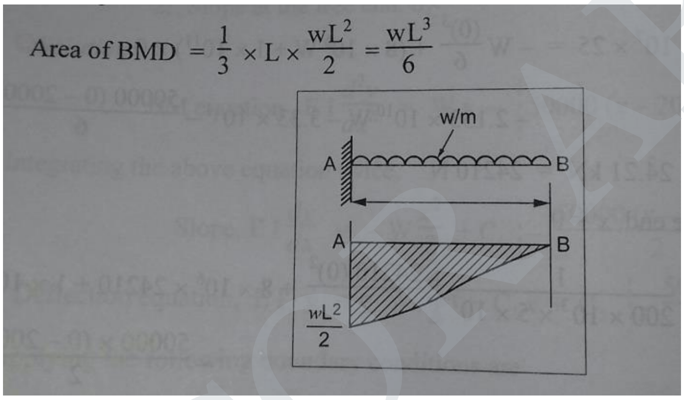
Y = AX / EI;

Where A is area of BM diagram between A and B and

X is distance of CG of area from B.

Q.19. Calculate area of BMD of a cantilever carrying UDL of W/m for the full span of 'L'

Ans:



Q.20. Where the maximum deflection will occur in SSB with UDL throughout the span and slope at this point?

Ans: The maximum deflection will occurs at the centre of the beam at which the slope is zero.

<u>Part 'B' Questions (13 / 15 marks):</u>

Q.1. A beam of length 6m is simply supported at its ends and carries two point loads of 48kN and 40kN at a distance of 1m and 3m respectively from the left support. Find

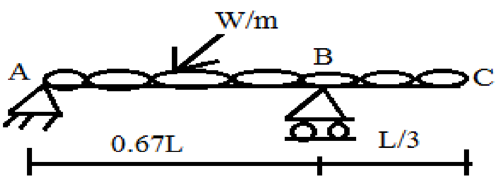
(i) Deflection under each load

(ii) Maximum deflection

(iii) The point at which the maximum deflection occurs. Take I=85×10^6 mm^4 E = 2×10^5N/mm^2

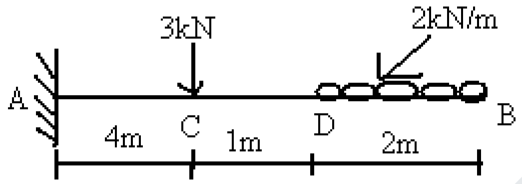
Q.2. For the beam shown in fig show that the deflection at the free end is

WL^4/684 EI. Use Macaulay's method.



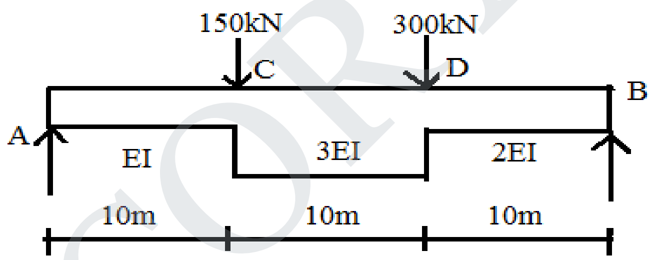
Q.3. A cantilever of length 2.5m is loaded with an udl of 10 kN/m over a length 1.5m from the fixed end. Determine the slope and deflection at the free end. Determine the slope and deflection at the free end of the cantilever L = 9500cm^4, E = 210 GN / m^2 Using Moment area method.

Q.4. Find the slope and deflection at the free end of the cantilever shows in fig. Take EI = 1x10^{10} kN/mm^2

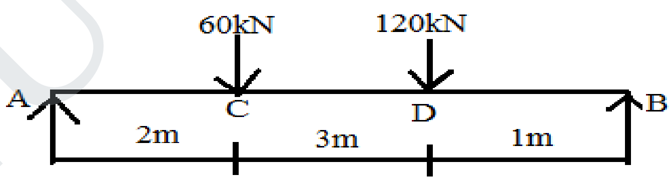


Q.5. A steel joist, simply supported over a span of 6 m carries a point load of 50 kN at 1.2 m from the left hand support. Find the position and magnitude of the maximum deflection. Take EI = 14 X 10^{12} N/mm^2

Q.6. Using conjugate beam method, obtain the slope and deflections at A, B, C and D of the beam shown in fig. Take E = 200GPa and I = 2x10^{-2} m^4.



