Quiz 1
ME 423

1. A thin spherical stainless-steel tank having a diameter of 16 in is used to store propane at a pressure of 3000 psi (lb/in^2).
   The properties of steel are as follows:
   - Yield stress in tension = 140,000 psi
   - Yield stress in shear = 65,000 psi
   - Maximum allowable normal strain = 1000x 10^{-6}
   - Modulus of elasticity = 30x10^6 psi
   - Poisson's ratio = 0.28

   The desired factor of safety for design with respect to yielding is 2.75.

   i. Determine the mode in which the material fails/yield. [15]
   ii. Determine the minimum permissible thickness, t_{min} of the tank. [10]

2. A weight W=45 kN is hung eccentrically from the end of the cantilevered pipe of length 750 mm as shown in Fig.1. The outer diameter is 250 mm, the wall thickness is 6 mm and a fluid in the pipe has a pressure of 3.5 MPa. Assume that the shear stresses are induced only due to torsion.
   i. Determine the point where the failure is likely to occur. Determine the failure stresses using von Mises and Tresca criteria [15]

   Note that the hydrostatic test standard demands 1.5 times the operating pressure and the designer wants to have 25% overload tolerance on the forces/moments.

   ii. Determine the design stresses and the factor of safety [10]

   $\sigma = \frac{M\,y}{I}$; $\tau = \frac{T\,r}{\mathrm{J}}$ where I is the area moment of inertia and J is polar moment of inertia

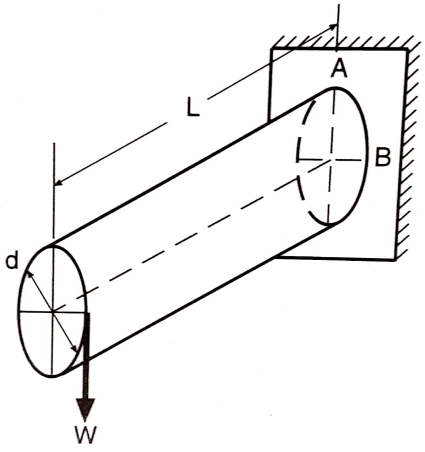

Fig. 1. Pressurized pipe with eccentric loading

3. In the diagram shown below (see Fig. 2), circular tie-rods A, B, C of length L=10 cm are loaded in simple uniaxial tension between two rigid plates. The cross-section is A=5 cm^2, B=3 cm^2 and C=1 cm^2. The total force is F and the displacement of all three bars, δ is same. The three bars have elastic-perfectly plastic behavior as shown in the figure. σ_{YC}=400 Mpa = 4 σ_{YB} = 8 σ_{YA}, modulus of elasticity, E =100 GPa.

