Problem 1: Read chapter 3 and answer the following questions

1) What is the primary purpose of tensile/compression test?
   Ans. It is used primarily to determine relationship between the average normal stress and average normal strain in many engineering materials such as metals, ceramics, polymers, and composites.

2) Give three examples of material properties.
   Ans. Young’s Modulus, ultimate stress and shear modulus.

3) What are the two different methods to measure strain?
   Ans. (a) Measuring specimen elongation using extensometer.
   (b) Measuring strain directly using calibrated electrical-resistance strain gauge.

4) What are the difference between convention stress-strain diagram and true stress-strain diagram?
   Ans. In a stress-strain diagram, cross-sectional area is assumed to be constant over entire region whereas in case of true stress-strain diagram; actual cross-sectional area of specimen is considered. This difference can be observed when magnitude of strain becomes significant, necking region of stress-strain diagram.

5) Give two examples each for ductile and brittle materials.
   Ans. Ductile: Mild steel and Brass.
       Brittle: Cast iron and concrete.
Problem 2:  A tensile specimen was tested until failure. The dimensions for the tensile specimen are: original gauge length $L_0=2\text{ in}$, original diameter $d_0=0.25\text{ in}$. The loads and gauge lengths recorded for each loading level are shown below. Write down the equations to calculate strain and stress from the given data. Plot the stress-strain curve in excel and identify the following material properties from the stress-strain curve: Young’s modulus, yield stress, ultimate stress, fracture stress, strain hardening region, and yield region.

<table>
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<th>Load (lb)</th>
<th>Length (in)</th>
<th>Stress (psi)</th>
<th>Strain (in/in)</th>
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Solution:
Given original gauge length, $L_0=2\text{ in}$
original diameter, $d_0=0.25\text{ in}$

\[
\text{Area, } A_0 = \frac{\pi}{4} d_0^2 = \frac{\pi}{4} (0.25)^2 = 0.049 \text{ in}^2
\]

\[
\text{Stress, } \sigma = \frac{P}{A_0} = \frac{P}{0.049} \text{ lb/in}^2 \quad \text{(i)}
\]

\[
\text{Strain, } \varepsilon = \frac{L-L_0}{L_0} = \frac{L-2}{2} \text{ in/in} \quad \text{(ii)}
\]

Using equation (i) & (ii), stress and strain has been calculated and listed in column 3 and 4 in the table.
From the stress-strain diagram, the following material properties have been calculated:

Young’s modulus, \( E = \frac{33,899.80}{0.0333} = 999.99 \text{ ksi Ans.} \)

Yield stress, \( \sigma_y = 36.999 \text{ ksi Ans.} \)

Ultimate stress, \( \sigma_u = 48.00 \text{ ksi Ans.} \)

Fracture stress, \( \sigma_f = 37.50 \text{ ksi Ans.} \)

Strain hardening region is the region BEFDB. Ans.

Yield region is the region ABDC A. Ans.
Problem 3: The bar DA is rigid and is originally held in the horizontal position when the weight W is supported from C. If the weight causes B to be displaced downward 0.025in., determine the strain in wires DE and BC. In addition, if the wires are made of A-36 steel and have a cross-section area of 0.002 in², determine the weight W. (FBD required)
Problem 4: The A-36 steel has a cross-section area of 10mm$^2$ and is un-stretched when $\theta=45.0^\circ$. Determine the applied load $P$ needed to cause $\theta=44.9^\circ$. (FBD required)
Problem 5: For example 1.4, determine the reduction in diameters for rod AB, BD, and BC if the diameters for these three rods are 0.75in., assume the material has a Young’s modulus of 25,000ksi and a Poisson’s ratio of 0.28. You have to solve example 1.4 first. (FBD required)
\[ \delta_{AB} = -\frac{F_{AB}}{A_{BD}} = -\frac{7930}{0.44} = -17613.64 \text{ ksi} \]

\[ \delta_{BD} = \frac{F_{BD}}{A_{BD}} = \frac{4650}{0.44} = 10568.18 \text{ ksi} \]

And

\[ \delta_{BC} = -\frac{F_{BC}}{A_{BC}} = -\frac{6200}{0.44} = -14090.91 \text{ ksi} \]

Now,

\[ \varepsilon_{\text{long}} = \frac{\delta}{E} \quad \text{and} \quad \gamma = -\frac{\varepsilon_{\text{lat}}}{\varepsilon_{\text{long}}} \Rightarrow \varepsilon_{\text{lat}} = -\gamma \cdot \varepsilon_{\text{long}} \]

\[ \varepsilon_{\text{lat}} = -\gamma \cdot \frac{\delta}{E} \]

Again,

\[ \varepsilon_{\text{lat}} = \frac{\delta_{\text{dia}}}{d_{\text{rod}}} \Rightarrow \delta_{\text{dia}} = \varepsilon_{\text{lat}} \cdot d_{\text{rod}} \]

Changes in diameter,

\[ \delta_{\text{dia}_{AB}} = -\gamma \cdot \frac{\delta_{AB}}{E} \cdot d_{\text{rod}} = -0.28 \times \frac{-17613.64}{25000 \times 10^{-3}} \times 0.75 \]

\[ \therefore \delta_{\text{dia}_{AB}} = 1.4795 \times 10^{-4} \text{ in} \]

\[ \delta_{\text{dia}_{BD}} = -\gamma \cdot \frac{\delta_{BD}}{E} \cdot d_{\text{rod}} = -0.28 \times \frac{10568.18}{25000 \times 10^{-3}} \times 0.75 \]

\[ \therefore \delta_{\text{dia}_{BD}} = -8.877 \times 10^{-5} \text{ in} \]

\[ \delta_{\text{dia}_{BC}} = -\gamma \cdot \frac{\delta_{BC}}{E} \cdot d_{\text{rod}} = -0.28 \times \frac{-14090.91}{25000 \times 10^{-3}} \times 0.75 \]

\[ \therefore \delta_{\text{dia}_{BC}} = 1.1836 \times 10^{-4} \text{ in} \]