

**CERI 7105/8105
Global Seismology
Homework Set #2
Under Stress and Strain**

1. Find eigenvalues and eigenvectors for the following matrices:

a. $\begin{pmatrix} 2 & 4 \\ 4 & 2 \end{pmatrix}$

b. $\begin{pmatrix} -1 & 3 \\ 3 & 1 \end{pmatrix}$

c. $\begin{bmatrix} 2.5 & -0.3 & 2.1 \\ -0.3 & 0 & 1.3 \\ 2.1 & 1.3 & -3.4 \end{bmatrix}$

You can use MatLab. Make sure your coordinate systems are right-handed.

2. Determine the principal strains and their directions for the following strain tensor:

$$\epsilon_{ik} = \begin{pmatrix} 2.5 & 1.3 & -4.0 \\ 1.3 & 1.1 & 2.0 \\ -4.0 & 2.0 & 3.4 \end{pmatrix} \times 10^{-7}$$

Compute the three strain invariants from this tensor and from the principal strain tensor. (Hint: They should be the same for the two tensors.)

3. (*8105 Students only; extra credit for 7105*) The Pinon Flat strain meter consists of 3 laser interferometers each 500m long that measure (positive) extension in the NS, EW, and NW/SE directions. Given these three measurements of strain, what strains are possible to determine in the geographic (NS/EW) coordinate system? Give a relation for them. (Hint: Rotate the known normal strain and the unknown normal and shear strains in NW/SE coordinate system into the geographic coordinate system. Relate the unknown strains to the known normal strains in the geographic coordinate system.)
4. Principal stresses are measured in a hydrofract experiment. North, East and down represent the x_1 , x_2 and x_3 directions, respectively, of a Cartesian coordinate system. Determine the stress tensor in this coordinate system if the following principal stress directions and magnitudes are measured:

$P_1 = -200 \text{ MP (} 10^6 \text{ Pascals)}$ (oriented N30°E on the horizontal plane)

$P_2 = -180 \text{ MP}$ (oriented N60°W on the horizontal plane)

$P_3 = -60 \text{ MP}$ (oriented vertically)

Remember that positive stress, in our convention, is tensional. Also remember that stress is not a vector. Make sure your coordinate systems are "right-handed".

What are the shear stresses on a hypothetical vertical fault plane oriented north-south?
What is the deviatoric stress tensor?