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Section: 0102 - 0103 - 0104

ENES 220 – Mechanics of Materials

Spring 2001

May 23, 2001

FINAL EXAM

Grading:

Problem 1:	______	/ 20
Problem 2:	______	/ 20
Problem 3:	______	/ 20
Problem 4:	______	/ 20
Problem 5:	______	/ 20
Total:	______	/ 100

Policies:

1. Write your name and section number on all sheets.
2. Use only the paper provided. Ask for additional sheets, if required.
3. Place only one problem on each sheet (front and back).
4. Draw a box around answers for numerical problems.
5. Give all answers to 3 or 4 significant figures.
6. Include free body diagrams (FBD's) for all equilibrium problems.
7. Closed book / closed notes; formula sheet permitted.
8. **<u>SHOW ALL WORK USED TO ARRIVE AT YOUR ANSWER</u>.**

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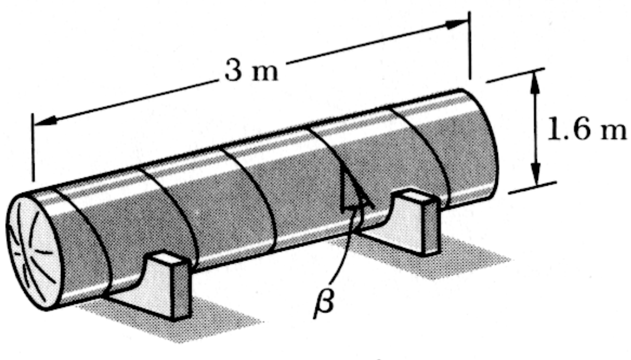
Problem #1 (20 points): A cylindrical compressed-air tank is fabricated by welding thin steel plate (thickness = 5 mm) along a helix forming an angle β = 30° with a transverse plane. The internal pressure is 900 kPa, and the weld metal is limited to normal and shearing stresses of 165 MPa and 100 MPa, respectively.



(a) Find the principal stresses (σ_1, σ_2) for a point on the surface of the tank.

(b) Determine the overall factor of safety for this structure.

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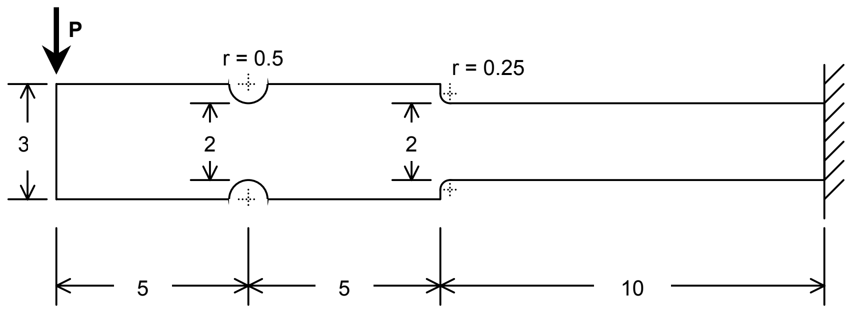
Problem #2 (20 points): Determine the largest load P that can be applied to the free end of a notched-and-stepped cantilever beam if the bending (normal) stress is limited to 45 ksi. All dimensions shown on the figure are in inches, and the beam has a thickness of 0.25 in. (into the page). Assume that the notches and the step are sufficiently far away from each other, from the wall, and from the point of load application such that the stress concentration charts (at the end of the exam) apply.



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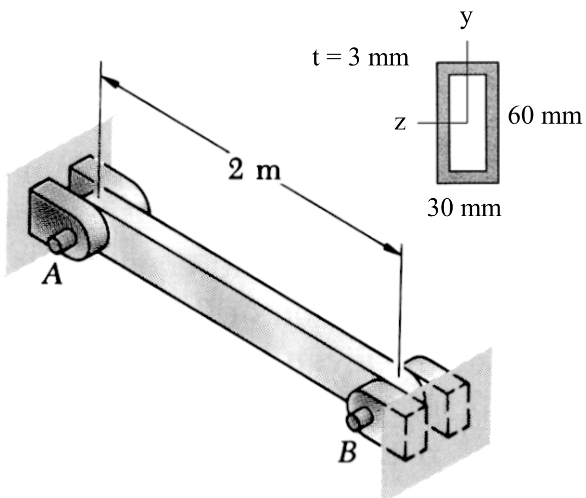
Problem #3 (20 points): The aluminum tube AB has a hollow, rectangular cross section with a thickness of 3 mm, and is supported by pins and brackets at the ends. The constraints produce a pinned-pinned condition about the z-axis, and a fixed-fixed condition about the y-axis. The tube is initially unloaded at room temperature, but then undergoes a temperature increase (ΔT) that produces an internal axial load (P). Assume E = 70 GPa, σ_{ys} = 250 MPa, and $\alpha = 23.6 \times 10^{-6}/°C$.



(a) Calculate the largest load (P_{max}) that AB can support without failing.

(b) Determine the temperature increase (ΔT) necessary to develop P_{max}.

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Problem #4 (20 points): Two forces are applied to the end of a solid rod depicted in figure 1. These forces cause internal forces and moments on a cut section 8 in. from the wall, in the directions shown in figure 2. The rod has a circular cross-section with a radius of 0.75 in. Points A and B lie on the cut surface, at the locations shown.

