1. (20%) The shaft shown in Fig. 1 is made from a steel tube, which is bonded to a brass core. If a torque of $T = 250\,\text{N}\cdot\text{m}$ is applied at its end, plot the shear-stress distribution along a radial line of its cross-sectional area. Take $G_{st} = 80\,\text{GPa}$, $G_{br} = 36\,\text{GPa}$. Please also calculate the angle of twist.

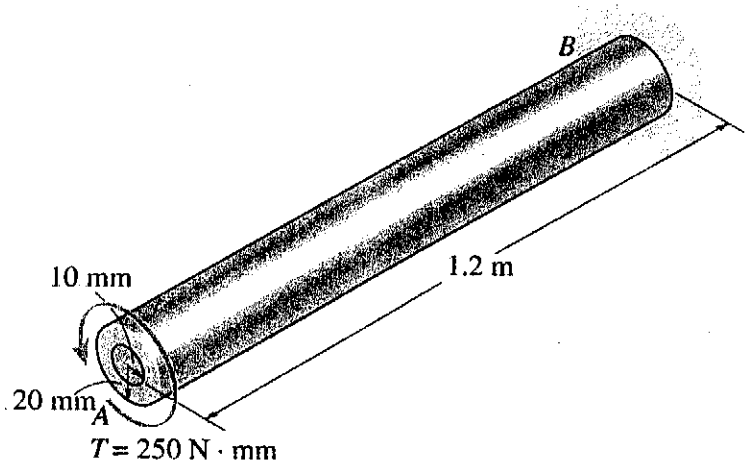
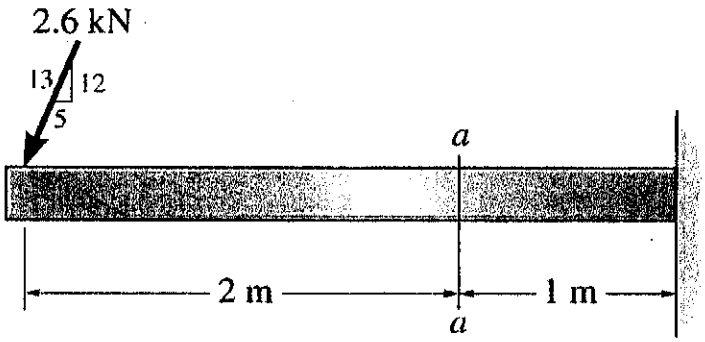
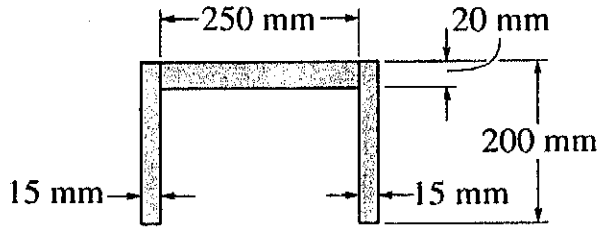


Fig. 1

2. (20%) The beam shown in Fig. 2a has a cross-sectional area in the shape of a channel, Fig. 2b. Determine the maximum bending stress that occurs in the beam at section *a-a*.



(a)



(b)
Fig. 2

3. (20%) A cylindrical tank having diameter d = 2.5 in. is subjected to internal gas pressure p = 300 psi and an external tensile load P = 1000 lb (see Fig. 3). Determine the required thickness t of the wall of the tank based upon an allowable shear stress of 3000 psi.

Fig. 3

4. (20%) The beam has a rectangular cross section and is subjected to the loading shown in Fig. 4. Determine the principal stresses and the maximum in-plane shear stress that are developed at point A and point B.

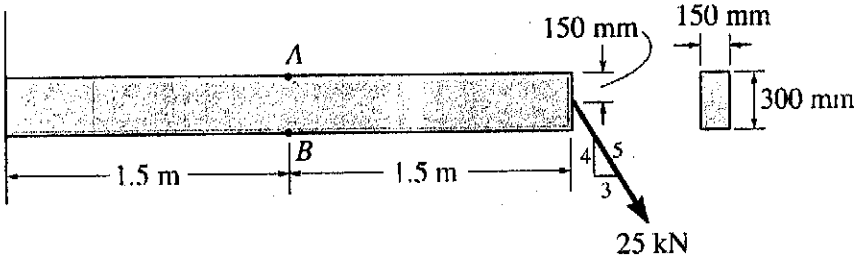


Fig. 4

5. (20%) Determine the vertical deflection and slope at point *A* of the cantilever loaded as shown in Fig. 5, using **only Castigliano's Theorem** or **Principle of Virtual Work**. Take all the members to be linear elastic and to have the same Young's modulus ***E***, but section *AB* has moment of inertia ***I*** and section *BC* has 2***I***.

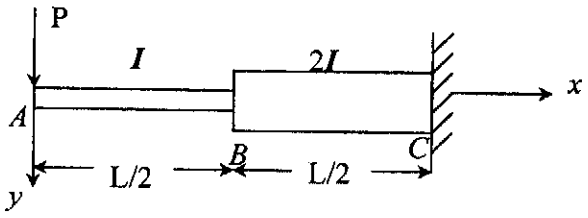


Fig. 5