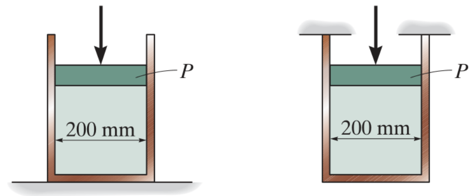
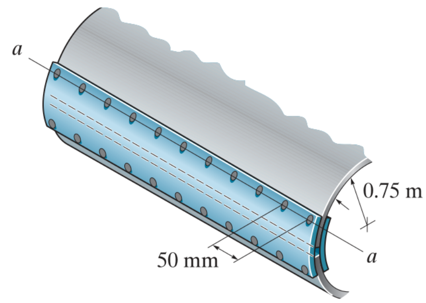
Tutorial Sheet 6: Miscellaneous Applications - I

1. The thin-walled cylinder can be supported in one of two ways shown. If the piston causes the internal pressure to be 0.6 MPa, determine the state of stress in the wall of the cylinder for both cases. The inner diameter of the cylinder is 250 mm and the wall has a thickness of 6 mm. [(a) 12.5 MPa, 0 MPa (b) 12.5 MPa, 6.25 MPa]

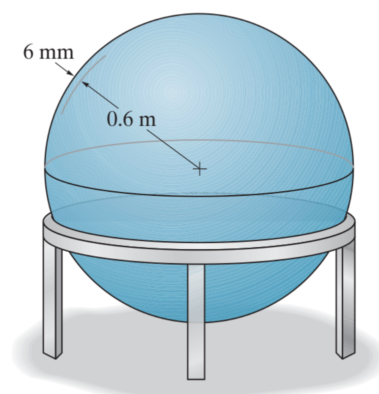


(a) (b)

2. A boiler is constructed of 8 mm thick steel plates that are fastened together at their ends using a butt joint consisting of two 8 mm thick cover plates and rivets having a diameter of 10 mm and spaced 50 mm apart as shown. If the steam pressure in the boiler is 1.35 MPa, determine (a) the hoop stress in the boiler plate apart from the seam, (b) the hoop stress in the outer cover plate along the rivet line *a*-*a*, and (c) the shear stress in the rivets. [(a) 127 MPa, (b) 79.1 MPa, (c) 322 MPa]

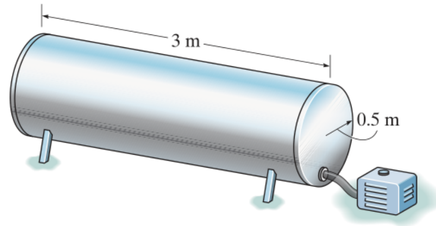


3. Two hemispheres having an inner radius of 0.6 m and wall thickness of 6 mm are fitted together, and the inside gauge pressure is reduced to −70 kPa. If the coefficient of static friction is $\mu_s = 0.5$ between the hemispheres, determine (a) the torque T needed to initiate the rotation of the top hemisphere relative to the bottom one, (b) the vertical force needed to pull the top hemisphere off the bottom one, and (c) the horizontal force needed to slide the top hemisphere off the bottom one. [(a) 23.869 kN·m, (b) 79.19 kN, (c) 39.58 kN]

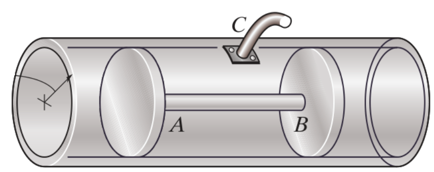


4. A thin walled spherical pressure having an inner radius r and thickness t is subjected to an internal pressure p. Show that the increase in the volume within the vessel is $\Delta V = \frac{2p\pi r^4}{Et}(1-\nu)$. Use a small-strain analysis.

