1. The stepped circular rod shown below is made of ductile material with at yield strength, S_y. The steady load P creates a stress, σ, at the smaller diameter at B and a stress 1.7 σ at A. The constant torque T develops a shear stress σ between B and C and $\sigma/4$ between A and B. Based on the distortion energy theory of failure, where would you expect the rod to fail? Justify your answer in detail. (15 points).
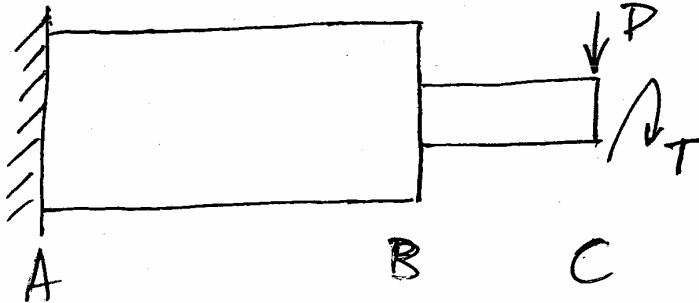

2. An M30x3.5 ISO grade 8.8 bolt is used in a preloaded joint that is subjected to a repeated tensile fatigue load alternating between zero and 80 kN. The joint (material) stiffness is twice the bolt stiffness. Determine the safety factor against fatigue failure. (15 points).

4. The element shown below is subjected to the stresses shown. All stresses are in MPa. (Note that some stress components are missing from the figure.) Determine the principal stresses at this location.(15 points).
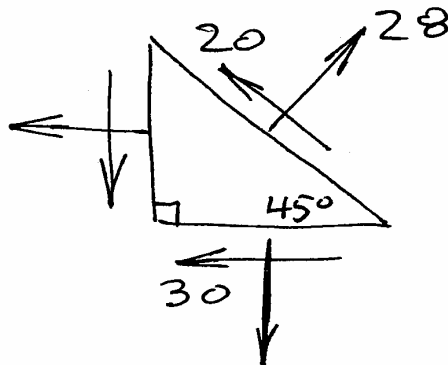
5. A fully reversed bending moment of 80 N-m is applied to the shaft shown below. The approximate relative values of the diameters are d'= 0.65D and d" = 0.75D. The shaft is machined of SAE 2340 high carbon steel with S_u =1226 MPa and S_y =1130 Mpa and Brinell hardness of at least 368. Using a safety factor of 2.5 determine the diameter d" for an infinite life.(20 points).

note $r = \left(\dfrac{d'' - d'}{2} \right)$
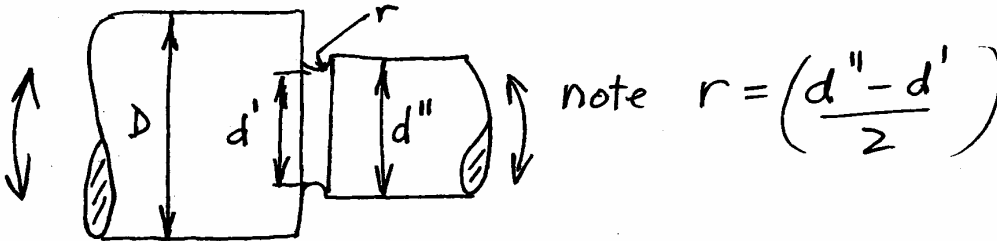
6. A full journal bearing is specified to operate with SAE 60 oil at an inlet temperature of 40 degrees C. The rotational speed is 30 revolutions per second, the applied load is 1000 lbf, and the length and diameter of the bearing are 1.5 in. The bearing is to be designed for maximum load capacity. Determine: i).the operating viscosity, ii).the radial clearance, iii).the coefficient of friction, iv). the total flow through the bearing, v).the fraction of side flow, and vi).the maximum pressure in the film. (20 points).

5. A steel spur gear with 45 teeth rotates at 1500 rpm
    and serves as the input to a gear set. The gear meshes
    with a pinion with 17 teeth which is on the output
    side of the gear set. The diametral pitch is 6/in and
    the pressure angle is 20 degrees. The face width is 1
    inch. Assume $k_a, k_b, k_c, k_d = 1$.   , The steel
                    . The Brinell hardness is 300. Both gears
    mesh externally.

a) What are the external dimensions of the gear set? (2
    pts.)

b) Determine the speed of the pinion. (2 pts.)

c) How much power can the gear set transmit if the mode
of failure is tooth bending and the gears are 100 per cent
efficient? Consider a safety factor of 2. (6pts.)