Q.7. Obtain the deflection under the greater load for the beam shown in fig using the conjugate beam method.



Q.8. A simply supported beam of span 3 m is subjected to a central load of 10 kN. Find the maximum slope and deflection of the beam. Take I = 12 ×10^6 mm^4 and E = 200 GPa.

Q.9. A beam AB of span 6m is simply supported at its ends is subjected to a point load of 20kN at C at a distance of 2m from left end. Using moment area method, Compute the deflection at the point C, slope at the points A, B and C. Take I = 6 x10^8 mm^4 and E = 200GPa.

Q.10 A steel cantilever of 2.5m effective length carries a load of 25kN at its free end. If the deflection at the free end is not exceed 40mm. What must be the I value of the section of the cantilever. Take E = 210 GN/m2 using moment area method.

Unit IV

Part 'A' two marks questions:

Q.1. What are the assumptions made in the theory of torsion?

Ans: In sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius. The theory of Torsion is based on the following Assumptions:
The material in the shaft is uniform throughout. The twist along the shaft is uniform.

Q.2. Define torsion and polar modulus.

Ans:

- A force that twists something is called torsion. The shape of the twisted object can also be called torsion, like the torsion of a tree's branches that makes it tricky to build a tree-house.
- The action of twisting or the state of being twisted, especially of one end of an object relative to the other.

Q.3 Write Torsional equation.

Ans: The torsion equation for circular members is as follows:

G x Ө / L

= T / J

= t / r

Where

G = shear modulus

Ө = angle of twist of the cross-section

L = length of the member

T = twisting moment

J = polar moment of inertia

t = shear stress at a given location

r = radial distance at that location

Q.4. Why hollow circular shafts are preferred when compared to solid circular shafts?

Ans:

- The torque transmitted by hollow circular shaft is greater than the solid circular shaft.
- For same material, length and given torque, the weight of the hollow shaft will be less than the solid circular shaft.

Q.5. Write the expression for power transmitted by a shaft.

Ans: Power transmitted is the work done.

$$\text{Work done per minute} = (\text{Force}) \times (\text{Distance})$$
$$= (\text{Average torque}) \times (\text{Angular displacement})$$
$$= T \times 2\pi N/60$$

$$\therefore \qquad \text{Power, } P = \frac{2\pi NT}{60} \text{ watts} \qquad (6.20a)$$

$$\text{also} \qquad P = T\omega \qquad (6.20b)$$

$$\text{where} \qquad \omega = \frac{2\pi N}{60}$$

Where, $\omega = 2\pi N / 60$

Q.6. Define springs. What are the different types of springs?

Ans: A spring may be defined as an elastic member whose primary function is to deflect or distort under the action of applied load; it recovers its original shape when load is released.

Types of different types of springs:

- Compression Spring.
- Helical spring
- Extension Spring.
- Torsion Spring.
- Constant Force Spring
- Belleville Spring
- Spring Clip
- Natural Spring
- Leaf spring

Q.7. What is leaf spring?

Ans:

- Leaf spring is a suspension system for vehicles that has been used as far back as medieval times. They were originally called carriage or laminated springs. Its system has been tried and true, primarily used on almost all vehicles up to the 1970's and still today on trucks and vans that haul heavy loads.
- The spring leaf is made up of an arc-shape, slender piece of steel that is stacked with the same material in smaller sizes and bolted together creating a reinforced bow-like item. It is then attached to the rear axle and the chassis providing support to any additional weight that is added to a vehicle, preventing the axle from buckling in and snapping from the pressure of an extreme amount of weight that it was not originally designed to carry.

Q.8. Define spring stiffness.

Ans: The stiffness, k, of a body is a measure of the resistance offered by an elastic body to deformation. Every object in this universe has some stiffness. Generally for spring the spring stiffness is the force required to cause unit deflection.

Q.9. What is a stepped shaft?

Ans:

- Shafts are manufactured in stepped as well as plain form. The main advantage of stepped shaft over plain shaft is its High Torsional Rigidity.
- These are of having different cross sections through-out the section.

Q.10. Compare close coiled and open coiled springs under the action of an axial load.

Ans:

<u>**Closed coiled spring**</u>	<u>**Open coiled spring**</u>
Wire of the close coiled helical spring is wound tightly providing no gap between two adjacent coils of the spring.	Wire of the open coiled helical spring is wound not so tightly and thus sufficient space or gap exists between two adjacent coils.
Helix angle of this spring is usually 10° or below that.	Helix angle of this spring is more than 10°.

