Introduction to Geophysics
Assignment: Stress Tensors, Mohr Circles, and Faulting Regimes

Instructions. Show all steps clearly. Compute principal stresses, draw (or computationally generate) Mohr circles, and interpret the tectonic regime for each stress tensor. Use SI units unless otherwise stated.

Part A: Stress tensors in three tectonic regimes

Below are three 2D stress tensors representing simplified crustal stress states. Components are given in MPa. Shear stresses satisfy $\sigma_{xy} = \sigma_{yx}$.

(1) **Compressional regime (reverse-faulting environment):**

$$\boldsymbol{\sigma}^{(C)} = \begin{pmatrix} 300 & 60 \\ 60 & 150 \end{pmatrix}.$$

(2) **Extensional regime (normal-faulting environment):**

$$\boldsymbol{\sigma}^{(E)} = \begin{pmatrix} 100 & 40 \\ 40 & 250 \end{pmatrix}.$$

(3) **Strike–slip regime (near-vertical σ_2):**

$$\boldsymbol{\sigma}^{(S)} = \begin{pmatrix} 200 & 120 \\ 120 & 180 \end{pmatrix}.$$

For *each* stress tensor, answer the following questions.

(a) Principal stresses. Compute the principal stresses σ_1 and σ_2 by:

$$\sigma_{1,2} = \frac{\sigma_{xx} + \sigma_{yy}}{2} \pm \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \sigma_{xy}^2}.$$

(b) Mohr circle. Construct the Mohr circle for each tensor:

$$\text{center: } \sigma_c = \frac{\sigma_{xx} + \sigma_{yy}}{2}, \qquad R = \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \sigma_{xy}^2}.$$

Label σ_1 and σ_2.

(c) Orientation of principal planes. Compute the rotation angle to principal stresses:

$$\theta_p = \frac{1}{2} \arctan\left(\frac{2\sigma_{xy}}{\sigma_{xx} - \sigma_{yy}}\right).$$

You may give the answer in degrees.

(d) Geological interpretation. For each tensor, state:

- whether σ_1 is horizontal or vertical,
- the corresponding tectonic setting (reverse, normal, strike–slip),
- which type of faulting would be expected.