1. A component is subjected to the stress state of

\[
\sigma_{ij} = \begin{pmatrix}
300 & 0 & 0 \\
0 & 100 & 0 \\
0 & 0 & 200
\end{pmatrix} \text{ MPa}
\]

The yield stress of the material in uniaxial tension is 173 MPa.

(a) Will the component yield under the given stress state, assuming the Tresca yield criterion?

(b) Will the component yield under the given stress state, assuming the von Mises yield criterion?

(c) Calculate the magnitude of each of the six independent components of the incremental plastic strain relative to the incremental plastic strain, \(d\varepsilon_{i}^{p}\). Comment on the volume conservation.

2. A specimen is placed in a creep machine and subjected to a load of 5000 N. The initial length of the circular rod was 200 mm, and its initial diameter was 5 mm. After several hundred hours, the length of the rod was found to be 230 mm.

(a) What was the rod diameter at this time?

(b) What were the true strain and engineering strain at this time?

(c) What were the true and engineering stress at this time?

(d) If the test were to be conducted under conditions of constant true stress, would the load on the sample remain the same or change and, if so, by how much?

3. In uniaxial tension tests, we make a distinction between engineering stress and strain (which are calculated directly from experimental load-displacement data) and true stress and strain. These are defined as follows:

\[
\sigma_{eng} = \sigma_n = F / A_0, \quad \sigma_{true} = \sigma_T = F / A_i
\]
\[
\varepsilon_{eng} = \varepsilon_n = \Delta L / L_0, \quad \varepsilon_{true} = \varepsilon_T = \Delta L / L_i
\]

where \(A_0\) = initial cross-sectional area of the sample gauge section,

\(A_i\) = instantaneous cross-sectional area of the gauge section
(A changes during plastic deformation because \( \Delta V = 0 \))

\[ L_0 = \text{initial gauge section length} \]

\[ L_i = \text{instantaneous gauge section length} \]

(a) Derive expressions which relate \( \sigma_T \) and \( \varepsilon_T \) to \( \varepsilon_n \) and \( \sigma_n \), given that \( \varepsilon_T = \ln(L_i / L_0) \). That is, \( \varepsilon_T = f(\varepsilon_n) \) and \( \sigma_T = f(\varepsilon_n, \sigma_n) \).

(b) From the following uniaxial tensile engineering stress-strain curve for 7075T6 Al, calculate the true stress at 8% plastic true strain. Note that the graph indicates a \( \sigma_y = 500 \text{MPa} \) and \( E = 70 \text{GPa} \).

![Graph of engineering stress-strain curve](image)

4. An aluminum thin-walled tube (radius/thickness = 20) is closed at each end and pressurized to 7 MPa to cause plastic deformation. Neglect the elastic strain and find the plastic strain in the circumferential (hoop) direction of the tube. The plastic (equivalent) stress-strain curve is given by \( \sigma_{eq} = 170(\varepsilon_{eq})^{0.25} \), where stress in MPa.

5. If the true stress-true strain curve is given by \( \sigma_T = 1400(\varepsilon_T)^{0.33} \), where stress is in MPa, what is the ultimate tensile strength of the material?
6. Obtain, for a simple two-dimensional case, a relationship between the hardness $H$ and $\sigma_y$ (yield strength) of a material using upper bound approach. Assume a flat indenter and deformation on one plane only, as shown below. Deformation is assumed to occur by the movement of blocks and this material does not work-harden.