GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Quarter 1998

Mechanics & Materials
EXAM AREA

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Assigned Number (DO NOT SIGN YOUR NAME)

- **Please sign your name on the back of this page—**

Please **p r i n t** your name here.

The Exam Committee will get a copy of this exam and will not be notified whose paper it is until it is graded.

Mechanics of Material, Fall 1998

PLEASE READ BEFORE YOU START:

You are required to finish *only* four (4) of the five (5) problems in the exam. Please circle below the four problems you would like to be graded:

Problem I **Problem II** **Problem III** **Problem IV** **Problem V**

If not specified, the four problems with the lowest scores will be considered (*No extra credit will be given for finishing all five problems*).

Problem I

A strain gauge rosette consisting of three gauges as shown below is mounted on the surface of a structural component. The component is linear elastic.

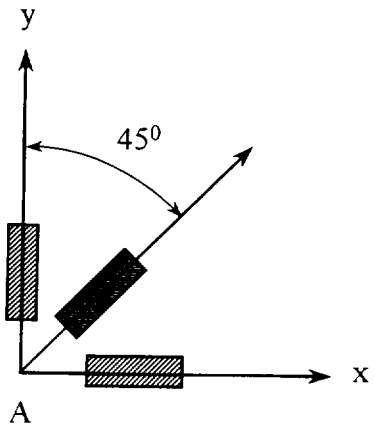
(a) What does each gauge measure?

(b) Find the maximum shear strain at this point.

(c) Find the Maximum and minimum normal strains at this point.

(d) What are the maximum and minimum normal stresses at this point?

(e) What are the maximum and minimum shear stresses at this point?



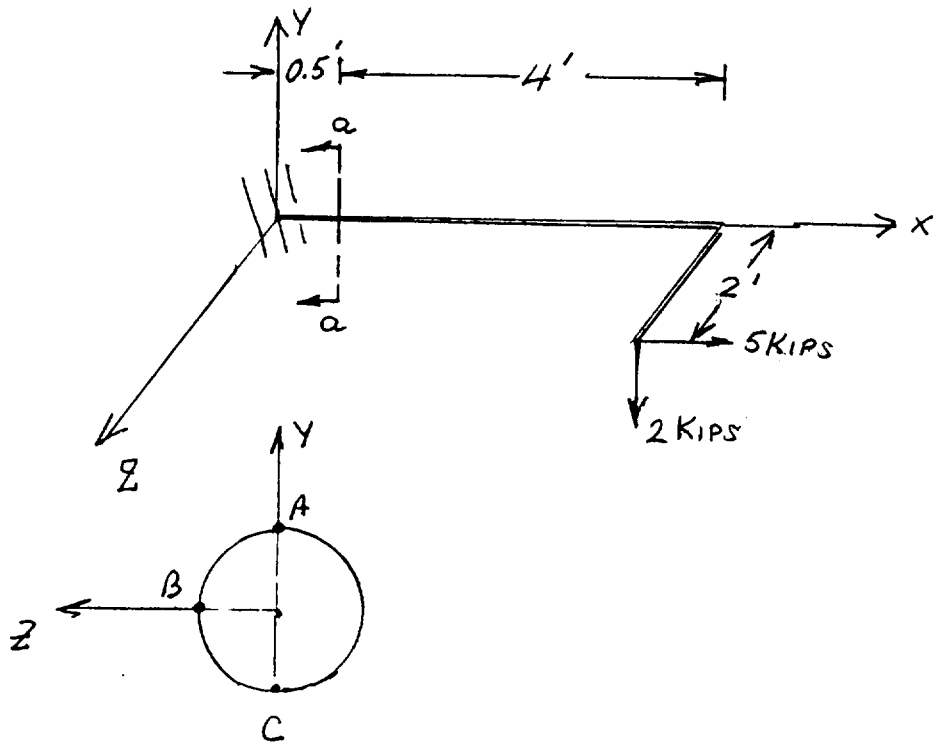
Problem II

A circular bar (E = 30 Ksi, ν = 0.25) of radius 2 inches is bent at 90 degrees as shown in the sketch below showing *centerline* of the bar. The bar loaded at the end by forces as shown in the sketch. Section a-a contains point A, B, and C as indicated in the sketch, also below.

(a) Determine the stresses at points A, B and C.

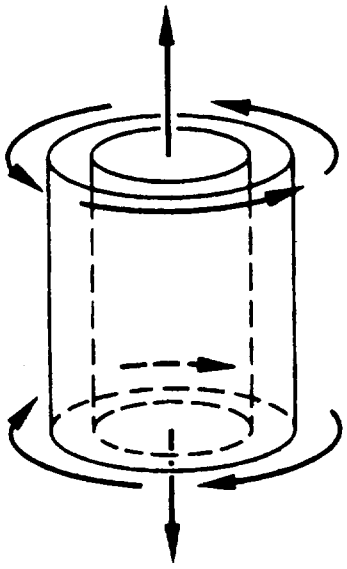
(b) Show the stresses at point A, B and C as they act on a properly oriented element. Be sure and *clearly* indicate the orientation of elements you sketch.

(c) If you were to consider plastic failure of the bar at the section containing points A, B and C, which point would be the most critical? For failure, assume that the maximum shear stress criterion holds.



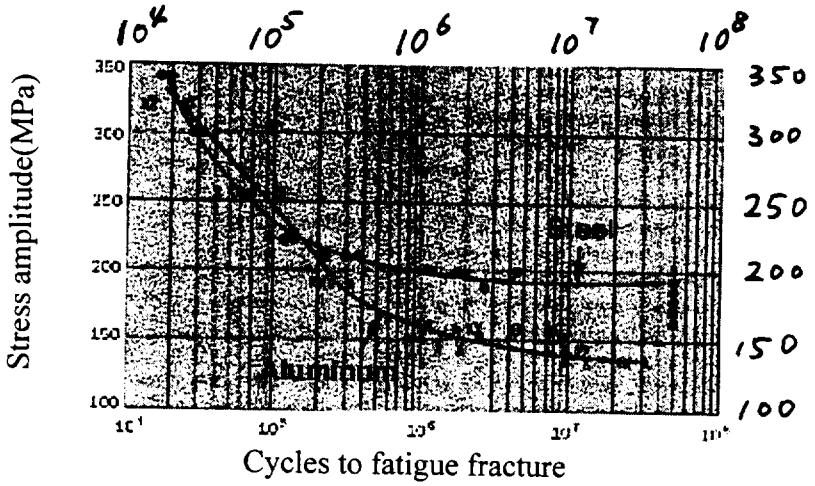
Problem III

Tension tests on a batch of steel show it to yield at 200 MPa. If a thin-walled tube is twisted and stretched as shown below, how much shear stress $\tau_{z\theta}$ can it take without yielding if the tension stress σ_{zz} = 70MPa ? Use both von Mises and Tresca criteria to determine $\tau_{z\theta}$.



Problem IV

A switching device consists of a rectangular cross-section metal cantilever 200 mm in length and 30 mm in width. The required operating displacement at the free end is ±2.7 mm. The switch should be designed for infinite fatigue life. Using the fatigue curves given below, determine the maximum height of the cantilever if made from (a) the steel
(E_{steel} = 208 GPa) and (b) the aluminum alloy ($E_{alum.}$ = 79 GPa). The deflection at the end of the beam is given by $\delta = \frac{PL^3}{3EI}$.



Problem V

Briefly define/describe the following concepts from fracture mechanics. Use sketches where appropriate.

1. Stress fields as given by linear elasticity
2. Stress intensity factor
3. Resistance curve (R – curve)
4. Stress singularity
5. J-Integral