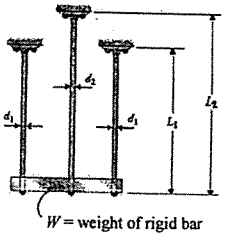
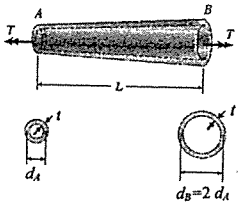
(15%) 1. A horizontal rigid bar of weight $W = 32$ kN is supported by three slender circular rods that are equally spaced. The two outer rods are made of aluminum ($E_1 = 70$ GPa) with diameter $d_1 = 10$ mm and length $L_1 = 1$ m. The inner rod is magnesium ($E_2 = 42$ GPa) with diameter d_2 and length L_2. The allowable stresses in the aluminum and magnesium are 165 MPa and 90 MPa, respectively.

If it is desired to have all three rods loaded to their maximum allowable values, what should be the diameter d_2 and length L_2 of the middle rod?



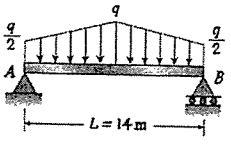
(15%) 2. A uniformly tapered tube AB of hollow circular cross section is shown in the figure. The tube has constant wall thickness t and length L. The average diameters at the ends are d_A and $d_B = 2d_A$. The polar moment of inertia may be represented by the approximate formula $I_P \approx \pi d^3 t/4$.

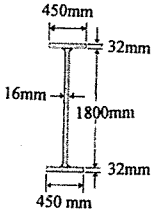
Derive a formula for the angle of twist ϕ of the tube when it is subjected to torques T acting at the ends.



(20%) 3. A bridge girder AB on a simple span of length $L = 14$ m supports a distributed load of maximum intensity q at mid-span and minimum intensity $q/2$ at supports A and B that includes the weight of the girder. The girder is constructed of three plates welded to form the cross section shown.

Determine the maximum permissible load q based upon (a) an allowable bending stress $\sigma_{allow} = 110$ MPa, and (b) an allowable shear stress $\tau_{allow} = 50$ MPa.





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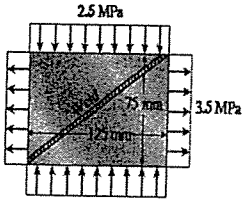
(15%) 4. A rectangular plate of dimensions 75 mm × 125 mm is formed by welding two triangular plates. The plate is subjected to a tensile stress of 3.5 MPa in the long direction and a compressive stress of 2.5 MPa in the short direction.

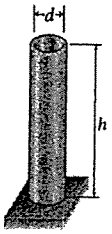
Determine the normal stress σ_w acting perpendicular to the line of the weld and the shear stress τ_w acting parallel to the weld. (Assume that the normal stress σ_w is positive when it acts in tension against the weld and the shear stress τ_w is positive when it acts counterclockwise against the weld.)



(15%) 5. A tall standpipe with an open top has diameter d = 2.2 m and wall thickness t = 20 mm.

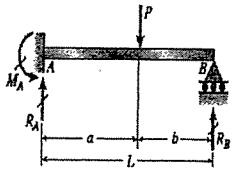
(a) What height h of water will produce a circumferential stress of 12 MPa in the wall of the standpipe? (10%)

(b) What is the axial stress in the wall of the tank due to the water pressure? (5%)



(20%) 6. A propped cantilever beam AB of constant flexural rigidity EI and length L carries a concentrated load P acting at the position shown in the figure.

Determine the reactions R_A, R_B and M_A for this beam. Also, draw the shear-force and bending-moment diagrams, labeling all critical ordinates.



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