JAN 16 1998

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Quarter 1997

Bioengineering
EXAM AREA

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Assigned Number (DO NOT SIGN YOUR NAME)

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

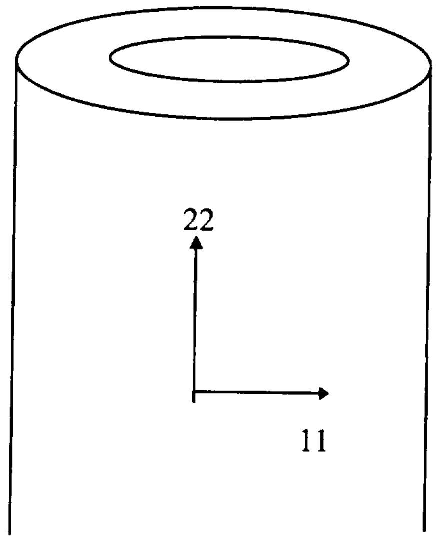
Please work all three problems.

1.

a. In the name of science, a researcher has instrumented his own tibia with strain gages while running training exercises with the Israeli army. Normal and shear strain data is collected in the x-y plane as shown below. Given the material properties below is the researcher in danger of fracturing his tibia?

b. List the assumptions made in your analysis of stress and strain in the tibia. Briefly comment on the validity of these assumptions.

$E = 20.9$ Gpa
$\nu = 0.3$
$\sigma_u = 250$ MPA ... Failure stress in Tension or Compression



Strain Data:

$e_{11} = -.0100$
$e_{22} = .0020$
$e_{12} = .0036$

2. A bi-axial test of treated bovine pericardium is conducted to determine the suitability of the treated tissue for use in a prosthetic heart valve. The uniformly thick (0.1 cm) tissue sample measures 2x2 cm and is stretched using long sutures as shown in the sketch below.

a. It is desired to measure the strain in the tissue by measuring the displacements of small (5 micron) particles fixed to the tissue which move as it deforms in the x-y plane. What is the *minimum* number of particles needed to determine the engineering strains ε_x ε_y γ_{xy}? Are more particles needed to determine the Green's strain? Sketch the needed number of particles as points and show EXACTLY how you would determine the strain from the measured deformation. State your assumptions, what you measure, what you calculate and how you calculate it.

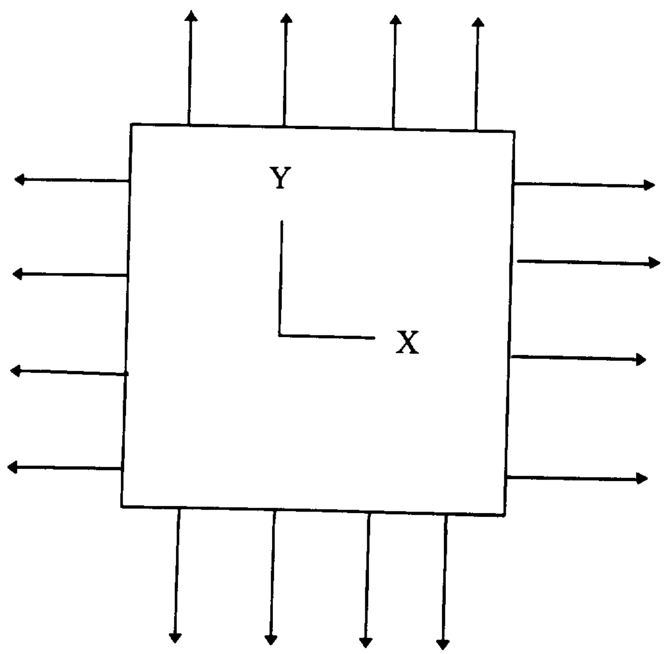
b. If the minimum number of particles is used, what assumption do you need to make about the strain field in the tissue?

c. Describe two key advantages of using more than the minimum number of particles to determine the strain.

d. If the pericardium is orthotropic in the plane of loading and the material axis align with the directions of stretch, do you expect to see any shear strain? Is there shear strain if the material is isotropic? How about anisotropic in the plane?

e. If a small hole is cut in the tissue before deformation, and the hole takes on an elliptical shape after the tissue is deformed, what, if anything, can you learn from this?

f. If the stretching forces are Fx and Fy, and the strains are known, how would you determine the Kirchoff stresses? State your assumptions.



3. Atherosclerosis of the carotid artery is considered to be hemodynamically significant when it forms a stenosis. (You may leave your answers in variables or assume reasonable dimensional values.)

   a. What would be the non-dimensional parameters which would be important in the analysis of flow though a stenosis?

   b. How can one estimate the local wavespeed in an elastic stenosis?

   c. What percent area stenosis is necessary to cause the local velocity, u, to reach the local wavespeed?

   d. What is the physical consequence of flow when the velocity reaches the wavespeed?

   e. What is the clinical significance of this phenomenon for atherosclerotic carotid disease?