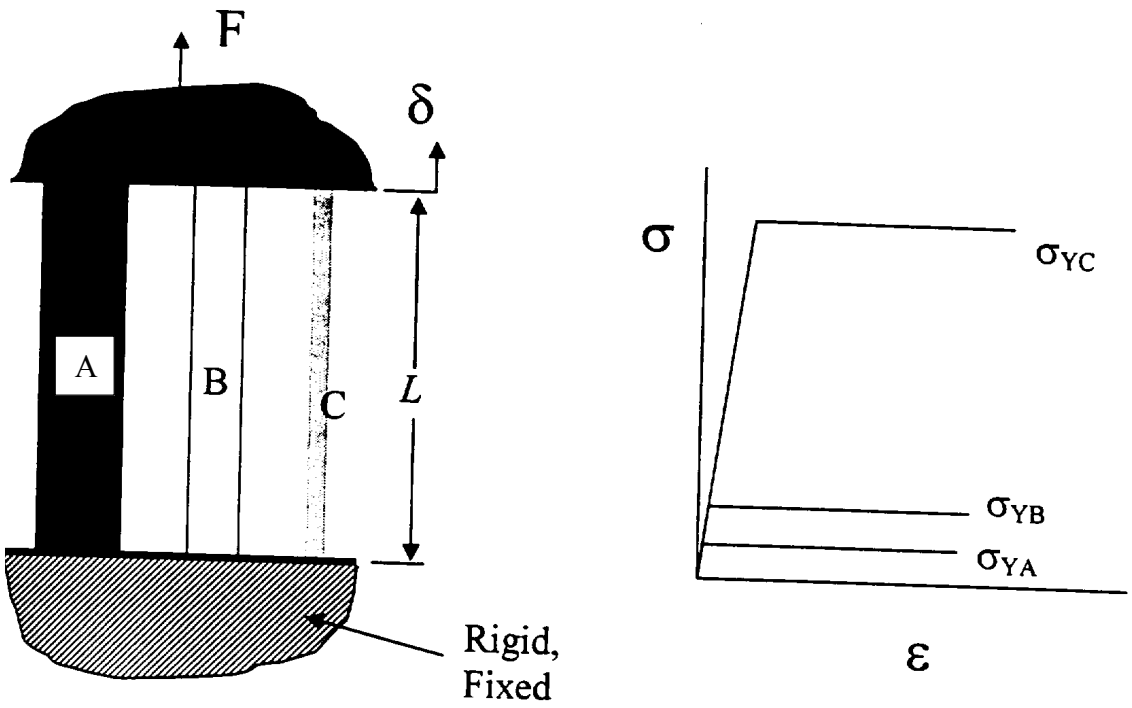

Fig. 2 Members in tension with varying properties

Find the force and deflection corresponding as the A, B and C yield and mark their respective locations in the force-deflection plot. [15]

4. A table has slender cylindrical legs which can be assumed to be a column. The length L of the column is specified. The constraints are that the legs should not buckle in design loads. The critical buckling load for column is given by, $F_{crit} = \frac{\pi^2 E I}{L^2}$, where I is the area moment of inertia. The objective is to (a) minimize the mass and (b) improve the slenderness (minimize the radius of the leg). The free variables are radius of the leg and the material.

    i. Find the material indices for minimizing the mass and the radius, respectively. Also select some of the candidates from the chart in Fig. 3 and find the value of the two material indices. [25]
    ii. Recommend the ideal selection with respect to just the material indices and an optimal recommendation based on material indices and cost. [10]

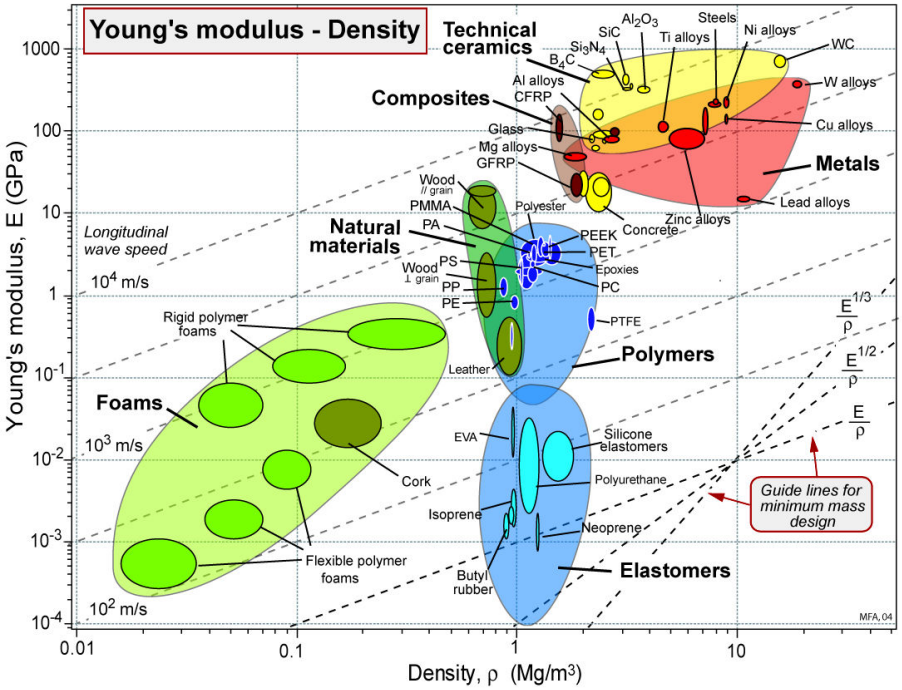

Fig. 2. Young's Modulus and density chart