M.Tech. Mechanical Engineering Design (CBCS) Semester - I

MED12 - Advanced Mechanics of Solids

P. Pages : 3 **GUG/S/23/14187**

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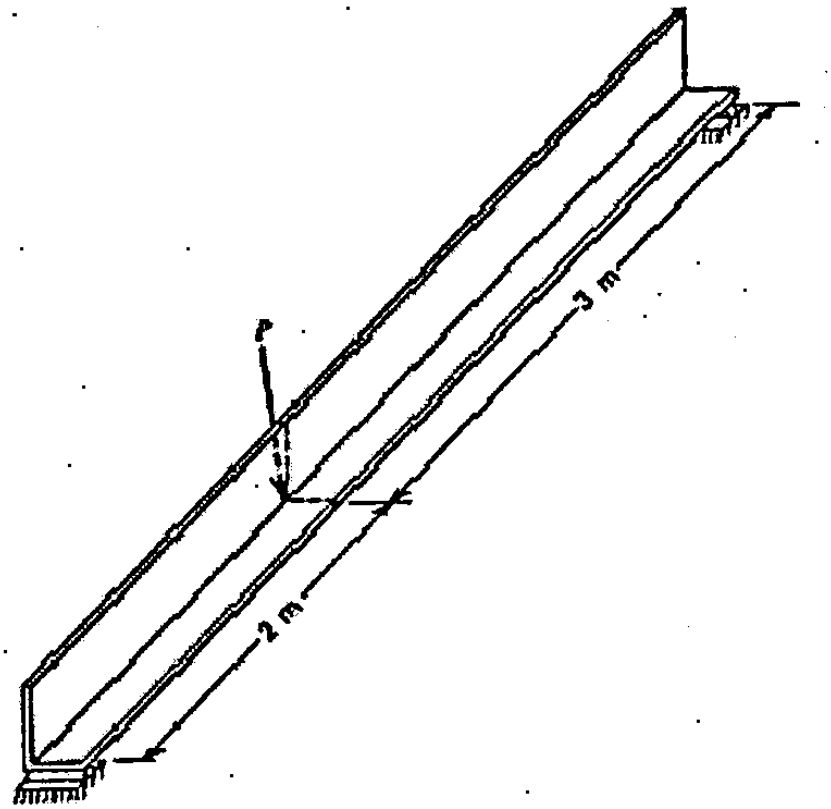
Time : Three Hours Max. Marks : 70

Notes :
1. All questions carry equal marks.
2. Assume suitable data wherever necessary.
3. Diagrams and Chemical equation should be given wherever necessary.
4. Illustrate your answers wherever necessary with the help of neat sketches.
5. Use of slide rule, Logarithmic tables, Steam tables, Mollier's chart, Drawing instruments, Thermodynamic tables for moist air, Psychrometric charts and Refrigeration charts is permitted. Use of non programmable calculator is permitted.
6. Solve **any five** questions.
7. Use of design data book is permitted.

1. a) Define shear center in bending symmetrical and nonsymmetrical bending. **4**

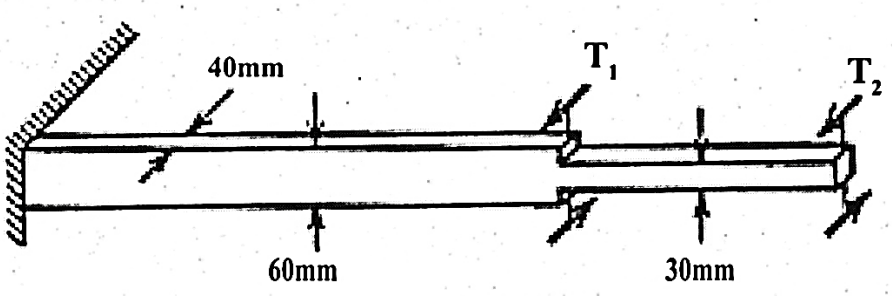
b) Plates are welded together to form the 120 mm X 80 mm X 10 mm angle section beam as shown in figure. The beam is subjected to a concentrated load P = 4kN as shown. The load P lies in the plane making an angle $\Phi = 2\pi/3$ with the X axis. Load P passed through shear center C. Determine the maximum tensile and compressive bending stresses at the section of the beam where the load is applied. Solve the problem using the load-stress relations derived for nonsymmetrical bending. **10**



2. Derive the equation for deflections of straight beams subjected to nonsymmetrical bending. **14**

3. Derive the equation for linear elastic solution for equilateral triangle cross section and rectangular cross section. **14**