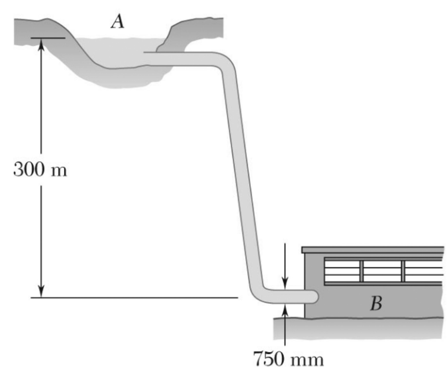
5. The thin-walled cylindrical pressure vessel shown in the figure is subjected to an internal gauge pressure of 15 MPa. If the thickness is 10 mm, and the material constants are $E = 200$ GPa and $\nu = 0.3$, determine the increase in both the diameter and the length of the pressure vessel. [3.19 mm, 2.25 mm]



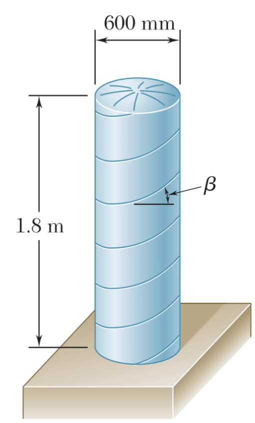
6. Air is pumped into the steel thin-walled presure vessel at C. The inner radius of the pressure vessel is 400 mm, and its thickness is 10 mm. For steel: $E = 200$ GPa and $\nu = 0.3$.
   (a) If the ends of the vessel are closed using two pistons connected by a rod AB, determine the increase in the diameter of the pressure vessel when the internal gauge pressure is 5 MPa. Also, what is the tensile stress in rod AB if it has a diameter of 100 mm?
   (b) If the pistons in part (a) are replaced by walls connected to the ends of the vessel, determine the increase in the diameter of the pressure vessel.
   [(a) 0.800 mm, 315 MPa, (b) 0.680 mm]



7. A steel penstock has a 750 mm outer diameter, a 12 mm wall thickness, and connects a reservoir at A with a generating station at B. Knowing that the density of water is 1000 kg/m^3, determine the maximum normal stress and the maximum shearing stress in the penstock under static conditions. [89.0 MPa, 44.5 MPa]

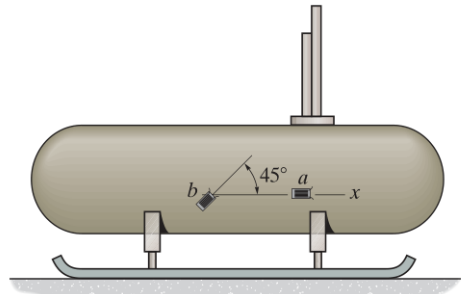


8. The cylindrical portion of the compressed air tank shown is fabricated of 8 mm thick plate welded along a helix forming an angle $\beta = 30°$ with the horizontal. Knowing that the allowable stress normal to the weld is 75 MPa, determine the largest gauge pressure that can be used in the tank. [3.29 MPa]

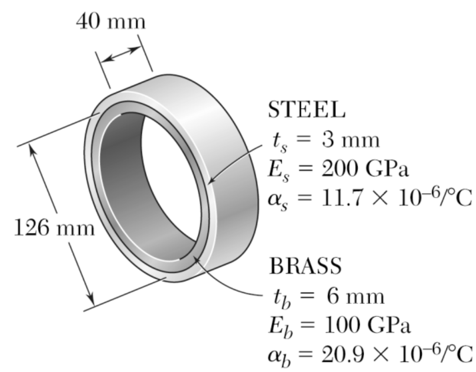


9. The gas tank shown has an inner diameter of 1.5 m and wall thickness of 25 mm. It is made of steel with $E = 200$ GPa and $\nu = 1/3$. Determine the pressure when:
   (a) the strain gauge a gives a reading of $\varepsilon_a = 100 \times 10^{-6}$.
   (b) the strain gauge b gives a reading of $\varepsilon_b = 250 \times 10^{-6}$.

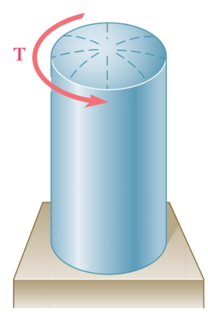
   [(a) 4 MPa, (b) 3.33 MPa]



