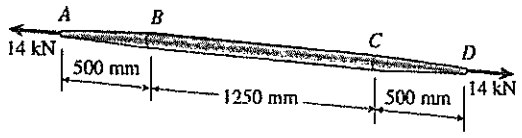
(15%) 1. Calculate the elongation of a copper bar of solid circular cross section with tapered ends when it is stretched by axial loads of magnitude 14 kN.
The length of the end segments is 500 mm and the length of the prismatic middle segment is 1250 mm. Also, the diameters at cross sections *A*, *B*, *C*, and *D* are 12, 24, 24, and 12 mm, respectively, and the modulus of elasticity is 120 GPa.

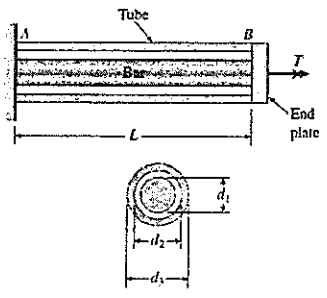


(20%) 2. A solid steel bar of diameter $d_1 = 25.0$ mm is enclosed by a steel tube of outer diameter $d_3 = 37.5$ mm and inner diameter $d_2 = 30.0$ mm. Both bar and tube are held rigidly by a support at end *A* and joined securely to a rigid plate at end *B*. The composite bar, which has a length $L = 550$ mm, is twisted by a torque $T = 400$ N · m acting on the end plate.

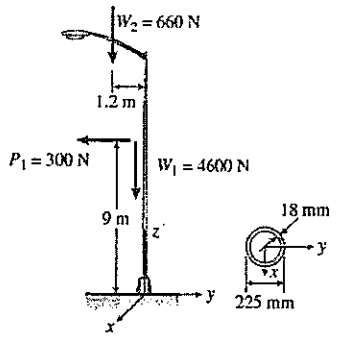
(a) Determine the maximum shear stresses τ_1 and τ_2 in the bar and tube, respectively. (8%)

(b) Determine the angle of rotation ϕ (in degrees) of the end plate, assuming that the shear modulus of the steel is $G = 80$ GPa. (7%)

(c) Determine the torsional stiffness k_T of the composite bar. (5%)



(15%) 3. An aluminum pole for a street light weights 4600 N and supports an arm that weights 660 N. The center of gravity of the arm is 1.2 m from the axis of the pole. A wind force of 300 N also acts in the (-*y*) direction at 9 m above the base. The outside diameter of the pole (at its base) is 225 m, and its thickness is 18 mm.
Determine the maximum tensile and compressive stresses σ_t and σ_c, respectively, in the pole (at its base) due to the weights and the wind force.



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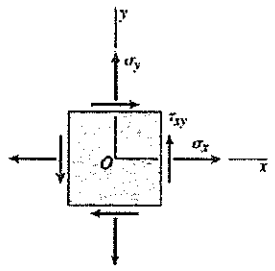
(20%) 4. An element in *plane stress* is subjected to stresses σ_x = 5.5 MPa, σ_y = -15 MPa, τ_{xy} = 20 MPa. Determine

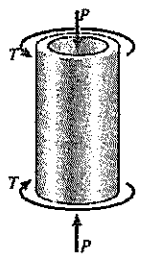
(a) the principal stresses and show them on a sketch of a properly oriented element. (10%)

(b) the maximum shear stresses and associated normal stresses and show them on a sketch of a properly oriented element. (10%)

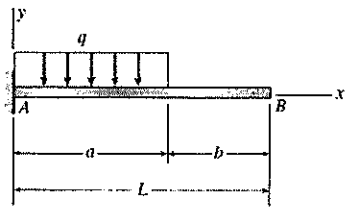


(15%) 5. A segment of a generator shaft of hollow circular cross section is subjected to a torque T = 25 kN · m. The outer and inner diameters of the shaft are 200 mm and 160 mm, respectively.

What is the maximum permissible compressive load P that can be applied to the shaft if the allowable in-plane shear stress is τ_{allow} = 45 MPa?



(15%) 6. Derive the equations of the deflection curve for a cantilever beam AB carrying a uniform load of intensity q over part of the span. Also, determine the deflection δ_B at the end of the beam.



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