Pitch of spring wire is smaller due to small helix angle.	Pitch of spring wire is comparatively larger as a result of larger helix angle.
Close coiled springs cannot undergo axial compression. It is designed to resist stretching and twisting.	Open coiled springs are designed to undergo extension and compression; and deflect its length accordingly under the action of axial load.
This type of spring is commonly used in heavy duty applications such as: • Garage doors • Vice-grip pliers • Self-closing door hinges • Bike or cycle stand spring	This type of spring is commonly used in low duty applications such as: • Spring-operated ball point pen • Bike shock absorber • Certain cam-followers, valves, brakes and clutches

Q.11. What are the assumptions made in torsional equation?

Ans: The assumptions are as follows:

1. The material of the body is perfectly homogeneous and obeys Hooke's law.
2. Twist is uniform along the length of the body / shaft.
3. The stress doesn't exceed the limit of proportionality.
4. The shaft circular in section remains circular after the application of load.
5. Strain and deformations are small.

Q.12. Write down the expression for torque transmitted by hollow shaft?

Ans: The expression is

$T = (\pi/16) \times \tau\, [(D^4-d^4) / D]$

Where, T = torque in N-mm; τ = Shear stress in N/mm^2; D = outer diameter in mm; d = inner diameter in mm.

Q.13. write down the expression for maximum stress od a solid circular section of diameter 'D' when subjected to a torque of 'T'.

Ans: The expression will be:

Torque $(T) = (\pi/16) \times C \times D^3$

Or, $\tau = (16 \times T) / (\pi \times D^3)$

Where, τ = shear stress in N/mm^2; T = Torque in N-mm and D = diameter in mm.

Q.14. Express Torsional rigidity.

Ans: The torsional equation is:

$T/J = C\,\Theta / l$

Or, $\Theta = T\,l / CJ$

Since C, l and J are constant for a given shaft, Θ (angle of twist) is directly proportional to T (Torque). Thus the term 'CJ' is known as torsional rigidity and it is represented as 'K'.

Q.15. What is meant by spring constant and spring index?

Ans:

- Spring constant is the ratio of mean diameter of the spring to the diameter of the wire.
- The spring index is the relationship between the mean diameter and wire diameter. The equation is shown below. This is a very important relationship to consider for manufacturing ease and cost control.

Q.16. What is the formula for the stiffness of a close coiled helical spring subjected to an axial load?

Ans: The expression is:

Stiffness (K) = $(Cd^4 / 64\ R^3\ n)$ N/mm

Q.17. A helical spring is made of 4mm steel wire with a mean radius of 25mm and number of turns of coil are 15. What will be the deflection of the spring under a load of 6N? Take C=80 x 10_3 N/mm^2

Ans: Given data,

D = 4mm, R = 25mm, n = 15, W = 6N & C = 80 x 10_3 N/mm^2.

Therefore, Axial deformation *dl* = $(64\ W\ R^3\ n) / (Cd^4)$

= $(64 \times 6 \times 25^3 \times 15) / (80 \times 10^3 \times 4^4)$

= 4.39mm (answer).

Q.18. The stiffness of a spring is 10 N/mm. What is the axial deformation in the spring when a load of 50N is acting?

Ans: Stiffness (K) = 10 N/mm; load acting is 50N.

As we know, K = W/*dl*

Or, *dl* = W/K = 50 / 10 = 5mm (Answwer).

Q.19. What are the uses of leaf spring?

Ans: The overall purpose of a leaf spring is to provide support for a vehicle. It also provides for a smoother ride absorbing any bumps or potholes in the road. Leaf springs are also used to locate the axle and control the height at which the vehicle rides and helps keep the tires aligned on the road.

Q.20 What is Torsion?

Ans:

- When a pair of forces of equal magnitude but opposite directions acting on a body. It is known as twisting moment or torsional moment or simply as torsion or torque.
- Torque is equal to the product of the force applied and the distance between the point of application of the force and the axis of the shaft.
- In the field of solid mechanics, torsion is the twisting of an object due to an applied torque. Torsion is expressed in either the Pascal (Pa), an SI unit for newton per square metre, or in pounds per square inch (psi) while torque is expressed in newton metres (N·m) or foot-pound force (ft·lbf).
- In sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius.
- In non-circular cross-sections, twisting is accompanied by a distortion called warping, in which transverse sections do not remain plane

Part B Questions (13 / 15 marks):

Q.1. i) Derive the torsion equation for a circular shaft of diameter 'd' subjected to torque 'T'.

ii) Find the torque that can be transmitted by a thin tube 6 cm mean diameter and wall thickness 1 mm. the permissible shear stress is 6000 N/cm^2.

