Exam Introduction to seismology en seismics, Part 1

December, 9, 2008, 11.00-13.00

1. The deformation of a cubic volume element is given by $u_1 = u_3 = 0$, $\frac{\partial u_2}{\partial x_1} = a > 0$, $\frac{\partial u_2}{\partial x_2} = b > 0$, and $\frac{\partial u_2}{\partial x_3} = 0$, where $\bar{u}$ is the displacement.
   (a) Sketch the deformation in the $x_1 - x_2$ plane of the volume element.
   (b) Give (the 9 elements of) the strain tensor associated with this deformation.

2. For the stress tensor

$$\sigma = \begin{pmatrix} 0 & 3 & 0 \\ 3 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

   find the principal stresses and associated directions.
   Your answer should give the size and direction (represented by a vector) of the maximum, intermediate, and minimum stresses.

3. A seismic (scalar) potential of a harmonic wave is given as

$$\phi(\bar{x}, t) = \sin(\omega t - xK \sin\theta - zK \cos\theta)$$

   where K and θ are constants.
   (a) Find the relation between K, ω, and v if the potential ϕ satisfies the wave equation

$$\nabla^2 \phi = \frac{1}{v^2} \frac{\partial^2 \phi}{\partial t^2}$$

   (b) Find the displacement field $\bar{u}$ associated with ϕ.
   (c) Does this displacement field represent a P-wave or an S-wave? Show this by taking the curl or divergence of $\bar{u}$.
   (d) What is the propagation direction of $\bar{u}$ and what is its particle motion direction? Illustrate with a sketch.

4. (a) Ray theory is a socalled 'high-frequency' (small wavelength) approximation to wave propagation. Which phenomenon does ray theory not describe properly?
   (b) State Fermat's principle.

- - >