1. (20 Pt) Figure 1 shows an instrument suspension consisting of two aluminum bars and one steel rod mounted in a stiff frame, together with a spring EA which is inclined at 45° to BA. In assembly the nut on the steel rod at D is tightened so there is no slack in the line BAD, and then the spring EA is installed with sufficient extension to produce a force of 10 lb.

Find the deflection of the joint A (relative to the frame) caused by the spring loading, assume that the steel rod to be pinned at point D.
Young's modulus of steel is 30×10^6 psi, Al is 10×10^6 psi.

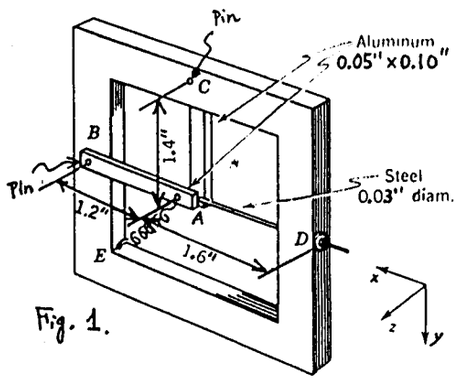

Fig. 1.

2. A materials test is performed by pressurizing the chamber shown. The specimen is machined to have cross-sectional area A at the ends and area kA in the test section ($0 < k < 1$).

(10pt) (a) What is the stress state in the test section when the pressure (above atmospheric) in the chamber is p?

(10pt) (b) Under atmospheric conditions, the material yields in simple tension at $\sigma_Y = 280$ MN/m². How large must the pressure p be to produce yielding? For this case, does it make any difference whether you use the Mises or the maximum shear-stress criterion?

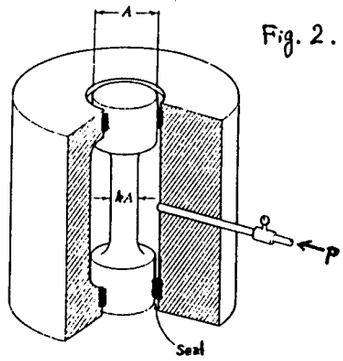

Fig. 2.

3. The compact torsion-bar spring sketched below consists of an inner shaft of radius R_i and a sleeve whose outer radius is R_o. There is a very small clearance between the shaft and the inner surface of the sleeve. The material has an elastic shear modulus G and a yield stress in shear of τ_Y.

(10pt) (a) Determine the torsional spring constant of the spring under the action of the twisting moment T.

(10pt) (b) In a well-designed spring the outer sleeve will yield under the same twisting moment as the inner shaft. Develop an equation for determining the ratio R_o/R_i in order that this will occur.

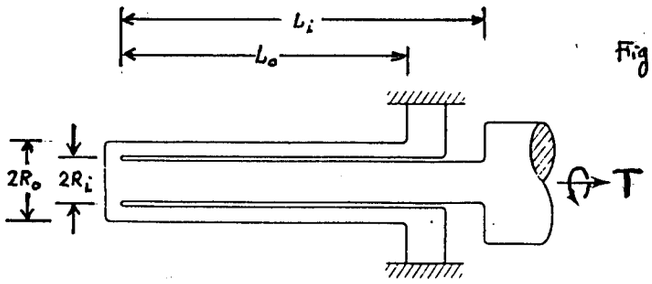

Fig. 3.

4.(20pt) A thin-walled cylindrical tank of radius r, thickness t, and length L is supported at its ends. It is filled with a heavy liquid which is vented to the atmosphere. If the weight of the tank is negligible compared with the weight of the liquid, show that the maximum bending stress in the tank is independent of the radius of the tank.

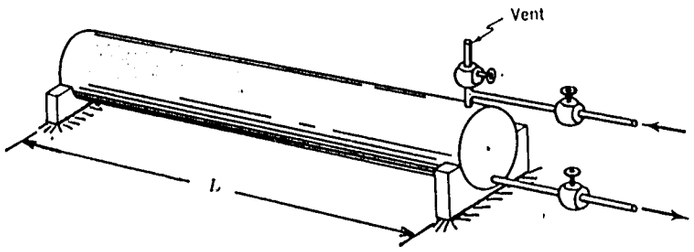

Fig. 4.

5.(20pt) The beam illustrated has cross-sectional proportions which are typical of "wide-flange" steel beams that are used extensively in building construction. Determine the ratio of the maximum bending stress σ_x to the maximum shear stress τ_{xy} when the beam carries a central load as indicated.

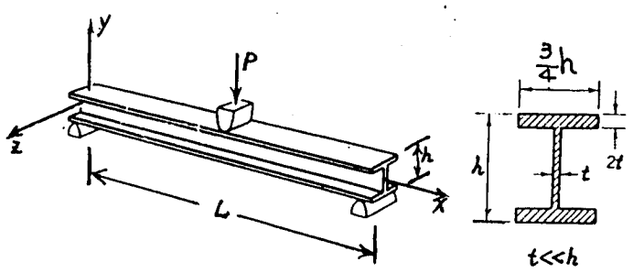

Fig. 5.