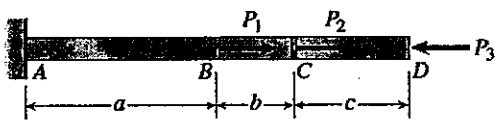
(20%) 1. An aluminum bar AD (see figure) has a cross-sectional area of $A = 250$ mm^2 and is loaded by forces $P_1 = 7560$ N, $P_2 = 5340$ N, and $P_3 = 5780$ N. The lengths of the segments of the bar are $a = 1525$ mm, $b = 610$ mm, and $c = 910$ mm.

(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%)

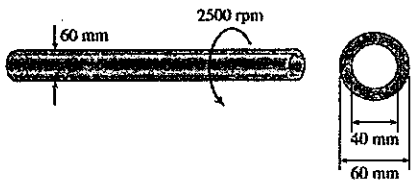
(c) If P_3 remains at 5780 N, what revised cross-sectional area for segment AB will result in no change of length when all three loads are applied? (6%)



(15%) 2. The drive shaft for a truck (outer diameter 60 mm and inner diameter 40 mm) is running at 2500 rpm (see figure).

(a) If the shaft transmits 150 kW, what is the maximum shear stress in the shaft? (8%)

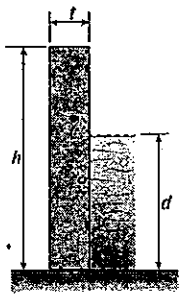
(b) If the allowable shear stress is 30 MPa, what is the maximum power that can be transmitted? (7%)



(15%) 3. A plain concrete wall (i.e., wall with no steel reinforcement) rests on a secure foundation and serves as a small dam on a creek (see figure). The height of the wall is $h = 2$ m and the thickness of the wall is $t = 0.3$ m.

(a) Determine the maximum tensile and compressive stresses σ_t and σ_c, respectively, at the base of the wall when the water level reaches the top ($d = h$). Assume plain concrete has weight density $\gamma_c = 23$ kN/m^3. (8%)

(b) Determine the maximum permissible depth d_{max} of the water if there is to be no tension in the concrete. (7%)



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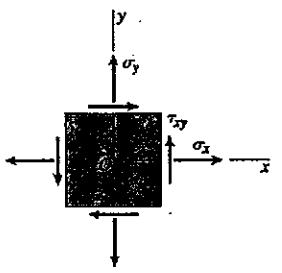
(15%) 4. An element in *plane stress* (see figure) is subjected to stresses $\sigma_x = 2150$ kPa, $\sigma_y = 375$ kPa, $\tau_{xy} = -460$ kPa

(a) Determine the principal stresses and show them on a sketch of a properly oriented element. (8%)

(b) Determine the maximum shear stresses and associated normal stresses and show them on a sketch of a properly oriented element. (7%)

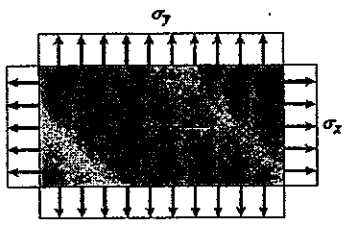


(15%) 5. A rectangular plate in *biaxial stress* (see figure) is subjected to normal stresses $\sigma_x = 67$ MPa (tension) and $\sigma_y = -23$ MPa (compression). The plate has dimensions 400×550×20 mm and is made of steel with $E = 200$ GPa and $\nu = 0.30$.

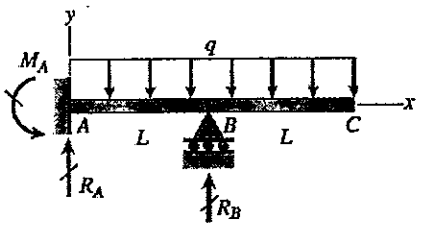
(a) Determine the maximum in-plane shear strain γ_{max} in the plate. (5%)

(b) Determine the change Δt in the thickness of the plate. (5%)

(c) Determine the change ΔV in the volume of the plate. (5%)



(20%) 6. A propped cantilever beam of length $2L$ with support at B is loaded by a uniformly distributed load with intensity q. Solve for all reactions. Also draw shear-force and bending moment diagrams, labeling all critical ordinates.



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