Q.2. A close coiled helical spring is made of a round wire having 'n' turns and the mean coil radius R is 5 times the wire diameter. Show that the stiffness of the spring = 2.05 R/n. If the above spring is to support a load of 1.2kN with 120mm compression. Calculate mean radius of the coil and number of turns assuming G = 8200 N/mm^2 and permissible shear stress, $\lambda_{allowable}$ = 250 N/mm^2.

Q.3. A steel shaft ABCD having a total length of 2400mm is contributed by three different sections as follows. The portion AB is hollow having outside and inside diameters 80mm and 50mm respectively, BC is solid and 80mm diameter. CD is also solid and 70mm in diameter. If the angle of twist is same for each section, determine the length of each portion and the total angle of twist. Maximum permissible shear stress is 50MPa and shear modulus 0.82x10^{5}MPa.

Q.4. It is required to design a close coiled helical spring which shall deflect 1mm under and axial load of 100N at a shear stress of 90MPa. The spring is to be made of round wire having shear modulus of 0.8x10^{5}MPa. The mean diameter of the coil is to times that at the coil wire. Find the diameter and length of the wire.

Q.5. A solid circular shaft transmits 75kW power at 200rpm. Calculate the shaft diameter, if the twist in the shaft is not to exceed one degree in 2m length of shaft and shear stress is not exceed 50 N/mm^2. Assume the modulus of rigidity of the material of the shaft as 100kN/mm^2.

Q.6. A shaft has to transmit 110 kW at 160rpm. If the shear stress is not to exceed 65N/mm^2 and the twist in a length of 3.5m must not exceed 1o, find a suitable diameter. Take C = 8x104 N/mm^4.

Q.7. A leaf spring 750mm long is required to carry a central load of 8kN. If the central deflection is not to exceed 20mm and the bending stress is not to be greater than200N/mm^2. Determine the thickness, width and number of plates. Assume the width of the plates is 12 times, their thickness and modulus of elasticity of the springs material as 200kN/mm^2.

Q.8. A closely coiled helical spring made out of a 10mm diameter steel bar has 12 complete coils, each of mean diameter of 100mm. Calculate the stress induced in the section of rod, the deflection under the pull and the amount of energy stored in the spring during the extension. It is subjected to an axial pull of 200N. Modulus of rigidity is 0.84x10^5 N/mm^2.

Q.9. A close coiled helical spring has a stiffness of 5N/mm. its length when fully compressed with adjacent coils touching each other is 40 cm. the modulus of rigidity of the material of the spring is 8x10^4 N/mm^2. Determine the wire diameter and mean coil diameter if their ratio is 1/10. What is the corresponding maximum shear stress in the spring?

Q.10. A circular shaft of 1000mm diameter and 2m length is subjected to a twisting moment which creates a shear stress of 20N/mm^2 at 30mm from the axis of the shaft. Calculate the angle of twist and the strain energy stored in the shaft. Take G=$8x10^4 N/mm^2$.

Q.11. A close coil helical spring of round steel wire 10mm in diameter has a mean radius of 120mm. the spring has 10 complete turns and is subjected to an axial load of 200N. Determine:
(i) Deflection of the spring. (ii) Maximum shear stress in the wire and (iii) Stiffness of the spring. Take G = $80kN/mm^2$.

Q.12. A close coiled helical spring made of steel wire is required to take a load of 800N. Determine the wire diameter if the stiffness of the spring is 10N/mm and the diameter of the helix is 80mm. Also calculate the number of turns required in the spring. Given value for G of steel is 80GPa and allowable stress is $200N/mm^2$.

Q.13. A helical spring in which the mean diameter of the coil is 8 times the wire diameter is to be design to absorb 0.2kNm of energy with an extension of 100mm. the maximum shear stress is not to exceed beyond $125N/mm^2$. Determine the mean diameter of the spring, diameter of the wire and the number of turns. Also find the load at which the extension of 40mm could be produced in the spring. Take G = $84kN/mm^2$.

