II B.Tech II Semester Supplementary Examinations, November/December 2005

MECHANICS OF SOLIDS

(Common to Mechanical Engineering and Production Engineering)

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

Answer any FIVE Questions

All Questions carry equal marks

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1. A round steel bar 25 mm diameter and 360 mm long is placed concentrically within a brass tube which has an outside diameter of 35 mm and an inside diameter of 27.5 mm. The length of the tube exceeds, that of the bar by 0.15 mm. Rigid plates are placed on the ends of the tube, through which an axial compressive force of 80 KN is applied on the compound bar. Determine the compressive stresses in the bar and tube. E for steel = $2.1\times10^5 N/mm^2$. E for brass = 10^5 N/mm^2. [16]

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. [16]

   (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

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

   (b) Derive the Bending equation from fist principle. [10]

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) Explain why 'wire wound their cylinders' are more efficient than 'ordinary thin cylinders'. [6]

(b) A seamless pipe of 1m diameter is carrying a fluid under a pressure of 10 N/mm^2. Calculate the necessary thickness of the pipe, if the maximum allowable stress in the pipe material is 100 N/mm^2. [10]

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. (a) A shaft tapers uniformly from radius r_1 at one end to radius r_2 at the other end in a length of L. Show that the angle of twist for the shaft under a uniform torque T is given by

$$\theta = \frac{2}{3}\frac{TL}{GJ}\left[\frac{r_1^2 + r_1 r_2 + r_2^2}{r_1^3 r_2^3}\right]$$ [6]

(b) A torque of 3.3kNm acts on the cross section of a solid circular shaft, 80mm diameter. What is the bending moment which can act on this section in addition to the given torque so that the maximum shear stress is 60MPa and maximum normal stress is 100MPa? Calculate the maximum and minimum principal stresses for this combination of torque and bending moment. [10]

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1. (a) Define the terms: [6]
   i. Normal stress
   ii. Tangential stress
   iii. Ductility
   iv. Brittleness.
   (b) A flat steel plate is of trapezoidal form of uniform thickness 't'. Its width at one end is 'a' and at the other end is 'b'. If its length is 'L', determine its elongation under an axial pull. [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. [16]
   (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

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) A water main 110mm internal diameter is made of mild steel plate 12mm thick and is running full. If it is freely supported at the ends find the maximum permissible span if the bending stress is not to exceed 5MPa. Unit weight if steel is 81 kN/m3 and unit weight of water = 9.8 kN/m^3. [10]
   (b) State the assumptions involved in the theory of simple bending. [6]

5. A beam A B of span 6 meters and of flexural rigidity EI = 8 $\times 10^4 kN - m^2$ is subjected to a clockwise couple of 60 kN-m at a distance of 4 m from the left end.
   Find the deflection at the point of application of the couple and the maximum deflection and slope. [16]

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 Euler's crippling load for a long column with following end conditions: [16]

   (a) both ends are hinged

   (b) both ends are fixed.

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 Figure1. Find the elongation of the bar. Take E = 2.1X10^8 KN/m^2. [10]

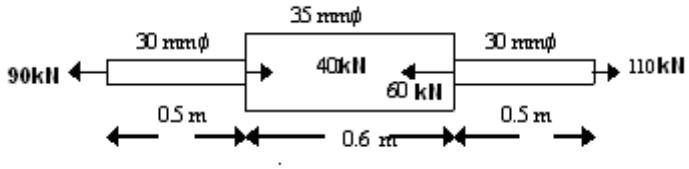

Figure 1:

2. (a) Draw stress-strain diagram for mild steel specimen tested under uni-axial tension till fracture and mark all the salient points. [8]

   (b) A metallic rod of 1 cm diameter, when tested under an axial pull of 10 kN was found to reduce its diameter by 0.0003 cm. The modulus of rigidity for the rod is 51 kN/mm^2. Find the Poisson's ratio, modulus of elasticity and Bulk Modulus. [8]

3. An overhanging beam of length 7m is supported centrally at two points 5m apart. It carries a uniformly increasing load of 400 N/m from the left end to 800 N/m at the midspan. It also carries a point load of 1000N at the right end. Draw the SF and BM diagrams and locate the point(s) of contra flexure. [16]

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

   (b) Derive the Bending equation from fist principle. [10]

5. (a) A girder of uniform section and constant depth is freely supported over a span of 2.5 meters. Calculate the central deflection and slopes at the ends of the beam under a central load of 25 kN. Given: I $_{XX} = 7.807 \times 10^{-6} m^4$ and E = 200 GN/m^2 . [8]

   (b) A simply supported 6 meters long rolled steel joist carries a uniformly distributed load of 9.5 kN/meter length. Determine slope and deflection at a distance of 3 meters from one end of the beam. [8]

6. A 2.4 m internal diameter and 6 m high vertical steam boiler is constructed with 20 mm thick plates for a working pressure of 1.1 N/mm^2. The end plates are flat and are not stayed. Calculate

(a) the stress in the circumferential plates due to resisting the bursting effect and the stress in the circumferential plate due to the pressure on the end plates. [8]

(b) the increase in length, diameter and volume. [8]

Assume the Poisson's ratio as 0.28 and E = 210 kN/mm^2.

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. 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]

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1. (a) Distinguish between : stress and strain, normal stress and shear stress, working stress and yield stress. [6]

   (b) An aluminium bar 60 mm diameter when subjected to an axial tensile load 100 kN elongates 0.20 mm in a gage length 300 mm and the diameter is decreased by 0.012 mm. Calculate the modulus of elasticity and the Poisson's ratio of the material. [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. [16]

   (a) Find the stresses in the rod and tube if the distance between the stops is increased by 0.30 mm.

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   Take $\mathrm{E}_S = 200kN/mm^2$; $\alpha_S = 11.2 \times 10^{-6} per^0\mathrm{C}$

   $\mathrm{E}_b = 90kN/mm^2$; $\alpha_b = 2.1 \times 10^{-5} per^0\mathrm{C}$

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) Derive the bending equation from first principles. State the assumptions involved. [8]

   (b) A cast iron beam is of I section having top flange of 80 mm wide and 20 mm thick and web of height 210 mm and thickness of web is 20 mm. The button flange is 180 mm wide and 40 mm thick. The beam is simply supported on a span of 5 m. If the tensile stress is not to exceed 20 MPa, find the safe udl which the beam can carry. Also find the max compressive stress. Show the bending stress diagram. [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) Define pressure vessel and discuss the most important considerations while designing pressure vessel. [6]

   (b) A boiler shell is made of 15 mm thick plate having a limiting tensile stress of 125 N/mm^2. If the longitudinal and circumferential efficiencies are 70% and 60% respectively, determine the maximum diameter of the shell. The allowable maximum pressure is 2.2 N/mm^2. [10]

7. Derive an expression for the Euler's crippling load for a long column with following end conditions: [16]

   (a) both ends are hinged

   (b) both ends are fixed.

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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