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

**II B.Tech. I Semester Supplementary Examinations, May -2005**
**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. In a tension test on a steel tube of outer diameter 18 mm and 12 mm bore, an axial load of 1.7 KN produced an elongation of 0.0045 mm on a length of 75 mm, while the outer diameter suffered a reduction of 0.00032 mm. Calculate the values of all the four elastic constants.

2. A bar of steel is 50 mm X 50 mm in section and is 150 mm long. It is subjected to a tensile load of 220 KN along the longitudinal axis and compressive loads of 300 KN and 200 KN on the lateral faces. E = 200KN/mm$^2$ . 1/m = 0.3,
   (a) Find the change in volume of the bar.
   (b) Find what axial longitudinal tensile load acting alone can produce the same longitudinal strain as in (a).

3. A beam of length 6m is simply supported at its ends. It is loaded with a gradually varying load of 750 N/m from left end to 1500 N/m to the right end. Construct the SF and BM diagrams and find the magnitude and position of the maximum BM.

4. (a) Discuss the assumptions in the theory of simple bending.
   (b) Compare the weight of two beams of the same material and equal strength. One beam is of solid circular cross section while other beam is of hollow circular section, the internal diameter being 0.78 times the external diameter.

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

6. (a) Derive the relation for the change of diameter and length of a thin cylindrical shell subjected to an internal pressure.
   (b) A thin cylinder steel shell of diameter 200 mm and wall thickness 4 mm has spherical ends. Determine the thickness of hemispherical ends if there is no distortion of the junction under pressure.

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 ?

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

   (b) the maximum shear stress and its plane

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

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1. A steel bar of 4 m long is 32 mm in diameter for 1m of its length, 28 mm in diameter for 2 m, and 25 mm in diameter for the remaining length. The bar is kept in tension, with stress in the smallest section being 110N/mm$^2$. If E = 2.127X10$^5$ N/mm$^2$, calculate the total elongation of the bar and the energy stored in it.

2. (a) What are the elastic constants ? Derive the relation between them.
   (b) A load of 2.0 KN is to be raised at the end of a steel wire. If the stress in the wire mus t not exceed 100N/mm$^2$, what is the minimum diameter of the wire? What will be the extension in 5.0 m long wire? Take E = 210N/mm$^2$,

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.

4. (a) What is elastic section modulus?
   (b) A beam resting freely on supports 5.8m apart carries a u.d.l of 12 kN/m and also a point load of 15 kN at 2m from the left support. If the permissible stress in timber is 5 MPa, design a suitable section by making the depth equal to 1.8 times the width.

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: $I_{XX}$= 7.807x10$^{-6}$m$^4$andE = 200GN/m$^2$.
   (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.

6. (a) Prove that the tendency to burst length wise is twice as great as a transverse section in a thin cylindrical shell subjected to an internal fluid pressure.
   (b) A thin cylindrical shell 3 m long is of 1 m diameter. Determine the changes in length and diameter, if the shell is subjected to an internal pressure of E = 20kN/mm$^2$. Take E = 200kN/mm$^2$ and 1/m = 0.28.

7. (a) Derive an expression for the maximum shear stress induced in the wire and stiffness of spring in case of close coiled helical springs.
   (b) What are the functions of springs ?

8. A close coiled helical spring 10 cm mean diameter is made of 20 turns of 1 cm diameter steel rod. The spring carries an axial load of 100 N. Find the shearing stress developed in the spring and the deflection of the load. Assume modulus of rigidity N = $0.84X10^5 N/mm^2$.

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1. (a) Derive the relationship between Modulus of Elasticity and Modulus of Rigidity.
   (b) A steel rod 600 mm long is of 20 mm diameter in the first 200 mm and 16 mm diameter in the second 200 mm and 12 mm diameter in the remaining length. It is subjected to a tensile load of (axial) of 50 KN. Determine the strain energy stored in the rod. Take E = 210KN/mm$^2$.

