Code No: RR211402 **Set No. 1**

II B.Tech I Semester Supplementary Examinations, November 2006
MECHANICS OF SOLIDS
(Common to Mechatronics, Metallurgy & Material Technology and Aeronautical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) The piston of a steam engine is 40 cm in diameter while the piston rod is 6 cm in diameter. The pressure of the steam acting is 1.05 N/mm^2. Find the stress in the piston rod and its elongation, if the piston rod is 75 cm long. E = 205 kN/mm^2 when the piston is on in the instroke. [8]

   (b) A reinforced concrete column 50 cm in diameter has four 30 mm diameter steel rods embedded, and carries an axial load of 850 kN. Calculate the stresses in each of the two materials. E for steel = $2.04\times10^5 N/mm^2$ and E for concrete = $0.136\times10^5 N/mm^2$. What is the adhesive force between steel and concrete. [8]

2. A bar of mild steel 20 mm diameter is subjected to an axial pull of 50 kN. The increase in length over a gauge length of 200 mm is measured to be 0.16 mm. The decrease in diameter was 0.0048 mm. From the above data determine the modulus of Elasticity and Poisson's ratio of mild steel. [16]

3. (a) Define statically determinate and statically indeterminate beams. Give examples. [6]

   (b) A cantilever beam of length 2m carries a uniformly distributed load of 2 kN/m over the whole length and a point load of 3 kN at the free end. Draw the SF and BM diagrams. [10]

4. (a) State the assumptions involved in the theory of simple bending. [6]

   (b) An unsymmetric I-section shown in Figure 4b is subjected to a moment of 23kNm, the top flange being in compression. Draw the flexural stress variation across the section making the salient points and compute the total moment resisted by the top flange. [10]

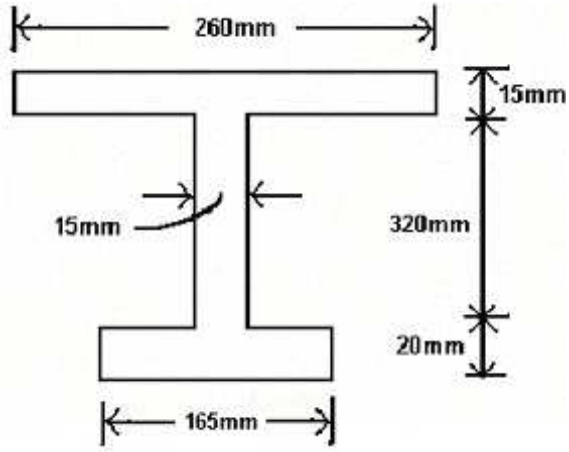

Figure 4b

5. (a) A beam of length L is supported at each end with a couple applied at an intermediate point. Deduce an expression for the deflection and hence calculate the deflection at the point of application of the moment. [8]

   (b) A beam of length L carries a uniformly distributed load w/unit length and rests on three supports, two at the ends and one in the middle. Find how much the middle support be lower than the end ones in order that the pressures on the three supports shall be equal. [8]

6. (a) Derive an expression for the proportional increase in capacity of a thin cylindrical shell when it is subjected to an internal pressure. [8]

   (b) A vertical gas storage tank is made of 25 mm thick mild steel plate and has to withstand maximum internal pressure of 1.5 MN/m^2. Determine the diameter of the tank if stress is 240 MN/m^2, factor of safety is 4 and joint efficiency is 80%. [8]

7. The principal stresses at a point in a material are 120 N/mm^2 and 60 N/mm^2, the third principal stress being zero. Both the stresses are tensile. Find by the circular diagram of stress, or otherwise, the magnitude and direction of the resultant stress on a plane inclined at 30^0 to the direction of the smaller principal stress and perpendicular to the plane across which the stresses are zero.

   From the same diagram, or otherwise, find also the plane on which the resultant stress is the most oblique and the value of this resultant stress and it's maximum obliquity. [16]

8. A propeller shaft, 160mm external diameter, 80mm internal diameter, transmits 450kW at 4/3 Hz. There is, at the same time, a bending moment of 30kN-m and an end thrust of 250kN. Find

   (a) the maximum principal stresses and their planes [6]

   (b) the maximum shear stress and its plane [6]

   (c) the stress, which acting alone, will produce the same maximum strain. Take poisson's ratio = 0.3 [4]

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1. (a) State Hooke's Law. Explain Elastic limit. [6]
   (b) A steel bar 1.6 m long is acted upon by forces as shown in the Figure1b. Find the elongation of the bar. Take E = 2.1×10^8 KN/m^2. [10]

