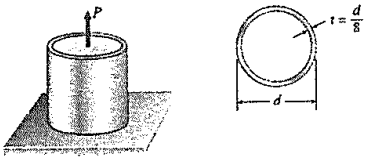
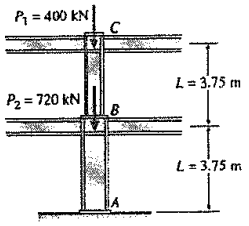
(20%) 1. A copper alloy pipe having yield stress $\sigma_Y = 290$ MPa is to carry an axial tensile load $P = 1500$ kN. A factor of safety of 1.8 against yielding is to be used. If the thickness t of the pipe is to be one-eighth of its outer diameter, what is the minimum required outer diameter d_{min}?



(20%) 2. A two-story building has steel columns AB in the first floor and BC in the second floor. The roof load P_1 equals 400 kN and the second-floor load P_2 equals 720 kN. Each column has length $L = 3.75$ m. The cross-sectional areas of the first- and second-floor columns are 11,000 mm^2 and 3900 mm^2, respectively.

(a) Assuming that $E = 206$ GPa, determine the total shortening δ_{AC} of the two columns due to the combined action of the loads P_1 and P_2. (10%)

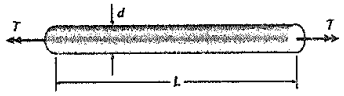
(b) How much additional load P_0 can be placed at the top of the column (point C) if the total shortening δ_{AC} is not to exceed 4.0 mm? (10%)



(20%) 3. A propeller shaft for a small yacht is made of a solid steel bar 104 mm in diameter. The allowable stress in shear is 48 MPa, and the allowable rate of twist is 2.0° in 3.5 meters.

(a) Assuming that the shear modulus of elasticity is $G = 80$ GPa, determine the maximum torque T_{max} that can be applied to the shaft. (10%)

(b) Repeat part (a) if the shaft is now hollow with inner diameter of $5d/8$. Compare T_{max} values to corresponding values from part (a). (10%)



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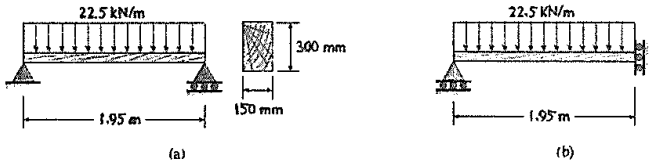
(20%) 4. Calculate the maximum shear stress τ_{max} and the maximum bending stress σ_{max} in a wood beam carrying a uniform load of 22.5 kN/m (which includes the weight of the beam) if the length is 1.95 m and the cross section is rectangular with width 150 mm and height 300 mm, and the beam is either

(a) simply supported as in the figure part a, or (10%)

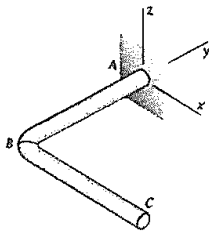
(b) has a sliding support at right as in the figure part b. (10%)



(20%) 5. An arm *ABC* lying in a horizontal plane and supported at *A* is made of two identical solid steel bars *AB* and *BC* welded together at a right angle. Each bar is 0.6 m long.

(a) Knowing that the maximum tensile stress (principal stress) at the top of the bar at support *A* is due solely to the weights of the bars is 7.2 MPa, determine the diameter *d* of the bars. (10%)

(b) If the allowable tensile stress is 10 MPa and each bar has diameter d = 50 mm, what is the maximum downward load *P* that can be applied at *C* (in addition to self-weight)? (10%)



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