Q.14. An open coiled helical spring made of 5mm diameter wire has 16 coils 100mm inner diameter with helix angle of 16^o. Calculate the deflection, maximum direct and shear stresses induced due to an axial load of 300N. Take G = 90GPa.

Q.15. Find the diameter of a solid circular shaft to transmit 150KW of power at 300 rpm, if the allowable shear stress is 90Mpa and twist is I degree over 2m length of the shaft. Take rigidity modulus is equal to 90GPa.

Unit V

Part 'A' Two marks question:

Q.1. What is mean by perfect frame?
Ans: A structural frame that is stable under loads imposed upon it from any direction, but which would become unstable if one of its members were removed or one of its fixed ends became hinged.
Q.2. What are the different types of frames?
Ans: Generally there are two types of frames:

- Rigid **frame** structure. Which can be further differentiated as: Fixed ended. Pin ended.
- Braced **frame** structure: Classification: Portal **frames**. Gabled **frames**

On the other hand in structural analysis basis, the frames are:

- Determinate or perfect frame.
- In-determinate or imperfect frame.

Q.3. What is mean by Imperfect frame?
Ans: A simple example of a perfect frame is a triangular frame which is formed by joining the three member with the help of three joints. Similarly Imperfect frames are the frames which can not be analysed to get the internal member forces and external support reactions by using the three conditions of static equilibrium.

Q.4. What is mean by deficient frame?
Ans: Deficient structure means the structure in which the required reactions are not provided. Generally these structures are unstable. Redundant structures means the structure provided with the extra reactions required for stability of structure.
Q.5. What is mean by redundant frame?
Ans:

- Redundant truss is the one that contains excess number of members that makes it impossible to determine all member forces solely with the set of equilibrium equations.
- If the numbers of member in frame are more than (2*j*-3), then the frame is called as redundant frame.

Q.6. What are the assumptions made in finding out the forces in a frame?
Ans: There are broadly 2 methods:

- Analytical method and
- Graphical method.

Analytical method again sub divided in to three methods:

- Methods of joints
- Method of section or method of moments
- Method of tension coefficient.

Q.7. What are the supports acting of a frame?
Ans:

- Fixed support
- Pin Jointed support
- Hinged support
- Roller support

Q.8. How will you Analysis of a frame?
Ans: We can analyse frame by using tension coefficient method.

- The first step in the analysis of frames and machines is to label the members.
- If the structure is independently rigid (no machines, and only some frames will be independently rigid), then analyse the structure as a single rigid body to determine the reaction forces acting on the structure.

Q.9. What is a space truss or frame? Give one example.
Ans: Space frame or truss is a three dimensional assemblage of line members, each members being jointed at its ends, either to the foundations or to the other members by friction less balls or socket joints.
For example, Station Yard structures, transmission line towers, Microwave towers.
Q.10. How will you determine the forces in a member by method of joints?
Ans:

- By using simple equilibrium method of forces acting on a joint, we can determine the forces acting on each of the members of the truss holding in that particular joint.
- The forces on the members associated with a joint are the algebraic sum of all the forces considering the direction of the forces.

Q.11. What is the relationship in between the number of members (m) and the number of joints (j) in a space truss?
Ans: The relationship in between the number of members (m) and the number of joints (j) in a space truss is given by; $m = 3j - 6$

Q.12. Why a systematic approach is needed in the case of analysis of a space frame?
Ans:
- As the geometry of space structures makes their analysis slightly more complex compared to plane frame or two dimensional structures, it needs a systematic approach.
- If a truss or frame has less number of members, the frame will be unstable and if it is opposite, the frame will be statically indeterminate.

Q.13. Enumerate the assumptions made for finding out the forced in a perfect frame.
Ans: The assumptions are as follows:
- All the members are pin jointed.
- The frame is loaded only at the joints
- The self-weight of the members are neglected unless stated.