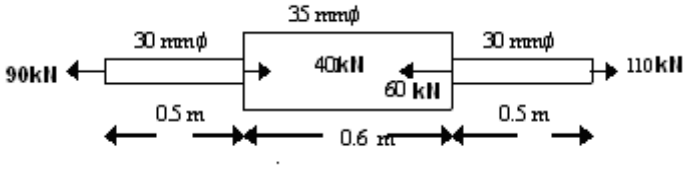

Figure 1b

2. (a) Derive the relationship between the three moduli of elasticity. [8]
   (b) Show that in a prismatic bar, the maximum stress intensity due to a suddenly applied load is twice the stress intensity produced by the same load applied gradually. [8]

3. A horizontal beam of 10m long is carrying a uniformly distributed load of 1 kN/m over the entire length. The beam is simply supported on two supports 6m apart. Find the position of the supports, so that the BM on the beam is as small as possible. Also draw the SF and BM diagrams. [16]

4. (a) A simply supported beam of span 6 m has a cross section 180 mm × 300 mm. If the permissible stress is 9 MPa, find the maximum concentrated load that can be applied at 2m from left end. [8]
   (b) A rolled steel joist of I section has top and bottom flanges 185 mm × 25 mm and web of size 300 mm × 15 mm. It is used as a simply supported beam over a span 5m to carry an uniformly distributed load of 75 kN/m over its entire span. Draw bending stress across a section at $(\frac{1}{5})$th the span. [8]

5. (a) What is moment area method? Explain the two Mohr's theorems, as applicable to the slope and deflection of a beam. [6]
   (b) A cantilever of uniform cross-section of length l carries two point loads, W at the free end and 2W at a distance a from the free end. Find the maximum deflection due to this loading. [10]

6. (a) Derive an expression for the proportional increase in capacity of a thin cylindrical shell when it is subjected to an internal pressure. [8]

(b) A vertical gas storage tank is made of 25 mm thick mild steel plate and has to withstand maximum internal pressure of 1.5 MN/m^2. Determine the diameter of the tank if stress is 240 MN/m^2, factor of safety is 4 and joint efficiency is 80%. [8]

7. (a) Obtain an expression for the major and minor principal stresses on a plane, when the body is subjected to direct stresses in two mutually perpendicular directions accompanied by a shear stress. [8]

(b) At a point in a strained material, the principal stresses are 60 N/mm^2 and 40 N/mm^2. Find the position of the plane across which the resultant stress is most inclined to the normal and determine the value of this stress. [8]

8. (a) Prove that for a given spring stiffness and given maximum shearing stress, the ratio of the mass of a close coiled helical spring made of tube to that of one made of solid wire of the same material and same external diameter is K^2/K^2+1, where K is the ratio of the outside diameter of the tube to its inside diameter. [8]

(b) Determine the mean coil radius, wire diameter and number of turns of a close coiled spring of 1kN/m stiffness and solid length 45mm. The shear stress in the spring under an axial load of 75N should not exceed 180MPa. Modulus of rigidity for the spring material =82Gpa. [8]

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1. (a) Define the terms:
   i. Proportional limit
   ii. Poisson's ratio
   iii. Proof stress
   iv. Strain energy. [6]
   (b) A compound bar 1 metre long is 40 mm diameter for 300 mm length, 30 mm diameter for the next 350 mm length. Determine the diameter of the remaining length so that its elongation under an axial load of 100 kN does not exceed 1mm. Take E = $2\times10^5 N/mm^2$. [10]

2. A 10 mm diameter rod was subjected to an axial pull of 10 kN and the change in diameter was observed to be 0.003 mm. Calculate Poisson's ratio and modulus of elasticity. Find also bulk modulus. Given rigidity modulus = $5\times10^4 N/mm^2$. [16]

3. (a) How do you classify loads? Give examples. [4]
   (b) A simply supported beam of length 5m carries a uniformly increasing load of 800 N/m run at one end to 1600 N/m run at the other end. Draw the S.F. and B.M. diagrams for the beam. [12]

4. (a) Obtain from first principles the expression for shear stress at any point in a circular section of a beam where it is subjected to a shear force F. Sketch the stress variation. [8]
   (b) An I-section has the following dimensions.
   Top and bottom flanges = 165 mm × 20 mm
   Web = 15 mm thick and 200mm deep
   The maximum shear stress developed in the beam is 17MPa.
   Find the shear force to which the beam is subjected. [8]

5. (a) A beam of length L is supported at each end with a couple applied at an intermediate point. Deduce an expression for the deflection and hence calculate the deflection at the point of application of the moment. [8]
   (b) A beam of length L carries a uniformly distributed load w/unit length and rests on three supports, two at the ends and one in the middle. Find how much the middle support be lower than the end ones in order that the pressures on the three supports shall be equal. [8]

6. (a) Derive the formula for the hoop stress in a thin cylindrical shell subjected to an internal pressure. [7]

