1. Show that the toughness or the plastic strain energy per unit volume (J or $U_p$) is given by

\[ J \text{ (or } U_p) = K \frac{\varepsilon^{n+1}}{n+1}, \]

for a material obeying the standard work-hardening law.

Calculate the toughness for stainless steel using data in Problems 6.27 and 6.36 (problems #6 and #7 of HW#5; show the units clearly).

2. A test bar 12.83mm in diameter with a 50mm gage length is loaded elastically with 156kN and is stretched 0.356mm. Its diameter is 12.80mm under load.
   a. What is the bulk modulus of the bar?
   b. What is its shear modulus?

3. A copper wire had a nominal breaking strength of 300 MPa. Its ductility was 77% RA. Calculate the true fracture stress in both SI and English units?

4. The graph shows results of a tensile test of 1040 steel.
   Specific values at several points are given below:

<table>
<thead>
<tr>
<th>Load</th>
<th>Length</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>kN</td>
<td>cm</td>
<td>mm</td>
</tr>
<tr>
<td>Initial 0.0</td>
<td>5.08</td>
<td>12.8</td>
</tr>
<tr>
<td>a   23.6</td>
<td>5.0848</td>
<td>12.796</td>
</tr>
<tr>
<td>b   27.1</td>
<td>5.19</td>
<td>-</td>
</tr>
<tr>
<td>c   46.4</td>
<td>5.56</td>
<td>12.4</td>
</tr>
<tr>
<td>d   52.5</td>
<td>6.25</td>
<td>10.9</td>
</tr>
</tbody>
</table>

i. Calculate the constants K and n for the plastic strain-hardening region.
ii. Calculate the modulus of elasticity.
iii. Estimate the yield strength.
iv. Calculate the maximum stress during the test.
v. Estimate the true uniform and necking strains if the fracture dia is 10mm.
vi. Evaluate the toughness of the material.

5. Show that the magnitude of the maximum stress that exists at the tip of an internal crack length of 0.001" with crack tip radius of $10^{-5}$ in. under a tensile stress of 25 ksi is 354 ksi?

6. Show that the critical crack size for an edge crack in a plate is 4.66 in if the stress is 14 ksi, the width of the plate is 70 in, the critical fracture toughness is 60 ksi $\sqrt{\text{in}}$, and the geometry factor Y is 1.12.

7. A sample of an Al-alloy with an edge crack of length $a=1.5\text{mm}$ fractures at a tensile stress of 364 MPa. If $E=200 \text{ GPa}$ and $\gamma_s=4 \text{ J/m}^2$ for the alloy, show that the critical fracture toughness ($K_{IC}$) is given by $25 \text{ MPa}\sqrt{\text{m}}$.

8. An aluminum alloy that has a plane strain fracture toughness of $25\text{ksi}\sqrt{\text{in}}$ fails when a stress of 42ksi is applied. Observation of the fracture surface indicates that fracture began at the surface of the part. Estimate the size of the flaw that initiated the fracture to be $0.093\text{in}$ given $Y=1.1$.

9. A tensile test performed on a copper alloy at 900K to a strain of 0.15 at a strain-rate of $3.32\times10^{-7}\text{s}^{-1}$ gave a flow stress value of 150MPa and a sudden change of the strain-rate at that strain (0.15) to $1.98\times10^{-6}\text{s}^{-1}$ exhibited an increase in the flow stress to a value of 250MPa. Calculate the strain-rate-sensitivity (m) of the material.

What is strain-rate-sensitivity (SRS) and what is its significance?