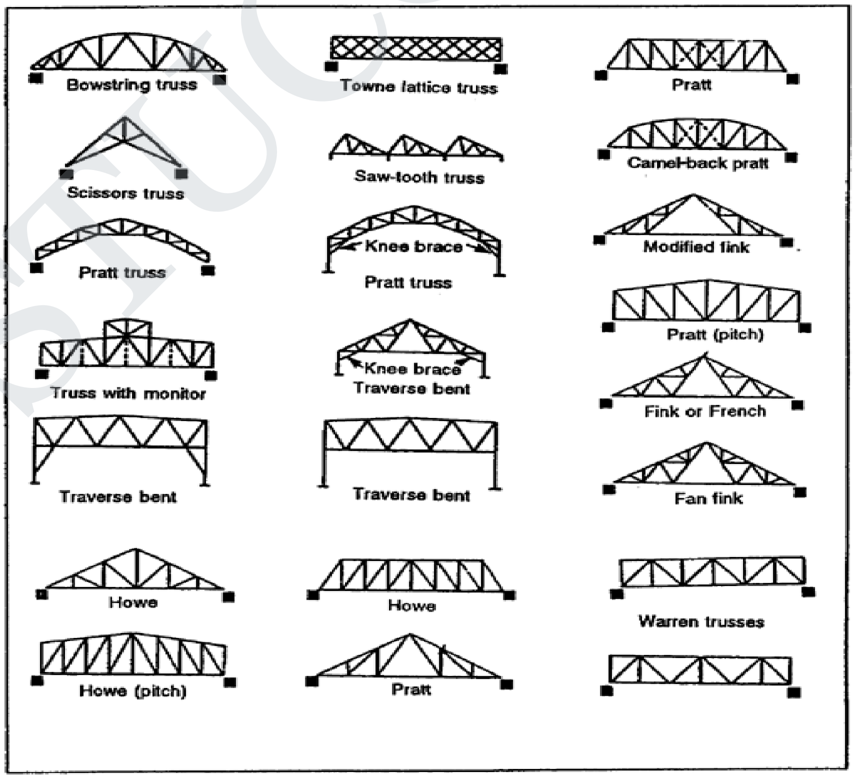
Q.14. What is known as method of joints?
Ans: In this method, each and every joint is taken separately as free body in equilibrium. The unknown forces are then determined by equating sum of all vertical forces at the joint is equal to zero as well as the sum of horizontal forces at the same joint is equal to zero.
Therefore, $\Sigma V = 0$ and $\Sigma H = 0$.

Q.15. What is Tension coefficient?
Ans: Tension coefficient is defined as the ratio between pull and length of member.

$T = P/L$

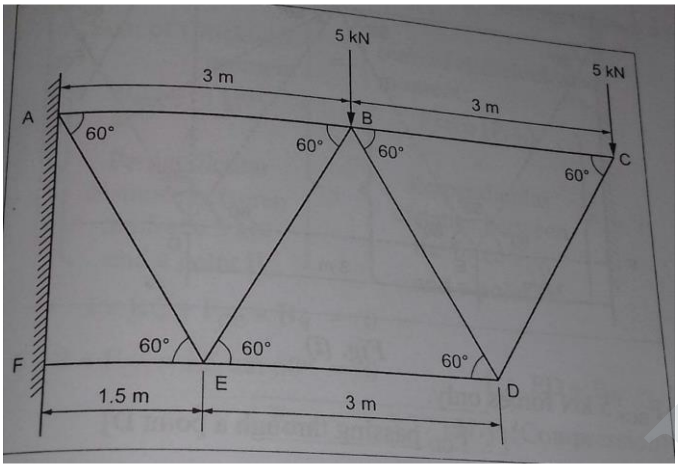
Where, T = Tension coefficient
P = Pull / tension force (in N)
L = Length (in m)

Q.16. What are the different types of trusses used in construction?
Ans:



Q.17. Draw a cantilever frame or truss with a load of 5kN at 3m from the fixed end and another 5kN at 6m from fixed end and with 3 inclined members at an angle of 60° at the point of fixed end and under loadings.

Ans:



Q.18. Trusses are subjected to which types of stresses?

Ans: Trusses are the members which are subjected to direct stress, as the truss is usually loaded at the point of intersection of its member only.

Q.19. Name the structures where the members connected don't lie in the same plane?

Ans: If all the members connected at the ends do not lie in the same plane then the structure (truss) is called as space truss. If the members lie in the same plane, then the structure is called plane truss.

Q.20. Which shape of frame offers a greater rigidity?

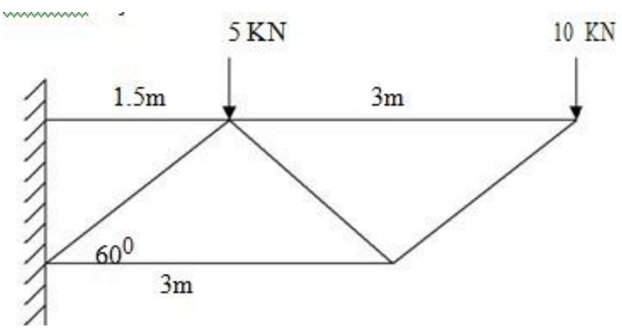
Ans: The framework of the truss should be built in a way that, it does not change its shape when loaded. The triangular shape of frame offers great rigidity and hence it is generally adopted.

