Introduction to seismology **Exercise 1**

1) Assume two monochromatic plane waves propagating in x-direction: a) P.wave $u_x=A_x\sin(kx-wt)$ and b) S-wave $u_y=A_y\sin(kx-wt)$. 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 (S-wave)? Would the P-wave contribute to the curl?

2) Express the vp/vs ratio as a function of Poisson's ratio defined as: $\sigma = \frac{\lambda}{2(\lambda+\mu)}$.

   Calculate the vp/vs ratio for σ=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 a horizontal phase velocity of 5km/s.

4) (From Shearer: Seismology). The university of California is running an observatory that is measuring deformations:

   a) at 5km depth the seismic velocities are v_p=6km/s, v_s=3.5km/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: $e_{11}=-0.26\text{x}10^{-6}$, $e_{12}=-0.69\text{x}10^{-6}$, $e_{22}=0.92\text{x}10^{-6}$. 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: $e_{11}=0.101\text{x}10^{-6}$, $e_{12}=0.005\text{x}10^{-6}$, $e_{22}=-0.02\text{x}10^{-6}$. 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 5x5x5km (not accounting for topography) deforms in z-direction only. The change in volume is 0.001%. What is the vertical deformation?