

Exam Number: _____

Department of Mechanical Engineering

Michigan State University

Solid and Structural Mechanics
Ph.D. Qualifying Examination

August 2009

Closed Book and Notes
You may use a one page formula sheet
All Questions are weighted equally.

Prepared by

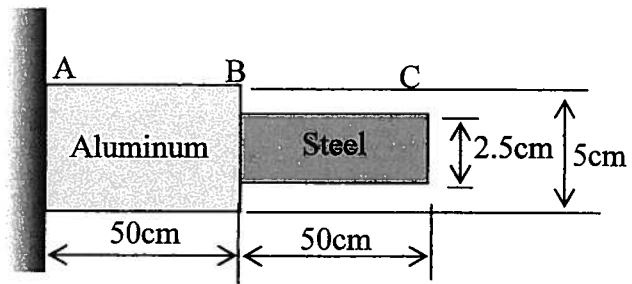
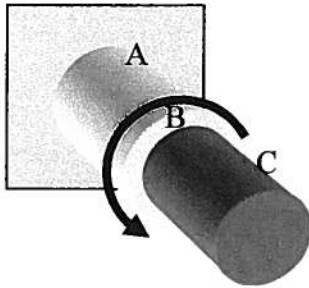
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1. The stress at a point is given by a 3x3 matrix shown below

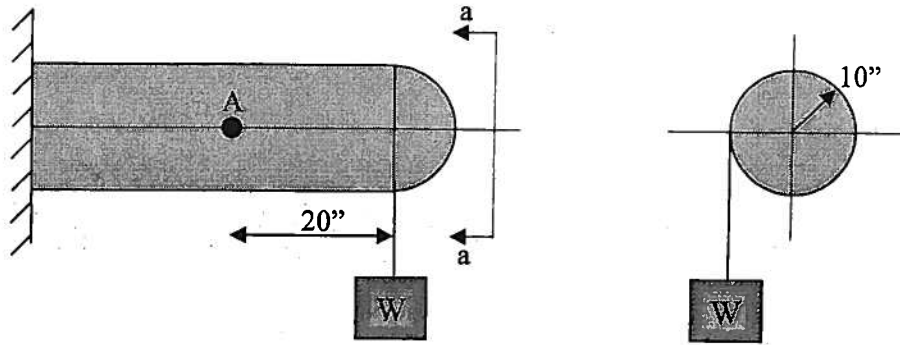
$$\sigma = \begin{bmatrix} 10 & 5 & 0 \\ 5 & 5 & 5 \\ 0 & 5 & 10 \end{bmatrix} \text{MPa}$$

on a part made of a ductile material. Determine the factors of safety when the yield strength is 50MPa using (a) Maximum Shear Stress Criteria and (b) Maximum Distortion Energy.

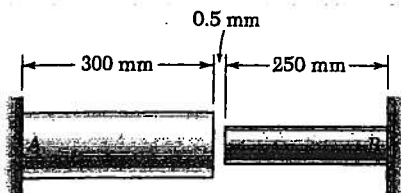
2. The bar made of two materials, aluminum and steel, shown below is loaded with the torque of $20\text{N}\cdot\text{m}$ at B. (a) Determine the maximum shear stresses in steel and aluminum. (b) Determine the angle of twist at B and C. The shear modulus of steel and aluminum are 75GPa and 25GPa , respectively.



3. A steel pressure vessel 20 inches in diameter and with wall thickness of 0.25 inches acts also as an eccentrically loaded cantilever as in the figure below. If the internal pressure is 275 psi and the applied weight is 35,000 pounds, determine the principal stresses at point A. For steel, the density is 0.3 lbs/in^3 , modulus of elasticity is $30 \times 10^6 \text{ psi}$, and Poissons' ratio is 0.25. Include the weight of the vessel in the solution.



View a-a



At room temperature (20°C) a 0.5-mm gap exists between the ends of the rods shown. At a later time when the temperature has reached 140°C , determine (a) the normal stress in the aluminum rod, (b) the change in length of the aluminum rod.

Aluminum

$$A = 2000 \text{ mm}^2$$

$$E = 75 \text{ GPa}$$

$$\alpha = 23 \times 10^{-6}/^{\circ}\text{C}$$

Stainless steel

$$A = 800 \text{ mm}^2$$

$$E = 190 \text{ GPa}$$

$$\alpha = 17.3 \times 10^{-6}/^{\circ}\text{C}$$