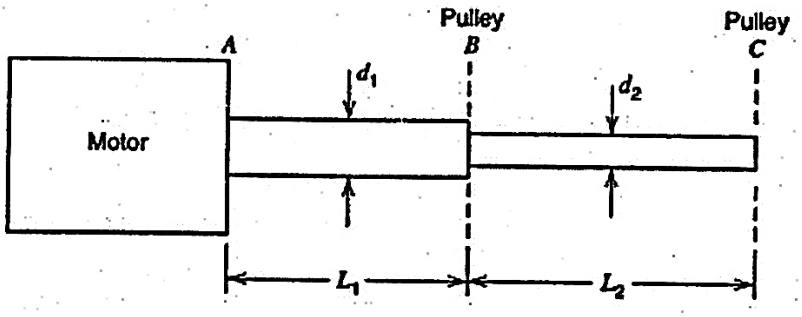
4. a) The rectangular section torsion member as shown in figure has a width of 40mm. The first 3m length of the torsion member has a depth of 60 mm, and the remaining 1.5 m length has a depth of 30 mm. The torsion member is made of steel for which G = 77.5 GPa. For $T_1 = 750\,N-m$ and $T_2 = 400N-m$, determine the maximum shear stress in the torsion member. Determine the angle of twist of the free end. The support at the left end prevents rotation of this cross section but does not prevent warping. **8**



b) Two pulleys, one at B and one at C, are driven by a motor through a stepped, steel drive shaft (G = 77 GPa) ABC, as shown in figure. Each pulley absorbs a torque of 113 m.N. The steeped shaft has two lengths $AB = L_1 = 1m$ long and $BC = L_2 = 1.27\,m$ long. The shafts are made of steel (Y=414 MPa). Consider the safety factor be SF = 2.0 for yield by the maximum shear stress criterion. **6**

i) Determine suitable diameter dimensions d_1 and d_2 for the two shaft lengths.

ii) With the diameters selected in part (i), calculate the total angle of twist β_c of the shaft.



5. Derive the equilibrium equations for small displacement theory of flat plates. **14**

6. Derive the Stress-Strain-temperature relations for isotropic elastic plates. **14**

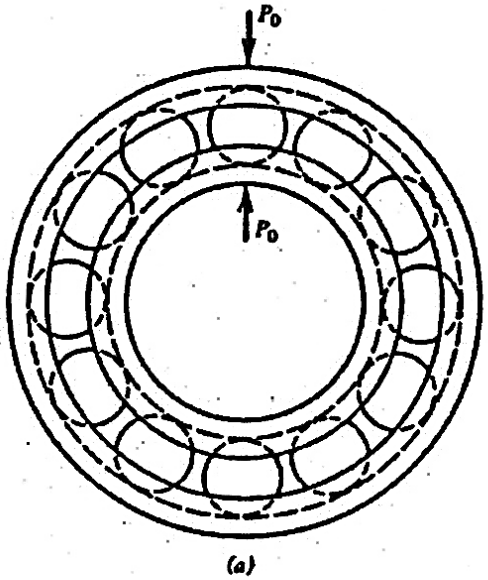
7. a) Explain the assumptions on which the solution of the problem of contact stresses is bases. **6**

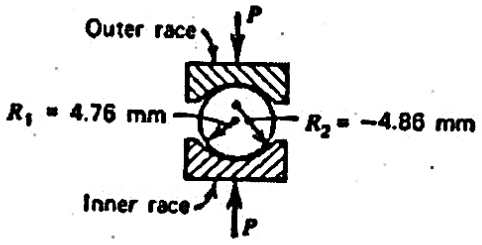
b) Describe the method of computing principal stresses and maximum shear stresses. **8**

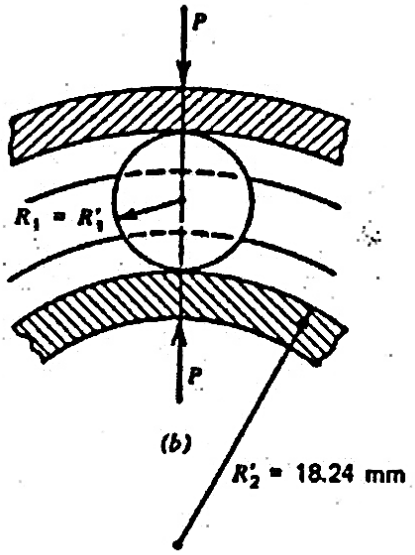
8. A steel ball bearing consisting of an inner race, an outer race, and 12 balls is sown in figure, E = 200 GPa, v = 0.29, and Y = 1600 MPa. A rated load of $P_o = 4.2kN$ is given in a manufacturer's handbook for this bearing when operated at 3000 rpm. An empirical relation Allen 1945 is used to determine the load P on the topmost ball that bears the largest portion of the load; $P = 5P_o / n = 1.75kN$ in which n is the number of balls. Use ball designation as shown in the figure. **14**

i) At the region of contact between the inner race and topmost ball, determine the maximum principal stress, maximum shear stress, maximum octahedral shear stress, dimensions of the area of contact, maximum orthogonal shear stress, and distance from the point of contact to the point where these stresses occur.

ii) What is the factor of safety against initiation of yielding based on the octahedral shear stress criterion of failure?







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