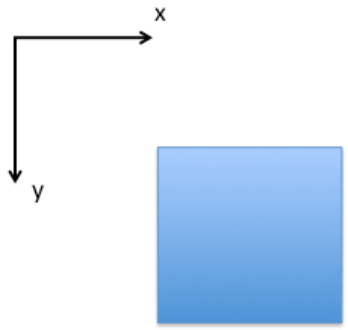
PGE 334 [Fall 2018] – Homework #2 **Instructor: DNE**

1) Draw the normal and shear stresses defined as positive on the four sides of the following square according to the given 2D coordinate system



2) Using the equations of linear elasticity ($\underline{\underline{\sigma}} = \underline{\underline{\underline{\underline{C}}}}\,\underline{\underline{\varepsilon}}$ *or* $\underline{\sigma} = \underline{\underline{C}}\,\underline{\varepsilon}$ in Voigt notation) show that by applying an isotropic stress σ_{iso} (no shear) the volumetric strain is equal to $\varepsilon_{vol} = \frac{3(1-2\nu)}{E}\sigma_{iso}$. Write out the resulting strain and stress tensors.

3) Using the equations of linear elasticity ($\underline{\underline{\sigma}} = \underline{\underline{\underline{\underline{C}}}}\,\underline{\underline{\varepsilon}}$ *or* $\underline{\sigma} = \underline{\underline{C}}\,\underline{\varepsilon}$ in Voigt notation) show that by applying stress in one direction (say 1) and not letting the solid expand in the other two, you can recover the following expression $\sigma_{11} = \frac{E(1-\nu)}{(1+\nu)(1-2\nu)}\varepsilon_{11}$. The proportionality coefficient is called "M" the constrained modulus. Is it lower or higher than E? What is the physical explanation? Write out the resulting strain and stress tensors.

4) The top of the Barnett shale is located at about 7950 ft TVD. At this depth:

   a. Compute the total vertical stress assuming a lithostatic gradient of 23.8 MPa/km.
   b. Compute the effective vertical stress assuming hydrostatic pore pressure gradient
   c. Compute horizontal effective stresses assuming linear isotropic elasticity, $\nu = 0.22$ and that horizontal strains are nearly zero.
   d. Write out the tensor of effective stresses.

e. Compute <u>total</u> horizontal stress.
f. Compute the ratio between effective horizontal stress and effective vertical stress
g. Compute the ratio between total horizontal stress and total vertical stress
h. Compute effective and total stresses assuming there is overpressure λ_p=0.7, tectonic strains ε_{hmin}=0 and ε_{Hmax}=0.0002 and the shale Young's modulus is E=5 MMpsi.