Home exercise 5.

Consider a 1D bar with length L_0 and cross section area S made of linear elastic, visco-plastic material with the equivalent uniaxial creep strain rate defined by $\dot{\varepsilon}^{cr} = A\sigma_e^n t^m$, where σ_e is the von Mises equivalent stress, t is time, and A, n, m are constants. The Young's modulus is E.

For a creep test with an instantly applied constant load (Fig.1, left), resulting in a 1D stress state,

1. **[2p]** Obtain an expression for a creep strain rate in a form $\dot{\varepsilon}^{cr} = f(\varepsilon^{cr})$.
2. **[3p]** Calculate at which time the displacement at the right end of the bar reaches value u_0. Hint: Consider the case when the displacement satisfies $u_0 > \sigma_0 L_0/E$.

For a relaxation test with a constant applied displacement at time $t = 0$ (Fig.1, right),

3. **[4p]** Obtain the dependence of stress on time in an explicit form (not in a rate form).

Figure 1. 1D creep test (left) and relaxation test (right).

After the displacement controlled cycling of the bar, the hysteresis loop, i.e., stress-strain (σ-ε) diagram, is obtained as shown in Fig. 2. The total strain $\varepsilon = \varepsilon^{el} + \varepsilon^{cr}$ is in range $[-u_0/L_0, u_0/L_0]$, the stress σ is in range $[-\sigma_m, \sigma_m]$.

4. **[1p]** Calculate the dissipated energy per cycle.

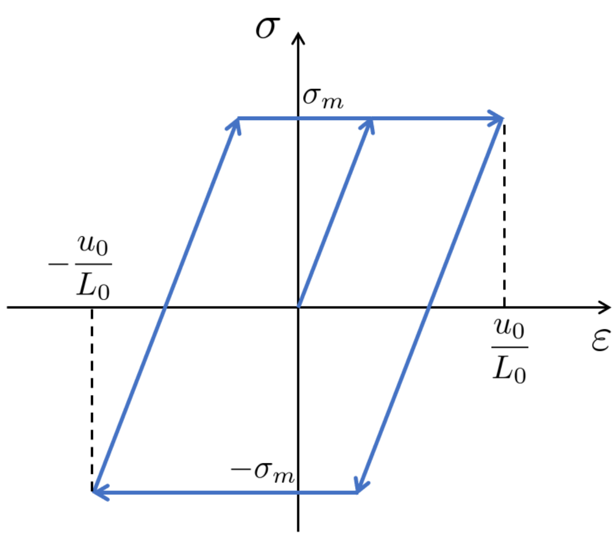

Figure 2. Hysteresis loop in 1D displacement controlled cycling test.