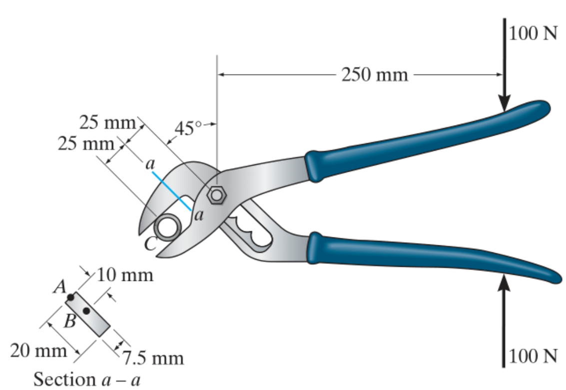
10. A brass ring of 126 mm outer diameter and 6 mm thickness fits exacts inside a steel ring of 126 mm inner diameter and 3 mm thickness when the temperature of boths rings is 10°. Knowing that the temperature of both rings is then raised to 52°, determine the pressure exerted by the brass ring on the steel ring and the tensile stress in the steel ring. Note that the strain due to temperature change is given by $\varepsilon_T = \alpha \Delta T$ and the strains due to pressure and temperature change add up to give the total strain. [1.67 MPa, 35.1 MPa]



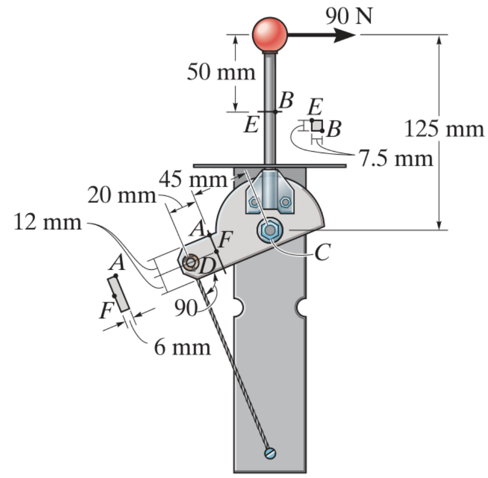
11. A torque of magnitude $T = 12$ kN·m is applied to the end of a tank containing compressed air under a pressure of 8 MPa. Knowing that the tank has a 180 mm inner diameter and a 12 mm wall thickness, determine the maximum normal stress and the maximum shearing stress in the tank. [68.6 MPa, 34.3 MPa]



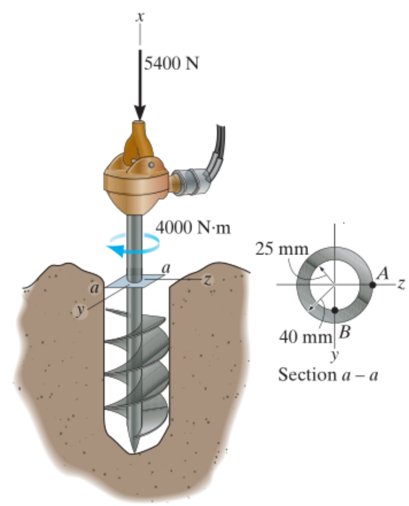
12. The rib-joint pliers are used to grip the smooth pipe C. If the force of 100 N is applied to the handles, determine the state of stress at points A and B on the cross section of the jaw at section a-a. [$\sigma_A = 25$ MPa (C), $\sigma_B = 0$, $\tau_A = 0$, $\tau_B = 5$ MPa]



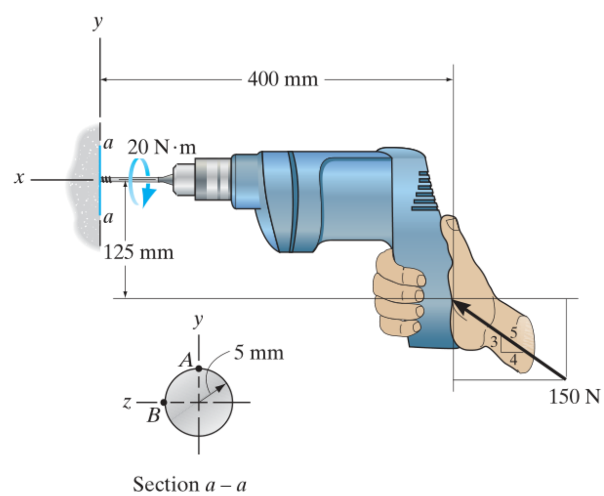
13. The control lever is subjected to a horizontal force of 90 N on the handle. Determine the state of stress at points A, B, E, and F. The assembly is pin connected at C and attached to a cable at D.
[$\sigma_A = 5184$ kPa (T), $\tau_A = 0$,
$\sigma_B = 64$ MPa (C), $\tau_B = 0$,
$\sigma_E = 64$ MPa (T), $\tau_E = 0$,
$\sigma_F = 0$, $\tau_F = 1875$ kPa]