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 = 5X10$^4$N/mm$^2$.

3. A ladder 4m long and weighing 150 N/m is resting against a smooth vertical wall and the bottom end is resting on rough ground. If a man weighing 800N stands midway on the ladder, draw the SF and BM diagrams and determine the maximum BM in the ladder. The ladder is inclined at 45° to the horizontal.

4. (a) A cantilever of length 2.8 m fails when a load of 4.7 kN is applied at the free end. If the section of the beam is 65 mm x 105 mm find the stress at failure.
   (b) A T-beam having flange 210 mm x 20 mm is simply supported over a span of 5 m. It carries a u.d.l of 8.8 kN/m over its entire span. Calculate the maximum compressive and tensile stress occurring in the section. What is the magnitude of flexural stress at the junction of flange and web? Draw the variation of stress across the section.

5. A beam of uniform section, 10 meters long, is simply supported at the ends. It carries point loads of 110 KN and 60 KN at distances of 2m and 5m respectively from the left end. Calculate: The deflection under each load and maximum deflection Given : E = 200x10$^6$N/m$^2$and I = 118x10$^{-4}$m$^4$.

6. (a) Explain about 'wire wound thin cylinder' and distinguish between wire wound thin cylinder and ordinary thin cylinder.
   (b) A cylindrical shell 3 m long, 0.6 m in diameter is made up of 15 mm thick plate. Determine the change in volume, when the shell is subjected to an internal pressure of 50N/mm$^2$.

7. Derive an expression for the Euler's crippling load for a long column with following end conditions:
   (a) both ends are hinged

(b) both ends are fixed.

8. Design a closely coiled helical spring of stiffness 20 N/mm. The maximum shear stress reached is not to exceed 90N/mm$^2$ under a load of 500 N. The diameter of the coil is to be 10 times the diameter of the wire. Take modulus of rigidity as 0.82X10$^5$N/mm$^2$.

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1. (a) Derive the expression for the elongation of a uniformly tapering rod subjected to an axial pull.
   (b) Prove that the deformation of bar under its own weight is equal to half the deformation, if the body is subjected to direct load equal to weight of body.

2. Two parallel walls 6m apart are stayed together by a 25 mm diameter steel rod at 80°C passing through washers and nuts at ends. If the rod cools down to 22°C, calculate the pull induced in the rod, if
   (a) the walls do not yield and
   (b) the total yield at ends is 1.5 mm E steel = $2X10^5 N/mm^2$,$\alpha$steel = $11X10^{-6}$per°C.

3. A beam AB 10m long is simply supported at the left hand end A and at a point C, 2m from the extreme right hand end B. It carries two concentrated loads on 50 kN each at 3m and 7m from A and a uniformly distributed load of 10 kN/m over the portion in between the two concentrated loads
   (a) What upward force may be applied at B to make the reaction at C joint equal to zero?
   (b) Under these loads, including the above-mentioned upward force at B, sketch the SF and BM diagrams.

4. (a) A simply supported beam of span 6 m has a cross section 180 mm x 300 mm. If the permissible stress is 9 MPa, find the maximum concentrated load that can be applied at 2m from left end.
   (b) A rolled steel joist of I section has top and bottom flanges 185 mm x 25 mm and web of size 300 mm x 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.

5. A beam ABC 13 m long is supported at A and B, such that AB = 10m and overhang BC = 3 m. It carries a point load of 4.5 KN from the end A and a uniformly distributed load of 0.4 KN/m over the entire overhang. Determine: Slope at the end A, Deflection at the free end C and Maximum deflection ;Take E = 200x106$KNm^2$andI = $3x10^{-5}m^4$.

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

(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.

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

   (b) Derive an expression for the Rankine's crippling load for a column

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

8. (a) Describe the advantages of hollow shafts over a solid shafts.

   (b) Prove that a hollow shaft of the same weight and material as that of a solid shaft can resist more torque.

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