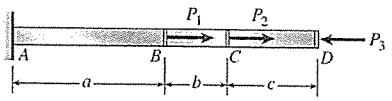
(20%) 1. An aluminum bar AD has a crosssectional area of $A = 250$ mm^2 and is loaded by forces $P_1 = 7560$ N, $P_2 = 5340$ N, and $P_3 = 5780$ N. The lengths of the segments of the bar are $a = 1525$ mm, $b = 610$ mm, and $c = 916$ mm.

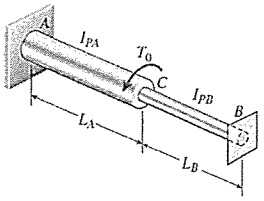
(a) Assuming that the modulus of elasticity $E = 72$ GPa, calculate the change in length of the bar. Does the bar elongate or shorten? (7%)

(b) By what amount P should the load P_3 be increased so that the bar does not change in length when the three loads are applied? (7%)

(c) If P_3 remains at 5780 N, what revised cross-sectional area for segment AB will result in no change of length when all three loads are applied? (6%)

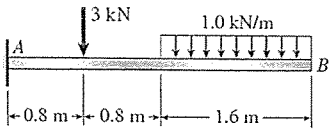


(15%) 2. A statically indeterminate stepped shaft ACB is fixed at ends A and B and loaded by a torque T_0 at point C. The two segments of the bar are made of the same material, have lengths L_A and L_B, and have polar moments of inertia I_{PA} and I_{PB}. Determine the angle of rotation ϕ of the cross section at C by using strain energy.



(15%) 3. The cantilever beam shown in the figure supports a concentrated load and a segment of uniform load.

Draw the shear-force and bending-moment diagrams for this cantilever beam.



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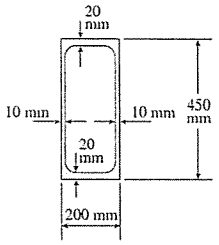
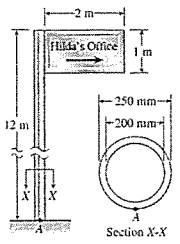
(15%) 4. A hollow steel box beam has the rectangular cross section shown in the figure. Determine the maximum allowable shear force V that may act on the beam if the allowable shear stress is 36 Mpa.



(20%) 5. A sign is supported by a pole of hollow circular cross section, as shown in the figure. The outer and inner diameters of the pole are 250 mm and 200 mm, respectively. The pole is 12 m high and weighs 18 kN. The sign has dimensions 2 m × 1 m and weighs 2.2 kN. Note that its center of gravity is 1.125 m from the axis of the pole. The wind pressure against the sign is 1.5 kPa.

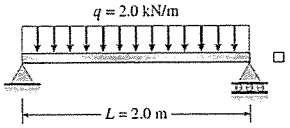
(a) Determine the stresses acting on a stress element at point A, which is on the outer surface of the pole at the "front" of the pole, that is, the part of the pole nearest to the viewer. (10%)

(b) Determine the maximum tensile, compressive, and shear stresses at point A. (10%)



(15%) 6. Calculate the maximum deflection δ_{max} of a uniformly loaded simple beam if the span length $L = 2.0$ m, the intensity of the uniform load $q = 2.0$ kN/m, and the maximum bending stress $\sigma = 60$ MPa.

The cross section of the beam is square, and the material is aluminum having modulus of elasticity $E = 70$ GPa.



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