Quiz 1
ME 423

Total Marks: 50 +5 bonus
Open books and notes, avoid web resources
The invigilator will award zero if any unfair means is used
Time allowed: 1 hour 25 minutes

1. 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 the fluid in the pipe has a pressure of 3.5 MPa. Assume that the shear stresses are induced only due to torsion.
   a. 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 a 25% overload tolerance on the forces/moments.
   b. 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 the polar moment of inertia

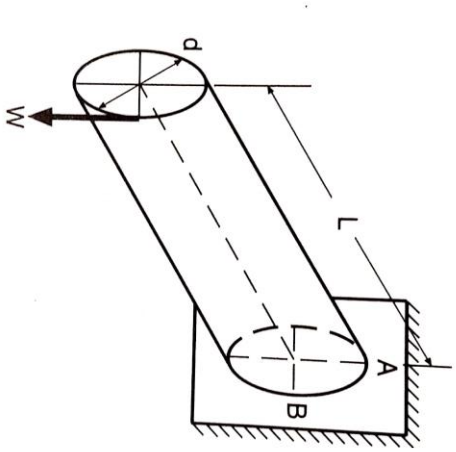

Fig. 1. Pressurized pipe with eccentric loading

2. A thick plate of steel is immersed in a cryogenic tank kept at -120°C for a short period. Given: E =200 GPa; coefficient of thermal expansion, $\alpha = 12 \times 10^{-6}/°\mathrm{C}$;
   a. What are the strains and stresses acting on the surface of the plate right after immersion? Provide the complete stress and strain tensor with signs ($+$ for tensile and $-$ for compressive). If the yield stress is 1 GPa, will yielding occur (use Tresca criteria)? [10]
   b. Physically explain the reason for that stress state. How will nature stress change if the fluid is very hot instead of cryogenic? [5 bonus]

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 the 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.

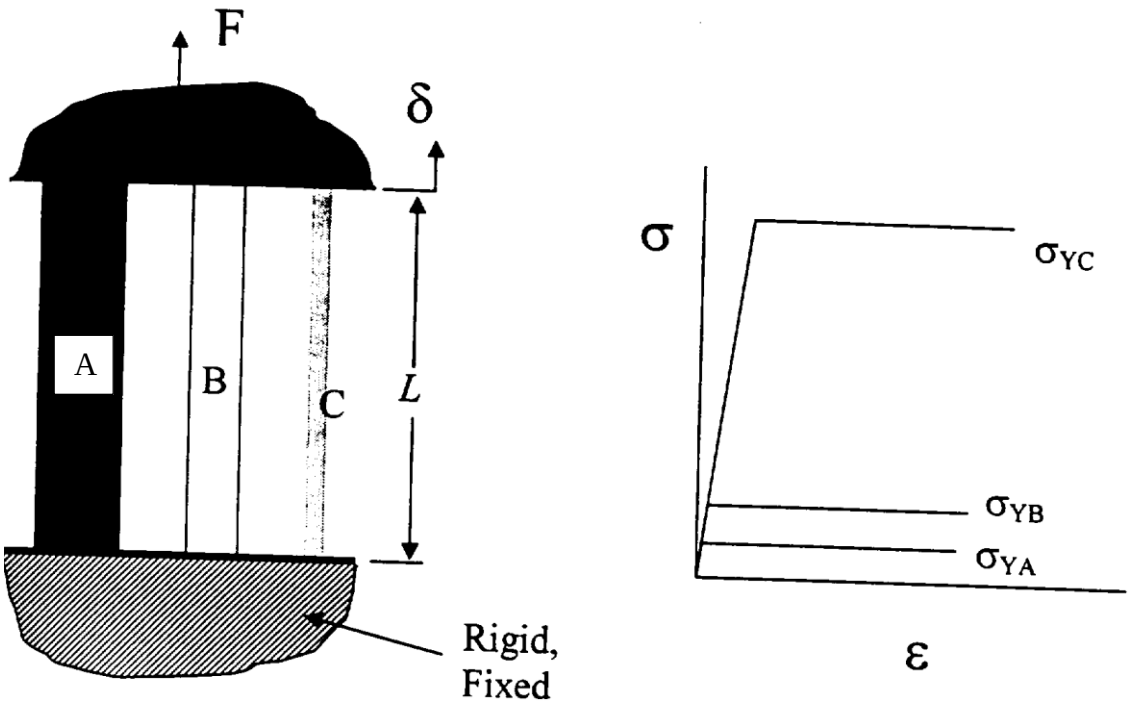

Fig. 2 Members in tension with varying properties

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