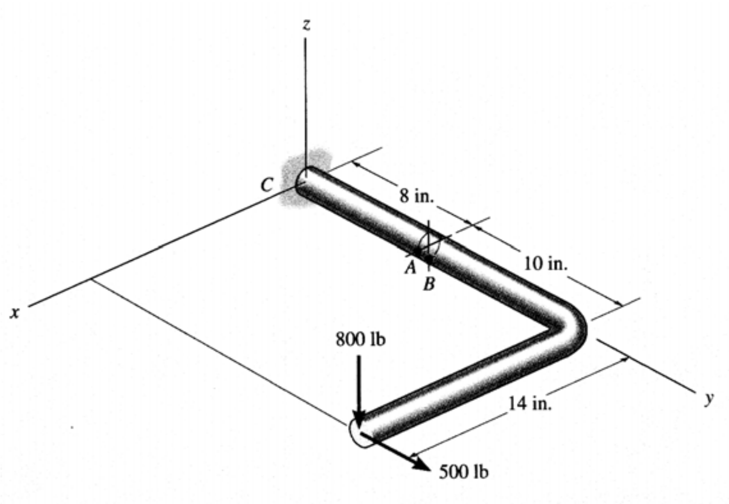


Figure 1

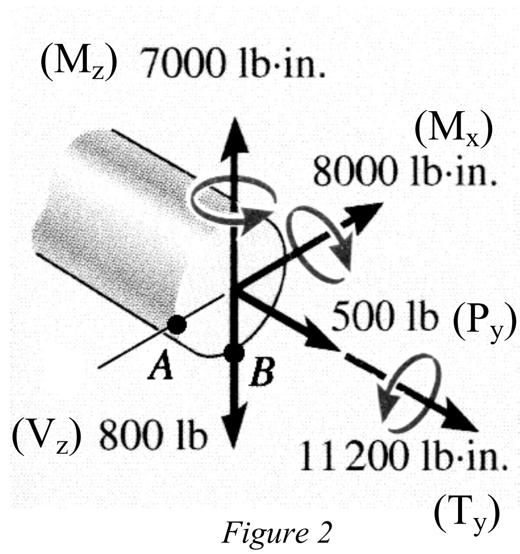
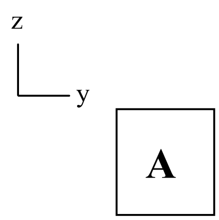
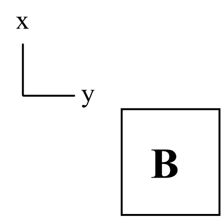


Figure 2

(a) Calculate the normal and shear stresses that act at points A and B.

(b) Illustrate the combined stress state for each point on the squares given.





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Problem #4 (con't.):

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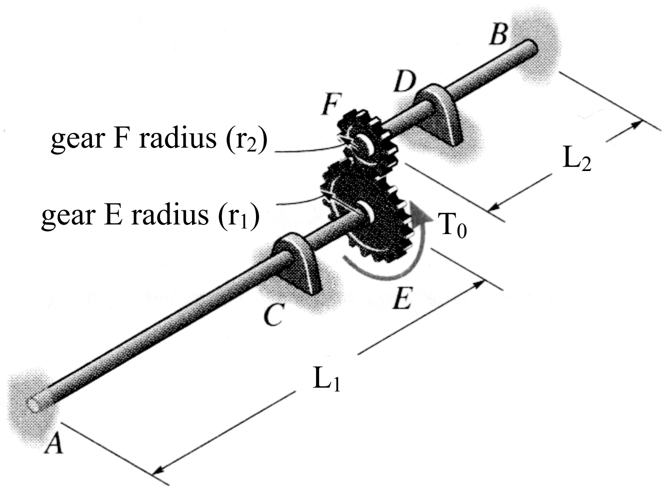
Problem #5a (20 points): Two solid shafts ACE and FDB are connected using gears fixed to their ends at E and F. The other ends are attached to fixed supports at A and B. The shafts are supported by bearings that allow free rotations along their axes. Shaft ACE has a diameter of d_1, shaft FDB has a diameter of d_2, and both shafts are made of the same material (E, G). A torque T_0 is applied to the gear at E in the direction shown. Write all equations necessary to solve for the reaction torques at the wall (T_A, T_B) in terms of the following known quantities: T_0, L_1, L_2, d_1, d_2, r_1, r_2, E, and G. DO NOT SOLVE THE EQUATIONS.



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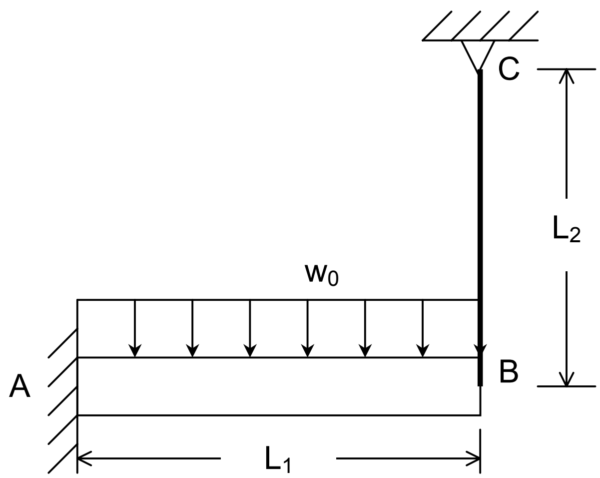
Problem #5b (20 points): The beam AB is rigidly fixed to the wall at A and is supported at B by a wire, that is attached to the ceiling. A uniform distributed load (w_0) acts along the entire length of the beam. The wire is taut but unstretched (i.e. internal load = 0) when the beam is unloaded. The beam has a modulus of elasticity E_1 and a moment of inertia I, and the wire has a modulus of elasticity E_2 and a cross-sectional area A. Write all equations necessary to solve for the reaction at the wall (M_A and A_y) and the tension in the wire (T_{BC}) in terms of the following known quantities: w_0, L_1, L_2, E, I, and A. DO NOT SOLVE THE EQUATIONS.



Hint1: This problem is easier to solve by using the superposition table (attached).

Hint2: Deflection at B $\neq 0$.