1. (25%) Measurements of strain are made at a location on a rectangular plate. The measurement is made with respect to a local coordinate system as shown. Strain tensor components are expressed in microstrain.

\[ \varepsilon_{x_1x_1} = 300 \quad \varepsilon_{x_1y_1} = -100 \quad \varepsilon_{y_1y_1} = -200 \]

a. Express the strains in the global XY coordinate system. Solve using the tensor methods developed in class. Clearly show your work.

b. Draw Mohr’s circle for the strain state. Clearly indicate both the local (x1-y1) and global (X-Y) orientations. Clearly label the Mohr’s circle axes and point coordinates. (See next page for a grid to use for the circle)

c. Verify that the angle between the strain states on Mohr’s circle matches the coordinate system rotation angle.
(extra page for working problem 1)
2. (25%) Derive a set of equations that, when solved simultaneously, will specify the components of the strain tensor (for the X-Y coordinate system) in terms of the individual gage readings \(a - b - c\) for the 120 degree Rosette gage shown. Follow the procedure outlined in class and work carefully. Show intermediate steps in the derivation. Express equations in matrix form. (There is extra work space on the following page.)
3. (25%) Evaluate the symmetry of the following 2D engineering compliance matrices. Is the matrix isotropic, cubic, or orthotropic? Clearly justify your answers. As part of your answer, calculate the underlying material property values.

a. First compliance matrix: Symmetry = ?

\[
\begin{bmatrix}
0.2 & -0.05 & 0 \\
-0.05 & 0.25 & 0 \\
0 & 0 & 0.25
\end{bmatrix}
\]

b. Second compliance matrix: Symmetry = ?

\[
\begin{bmatrix}
0.2 & -0.05 & 0 \\
-0.05 & 0.2 & 0 \\
0 & 0 & 0.3
\end{bmatrix}
\]

c. Third compliance matrix: Symmetry = ?

\[
\begin{bmatrix}
0.2 & -0.05 & 0 \\
-0.05 & 0.2 & 0 \\
0 & 0 & 0.5
\end{bmatrix}
\]
4. (25%) For each of the compliance matrices shown in Problem 3, perform a positive 30 degree coordinate system rotation, and calculate the corresponding compliance matrix. Use the tensor-based technique developed in class. You may use Excel or Matlab to perform the calculation, but explain the mathematical process. Interpret the result of your calculation in the context of material property symmetry.

Rotation process =

| \begin{array}{ccc}
| 0.2 & -0.05 & 0 \\
| -0.05 & 0.25 & 0 \\
| 0 & 0 & 0.25 \\
| \end{array} |

| \begin{array}{ccc}
| 0.2 & -0.05 & 0 \\
| -0.05 & 0.2 & 0 \\
| 0 & 0 & 0.3 \\
| \end{array} |

| \begin{array}{ccc}
| 0.2 & -0.05 & 0 \\
| -0.05 & 0.2 & 0 \\
| 0 & 0 & 0.5 \\
| \end{array} |

---

### a. First compliance matrix: \([S]\) (engineering) 30 degrees = ?

### b. Second compliance matrix: \([S]\) (engineering) 30 degrees = ?

### c. Third compliance matrix: \([S]\) (engineering) 30 degrees = ?