   (b) A gas cylinder of thickness 25 mm and has an internal diameter of 1500 mm. The tensile stress in the gas cylinder material is not to exceed 100 N/mm^2. Calculate the allowable internal pressure of the gas inside the cylinder. [9]

7. Derive an expression for the shear stress produced in a circular shaft which is subjected to torsion. What are the assumptions made in the above derivation ? [16]

8. A circular shaft supported in bearings 4m apart transmits 75 kW power at 120 r.p.m. A pulley provided at 1.5 m from one bearing exerts a transverse load of 40 kN on the shaft. Determine a suitable diameter of the shaft if

   (a) The maximum direct stress is not to exceed 90 N/mm^2

   (b) The maximum intensity of shear stress is not to exceed 45 N/mm^2

   (c) The stress which acting alone, would produce the same maximum strain is not to exceed 90 N/mm^2

   (d) The direct stress which acting alone would produce the same maximum strain energy, is not to exceed 90 N/mm^2 Take 1/m = 0.25. [4×4=16]

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Answer any FIVE Questions
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1. (a) Define the terms:
   i. Proportional limit
   ii. Poisson's ratio
   iii. Proof stress
   iv. Strain energy. [6]
   (b) A compound bar 1 metre long is 40 mm diameter for 300 mm length, 30 mm diameter for the next 350 mm length. Determine the diameter of the remaining length so that its elongation under an axial load of 100 kN does not exceed 1mm. Take E = $2\times10^5 N/mm^2$. [10]

2. A steel rod 28 mm diameter is fixed concentrically in a brass tube of 42 mm outer diameter and 30 mm inner diameter. Both the rod and tube are 450 mm long. The compound rod is held between two stops which are exactly 450 mm apart and the temperature of the bar is raised by 70^0C.
   (a) Find the stresses in the rod and tube if the distance between the stops is increased by 0.30 mm.
   (b) Find the increase in the distance between the stops if the force exerted between them is 90 kN

   Take $E_S = 200kN/mm^2$; $\alpha_S = 11.2 \times 10^{-6} per^0$C
   $E_b = 90kN/mm^2$; $\alpha_b = 2.1 \times 10^{-5} per^0$C [16]

3. Draw the SF and BM Diagrams for the beam loaded as shown in the Figure3. [16]

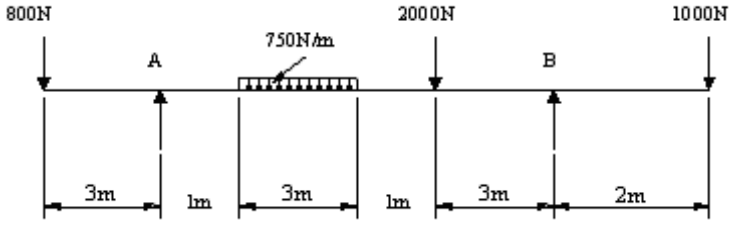

Figure 3

4. (a) A rectangular beam 125mm wide is subjected to maximum shear force of 110kN. Find the depth of the beam if the maximum permissible shear stress is 7MPa. [8]

   (b) A beam of I-section is having overall depth of 700mm and overall width as 230mm. The thickness of the flanges is 25mm where as the thickens of the web is 20mm. If the section carries a shear force of 64kN, Calculate the shear stress at salient points. [8]

5. (a) What is moment area method? Explain the two Mohr's theorems, as applicable to the slope and deflection of a beam. [6]

   (b) A cantilever of uniform cross-section of length l carries two point loads, W at the free end and 2W at a distance a from the free end. Find the maximum deflection due to this loading. [10]

6. (a) Derive the expression for the change of diameter and length of a thin cylindrical shell subjected to an internal pressure. [8]

   (b) A cylindrical shell 2.4 m long 0.6 m in diameter is made up of 12 mm thick plate. Find the changes in the length and diameter, when the shell is subjected to an internal pressure of 2 N/mm^2. [8]

7. (a) Define slenderness ratio. State the limitations of Euler's formula. [4]

   (b) Derive an expression for the Rankine's crippling load for a column. [8]

   (c) How will you justify the Rankine's formula is applicable for all lengths of columns, ranging from short to long columns. [4]

8. An open coiled helical spring is made out of 10 mm diameter steel rod, the coils having 10 complete turns, and a mean diameter 80 mm, the angle of helix 15^0. Calculate the deflection under an axial load of 250 N and the maximum intensities of direct and shear stresses induced in the section of the wire. If the axial load of 250 N is replaced by an axial torque of 6 N.m, calculate the angle of rotation about axis of the coil and actual deflection. N=$0.85\times10^5 N/mm^2$ and E=$2.5\times10^5 N/mm^2$. [16]

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