<u>Part 'B' Questions (13 / 15 marks):</u>

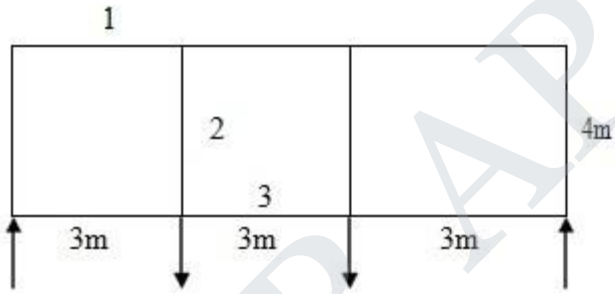
Q.1. A rectangular block of material is subjected to a tensile stress of 110 N/mm^2 on one plane and a tensile stress of 47 N/mm^2 on the plane at right angle to the former. Each of the above stress is accompanied by a shear stress of 63 N/mm^2 Find (i) The direction and magnitude of each of the principal stress (ii) Magnitude of greatest shear stress.

Q.2. At a point in a strained material, the principal stresses are100 N/mm^2 (T) and 40 N/mm^2 (C). Determine the resultant stress in magnitude and direction in a plane inclined at 60^0 to the axis of major principal stress. What is the maximum intensity of shear stress in the material at the point?

Q.3. A cantilever truss is show in fig. Find the forces in the members of the truss by the method of joint.



Q.4. A truss of span 9m is loaded as shown in fig. Find the reaction and forces in the members marked 1, 2, and 3 by using method of section.



Q.5 At a point in a strained material, the principal stresses are 100 N/mm2 (T) and 40 N/mm^2. Determine the direction and magnitude in a plane inclined at 600 to the axis of major principal stress. What is the maximum intensity of shear stress in the material at the point

Q.6. Find the magnitude and nature of the forces in the given truss carrying loads as shown in Fig. 12(a).

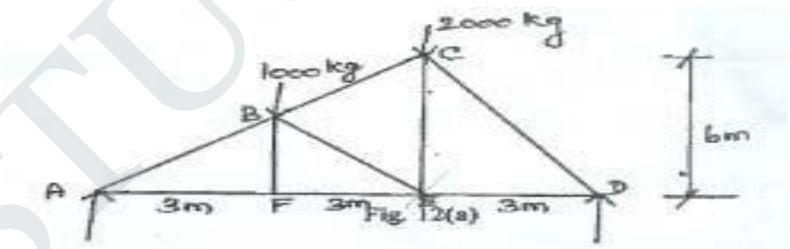
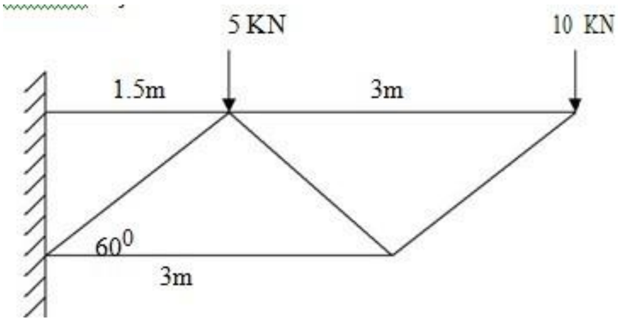


Fig. 12 (a)

Q.7. A Simply Supported truss is show in figure above. Find the forces in the members of the truss by the method of joint Fig. 12(a).

Q.8. A cantilever truss is show in fig. Find the forces in the members of the truss by the method of section.



Q.9. Determine the normal, shear and resultant stress in magnitude and direction in plane, the normal of which makes an angle of 30^o with the direction of $30MN/m^2$ stress (Tensile). The Value of other tensile stress is $15MN/m^2$.

Q.10 The principal stresses in the wall of a container are 40 MN/m^2 and 80 MN/m^2. Determine the normal, shear and resultant stresses in magnitude and direction in a plane, the normal of which makes an angle of 30^o with the direction of maximum principal stress.