1. (20pt) A solid shaft with radius r_s and a hollow shaft with inner radius r_i and outer radius r_o. They are made of the same steel (Young modulus= 200Gpa, Poisson's ratio= 0.3) and are of the same weight and length. Denoting by $R = r_i/r_o$ and T_s/T_h =(Torque T_s in the solid shaft)/(Torque T_h in the hollow shaft), show that: (a) If the maximum stress is the same in each shaft then what is the T_s/T_h in terms of R ? (b) If the angle of twist is the same for each shaft, then what is the T_s/T_h in terms of R ?

2. (20pt) An 800mm circular rod of cross section area A_r = 45mm^2 is placed inside a tube of the same length and of cross-sectional area A_t = 60mm^2 . The ends of the rod and tube are attached to a rigid support on one side, and to a rigid plate on the other. The rod and tube are both assumed to be elastic - (perfect) plastic, with moduli of elasticity E_r = 200Gpa and E_t = 100Gpa, and yield strength $(\sigma_r)_Y$ = 200Mpa and $(\sigma_t)_Y$ =250Mpa. If the load P applied longitudinally to the rod-tube assembly is increased from zero to 19.5KN and then is removed, determine (a) The maximum elongation of the assembly, (b) The permanent set after the load has been removed (c) The residual stresses in the rod and in the tube.

3. (20pt) A rectangular beam is made of a material for which the modulus of elasticity is E_t in tension and E_c in compression. Shown that the curvature in pure bending is $\frac{1}{\rho} = \frac{M}{E_r I}$ where $E_r = \frac{4E_tE_c}{(\sqrt{E_t}+\sqrt{E_c})^2}$.

4. (20pt) A cylindrical storage tank used to transport gas under pressure P has an inside diameter of 600mm and a wall thickness of 20mm. The tank is made of steel with shear modulus = 80Gpa, ν = 0.3 and shear strength = 150Mpa. We use a pressure sensor (as shown in Fig) to measure pressure. (a) The arrangement of the apparatus will lead to positive $(\varepsilon_1 - \varepsilon_2)$ reading, why ? (b) Determine the pressure in terms of sensor's reading (c) If the maximum shear strength theory is used to limit the maximum pressure in the tank, then what is the maximum reading corresponding to the maximum pressure ?

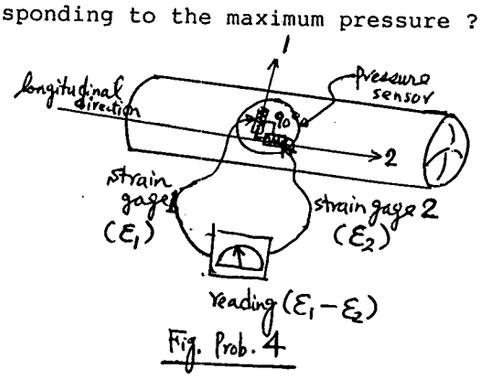

Fig. Prob. 4

5. (20pt) A centric axial force P and a horizontal force Q_x are both applied at point C of the rectangular bar shown. Knowing that a 45° - rosette strain gage on the surface of the bar at point A indicates strains $\varepsilon_1 = -60\mu$, $\varepsilon_2 = 240\mu$, and $\varepsilon_3 = 200\mu$, (a) Determine the magnitude of P and Q_x (b) If the maximum normal strength theory is used to predict the future crack generated and its crack propagation, then at point A what is the direction of future crack propagation by prediction ?

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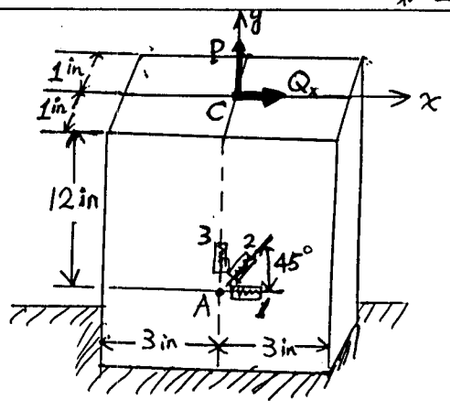

Fig. Prob.5