1. **Elasticity and Stress.** [25 pts] Two specimens of a granite are to be studied in the laboratory. The cross-sectional area of each sample is 1 cm². One sample is 11 cm in length. By experimenting, you find that a uniaxial load of 375 MPa causes a deformation of 508 microns on the 11-cm long sample. The second granite sample has stiffness $k$ of $5.08 \times 10^7$ N/m.

1.1 What is Young's modulus $E$ of the granite? Is this a reasonable value, for say Westerly Granite? Please justify your answer using a reference where the elastic properties of Westerly granite have been measured. Summarize the results of this paper in one or two sentences.

1.2 The stiffness $k$ can be expressed in units of force per displacement. Please give an equation for stiffness in terms of $E$ and other variables.

1.3 How long is the second granite sample?

2. **Horizontal Stress.** [25] For regions far from significant tectonic stresses, the horizontal stress in the crust is produced by the vertical overburden stress and Poisson expansion, assuming uniaxial strain (e.g., strain occurs in the vertical direction but lateral strain is essentially zero, just enough to generate a horizontal stress). The relevant equations are written in terms of effective stress:

$$\sigma_h^' = \sigma_v^' \left[\frac{\nu}{1-\nu}\right]$$

where $\nu$ is Poisson’s ratio, $\sigma_h^'$ is effective horizontal stress, and $\sigma_v^'$ is effective vertical stress. Assuming a Poisson ratio of 0.25 and a rock density of $2.5 \times 10^3$ kg/m³ calculate

2.1 The vertical effective stress at 10 km

2.2 The horizontal effective stress at 10 km

3. **Stress Analysis** [25] Construct a Mohr circle for principal stresses of $\sigma_1=70$ MPa and $\sigma_2=10$ MPa. Determine

3.1) the **maximum shear stress**

3.2) the **mean stress**

3.3) the **stresses on a plane whose normal makes an angle of 21° to $\sigma_1$.**

3.4) Make a detailed sketch of the principal stresses and all planes of interest (e.g., those in 3.1 and 3.3).