Name, Matriculation Number	1.	2.	3.	4.	$\sum$	Note

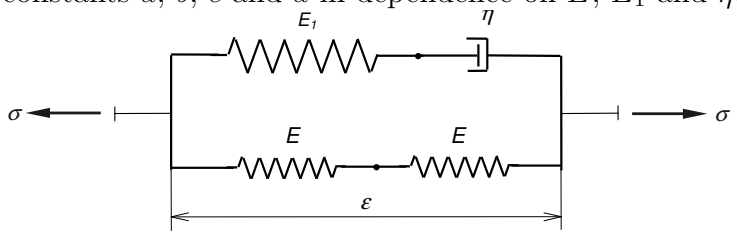
Examination Mechanics of Materials

Study courses: WWT, BGI, BFWK,CMS

20th March 20xx, 8-10 am

Room MM–1020

1. Develop the one-dimensional material law (relation between stress σ and strain ε) in terms of $a\sigma + b\dot{\sigma} = c\varepsilon + d\dot{\varepsilon}$ for the depicted rheological model. Furthermore, specify the constants a, b, c and d in dependence on E, E_1 and η.



2. A tensile bar is fixed at one end and strain loaded by $\varepsilon(t)$

$$\varepsilon(t) = \begin{cases} Bt, & \text{for } t \geq 0 \\ 0, & \text{for } t < 0 \end{cases}$$

. Note that t represents the time and B=0.05$\frac{1}{s}$. Calculate the tensile stress of the bar $\sigma = \sigma(t)$ for $t \geq 0$, if the material law is given by the visco-elastic standard model

$$\sigma(t) = M \cdot \left[\varepsilon(t) - \frac{1 - \frac{L}{M}}{T} \int_{-\infty}^{t} \exp\left[\tfrac{1}{T}(\tau - t)\right] \varepsilon(\tau) d\tau \right]$$

with the material parameters

- M=2·10^5 MPa (instantaneous modulus),
- L=9·10^4 MPa (long time modulus) and
- T=81 s (relaxation time).

Hint: Write the stress $\sigma = \sigma(\xi)$ in dependence on the dimensionsless time variable ξ=t/s. The numbers evaluated in this relations must be used with at least three digits.

(Please flip over!)

3. The first invariant of the stress tensor is given by I_1^σ=400 MPa. Furthermore, the components of the deviatoric stress tensor are given by::

   $$\sigma_{xx}^D = -250 \text{ MPa},\ \sigma_{yy}^D = 600 \text{ MPa},\ \sigma_{zz}^D = -350 \text{ MPa},\ \tau_{yz}^D = -300 \text{ MPa},\ \tau_{xy}^D = \tau_{xz}^D = 0.$$

   Calculate the absolute values of the normal tractions, of the tangential tractions and the total tractions of the considered stress state acting in the sectional plane defined by (n_x=$\frac{1}{2}$, n_y=$\frac{1}{\sqrt{2}}$, n_z=$\frac{1}{2}$). Use the unit MPa and two digits during calculation.

4. A stress state is defined by the following components of the stress tensor:

   $$\sigma_{xx} = 250 \text{ MPa},\ \sigma_{yy} = -100 \text{ MPa},\ \tau_{xy} = 200 \text{ MPa},\ \sigma_{zz} = \tau_{xz} = \tau_{yz} = 0.$$

   Furthermore it is known, that the considered solid fails according to the Mohr-Coulomb failure criterion with a linear limit curve in the R-σ_M-plane (R – radius of the Mohr circle, σ_M – center point of the Mohr circle). The limit curve is characterized by its negative slope ($\tan\rho$) with $\rho = \frac{\pi}{3}$ and the intersection point with the R-axis at τ_{c0}=1000 MPa. Calculate the smallest possible factor f, with which all given stress components must be multiplied, in order to reach failure for the modified stress state ($f\sigma_{xx}$, $f\sigma_{yy}$,...).