14. The tubular shaft of the soil auger is subjected to the axial force and torque shown. If the auger is rotating at a constant rate, determine the state of stress at points A and B on the cross section of the shaft at section *a*-*a*.
[$\sigma_A = \sigma_B = 1762.2$ kPa (C)
$\tau_A = 46.9352$ MPa, $\tau_B = 29.3457$ MPa]

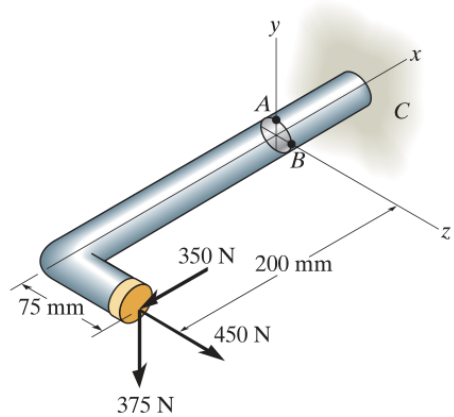


15. The drill is jammed in the wall and is subjected to the torque and force shown. Determine the state of stress at points A and B on the cross section of drill bit at section *a*-*a*.
[$\sigma_A = 215$ MPa (C),
$(\tau_{xy})_A = 0$, $(\tau_{xz})_A = 102$ MPa,
$\sigma_B = 1.53$ MPa (C),
$(\tau_{xy})_B = \tau_{\text{torsion}} - \tau_{\text{transverse}} = 100.33$ MPa]

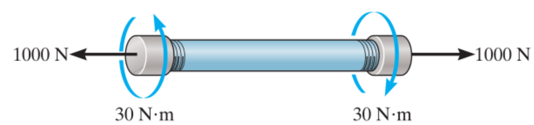


16. The 25 mm diameter rod is subjected to the loads shown. Determine the state of stress at points A and B.

    [$\sigma_A = 49.61$ MPa (C), $\tau_A = 10.39$ MPa, $\sigma_B = 40.84$ MPa (C), $\tau_B = 9.58$ MPa]

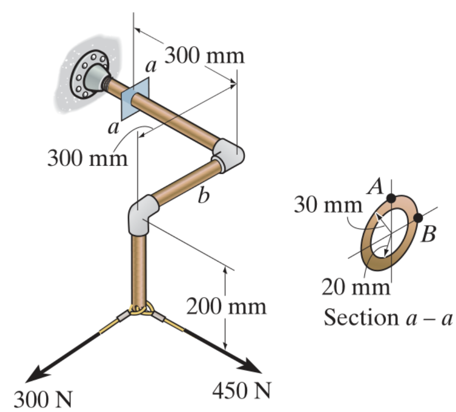


17. The thin-walled pipe has an inner diameter of 12 mm and a thickness of 0.6 mm. If it is subjected to an internal pressure of 3.5 MPa and the axial tension and torsional loadings shown, determine the principal stress at a point on the surface of the pipe. [272.3 MPa, −162.7 MPa]



18. Determine the principal stresses and maximum in-plane shear stresses at points A and B on the cross section of the pipe at section *a*-*a*.

    [A: $\sigma_1 = 0.361$ MPa, $\sigma_2 = -5.36$ MPa, $\tau_{\text{max,in-plane}} = 2.86$ MPa
    B: $\sigma_1 = 0.942$ MPa, $\sigma_2 = -3.30$ MPa, $\tau_{\text{max,in-plane}} = 2.12$ MPa]



19. A close-coiled spring is made of a circular wire of radius r tht is formed into a helix of radius R. Determine the maximum shearing stress produced by the two equal and opposite forces P and P'. (First determine the shear and the torque in a transverse cross section of the wire.) [$\tau_{\max} = \dfrac{P}{\pi r^3}\left(2R + \dfrac{4r}{3}\right)$]