Exam Introduction to seismology and seismics, part 1

January 19, 2010, 10.00-12.00

1. (a) Give an example of a strain tensor for which there is a volume increase, and illustrate the associated displacements with a sketch.
   (b) Give an example of a strain tensor for which there is shear strain, and illustrate the associated displacements with a sketch.

2. For the stress tensor

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

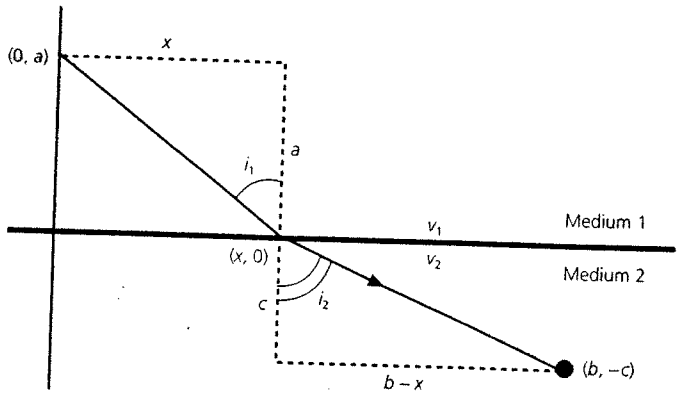
   find the principal stresses and associated directions.
   Your answer should give the size and direction (represented by a vector) of the maximum, intermediate, and minimum stresses.

3. The displacement field $\bar{u}$ of a seismic wave is given by:

$$\bar{u}(x, y, z, t) = \begin{pmatrix} \cos\theta \\ 0 \\ \sin\theta \end{pmatrix} \sin\left[\omega t - (K \sin\theta)x + (K \cos\theta)z\right]$$

   (a) Does this displacement field represent a P-wave or an S-wave? Explain by taking the divergence and/or the curl of $\bar{u}$.
   (b) What is the direction of wave propagation, and what is the particle motion direction (or polarization). Make a sketch.

4. (a) State Fermat's principle.
   (b) Derive Snell's law using Fermat's principle and the following figure.



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5. A seismic P-wave refraction experiment is carried out for a structure with 2 horizontal layers over a halfspace. Make a sketch of the situation and indicate the layer velocities and thicknesses.
   (a) Give the travel times as a function of distance of the two head waves in terms of distance, layer velocities and thicknesses.
   (Full derivation of the expressions is not required.)
   (b) How can one determine the velocities of the first, second, and third layer from the measurements of this experiment?
   (c) How can one determine the thicknesses of first and second layer?
   (d) For which cases does this method give incorrect results? Explain.

Exam Introduction to seismology and seismics, Part 2

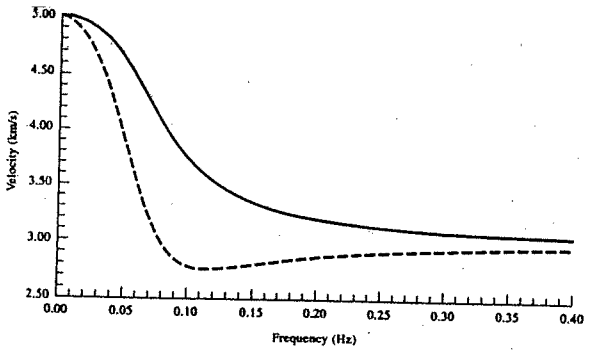
January 26, 2010, 9:00-12.00

1. Explain how subsurface reflectors (i.e. interfaces of the seismic velocity structure) can be imaged using multichannel reflection seismics.
   Use (and explain) the terms
   * common midpoint (CMP) gather,
   * normal move out (NMO),
   * common midpoint stacking,
   * root mean square (RMS) velocity,
   * Dix equation, and
   * migration.

2. Sketch the ray paths and the travel time curves for the following velocity structures:
   (a) A seismic velocity structure with a gradual velocity increase as a function of depth.
   (b) Similar to (a) but with a sharp velocity increase at certain depth.
   (c) Similar to (a) but with a low velocity zone.

3. An earthquake is recorded by a large number (N) of seismic stations. Explain how the origin time and the location of the earthquake can be determined from the P-arrival times at the stations for a given seismic velocity structure. Show the procedure for the case of a homogeneous subsurface structure.

4. (a) Explain the terms dispersion, phase velocity and group velocity.
   (b) Give expressions for the phase velocity (c) and the group velocity (U). Find the relation between c and U and the wavelength (λ).
   (c) The figure below shows Love wave phase and group velocity curves for a seismic model of a layer over a halfspace.
   Which of the two curves represents the phase velocity?
   Give estimates of the S-wave velocities of the layer and the halfspace.
   Explain your answers.



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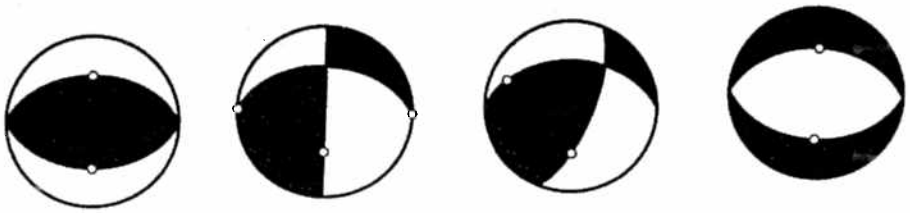
5. (a) Give the types of faulting for the focal mechanisms shown below. The plane with an east-west strike is the fault plane. In case of strike-slip faulting specify whether it is left lateral or right lateral.



(b) Explain the terms magnitude, intensity and seismic moment.