Name:

Student Id. #

Question 1: (***5 marks***)

A Metallic wire of length 200 mm is subjected to a load of 2000 N. The yield strength of the material is 100 MPa. Under this load, the length of the wire is measured to be 200.1 mm.

1- What will be the length of the wire after the load is removed?

(The young modulus of this alloy is 97 GPa. The cross sectional are of the wire is 25 mm^2.)

2- This wire has been used to hang a heavy load of 5 kN when it experiences an elongation of 1.0 mm. In this case what will be the length of the rod after the load is removed?

Solution:

(1) $\sigma = \frac{F}{A}$ = 2000/ 25 = 80 MPa

80 MPa < 100 MPa

Therefore, the wire will deform elastically. The length of the wire will remain 200 mm.

(2) $\sigma = \frac{F}{A}$ = 5000/ 25 = 200 MPa

200 MPa > 100 MPa

Therefore, the deformation is plastic. Elastic recovery need to be calculated

Total strain, $\varepsilon_T = \Delta l / lo = 1/200 = 0.005$

Elastic recovery, $\varepsilon_e = \sigma / E = 200 / 97000 = 0.002$

Hence, Plastic or permanent strain, $\varepsilon_P = \varepsilon_T - \varepsilon_e = 0.005-0.002 = 0.003$

Let the final length of the wire be lf.

$\varepsilon_P = (l_f - l_o) / l_o = (l_f – 200) / 200$

So, l_f = 200.6 mm

Question 2: (***5 marks***)

For some metal alloy, a true stress of 415 MPa produces a plastic true strain of 0.475. How much will a specimen of this material elongate when a true stress of 325 MPa is applied if the original length is 300 mm? Assume a value of 0.25 for the strain-hardening exponent n.

Solution:

Firstly it is necessary to solve for K from the given true stress and strain. Rearrangement of equation 6.19 yields;

$$\mathrm{K} = \frac{\sigma_\mathrm{T}}{(\varepsilon_\mathrm{T})^\mathrm{n}} = \frac{415}{(0.475)^\mathrm{n}} = 500\ \mathrm{MPa}$$

Next we must solve for the true strain produced when a true stress of 325 MPa is applied, also using Equation 6.19, thus;

$$\varepsilon_T = \left[\frac{\sigma_T}{K}\right]^{1/n} = \left[\frac{325}{500}\right]^{1/0.25} = 0.179$$

Now, rearrangement of equation 6.16 for solving l_i gives:

$$\varepsilon_T = ln\left(\frac{l_i}{l_0}\right) \rightarrow l_i = l_0 e^{0.179} = (300mm)e^{0.179} = 358.8\,mm$$

And finally, the elongation Δl is:

$$\Delta l = l_i - l_0 = 358.8 - 300 = 58.8\,mm$$