

Introduction to seismology

- 1) Assume two monochromatic plane waves propagating in x-direction: a) P-wave $u_x = A_x \sin(kx - \omega t)$ and b) S-wave $u_y = A_y \sin(kx - \omega t)$. Calculate in both cases the elements of stress and strain tensors. Assume that it is possible to observe the vertical component of the curl. The rotation rate around a vertical component is given as the time derivative of the curl applied to the displacement field. How is the rotation rate related to the transverse acceleration? Does the P-wave contribute to the curl?
- 2) Express the v_p/v_s ratio as a function of Poisson's ratio defined as: $\nu = \frac{\sigma}{2(\sigma + \mu)}$.
Calculate the v_p/v_s ratio for $\sigma = 0.3$.
- 3) The 2003 Hokkaido earthquake (M8.1) lead to a maximum horizontal displacement of 1.5cm for Love waves of approximately 25 seconds period. Estimate the maximum dynamic strain induced by the passing wavefield for horizontal phase velocity of 5km/s.
- 4) The university of California is running an observatory that is measuring deformations:
 - a) at 5km depth the seismic velocities are $v_p = 6\text{km/s}$, $v_s = 3.5\text{km/s}$ and the density is 2700kg/m^3 . Calculate the values of the Lamé parameters in Pascal.
 - b) After the Landers earthquake 1992 (M7.3) the following deformations were measured 80km to the north of the observatory: $e_{11} = -0.26 \times 10^{-6}$, $e_{12} = -0.69 \times 10^{-6}$, $e_{22} = 0.92 \times 10^{-6}$. Indices 1 and 2 correspond to East and North, resp. Calculate – assuming that these values are also true at depth – the changes in stress at 5km depth with the results from (a). Treat this is a 2D problem and neglect stress in vertical direction.
 - c) Calculate the dominant stress directions (horizontal as azimuth over North).
 - d) The yearly deformation rates were measured as: $e_{11} = 0.101 \times 10^{-6}$, $e_{12} = 0.005 \times 10^{-6}$, $e_{22} = -0.02 \times 10^{-6}$. Assume that this deformation continues for 1000 years. Calculate the stress change at 5km depth (without hydrostatic stress).
 - e) A farmer owns 1km^2 near the observatory. How much land does he win or loose every year? How much land did he win or loose with the Landers earthquake?
- 5) A volcano with approximate dimensions $5 \times 5 \times 5\text{km}$ (not accounting for topography) deforms in z-direction only. The change in volume is 0.001%. What is the vertical deformation?