



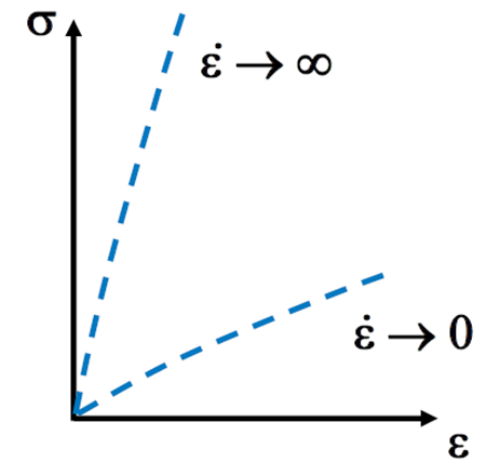
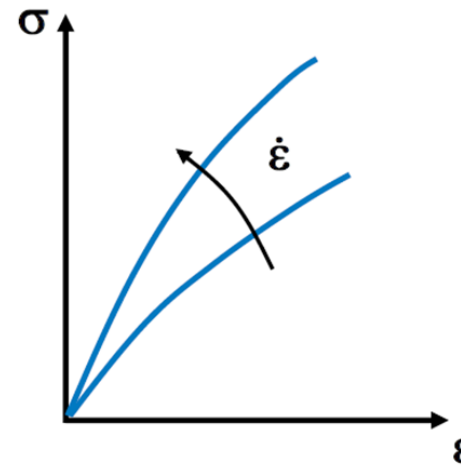
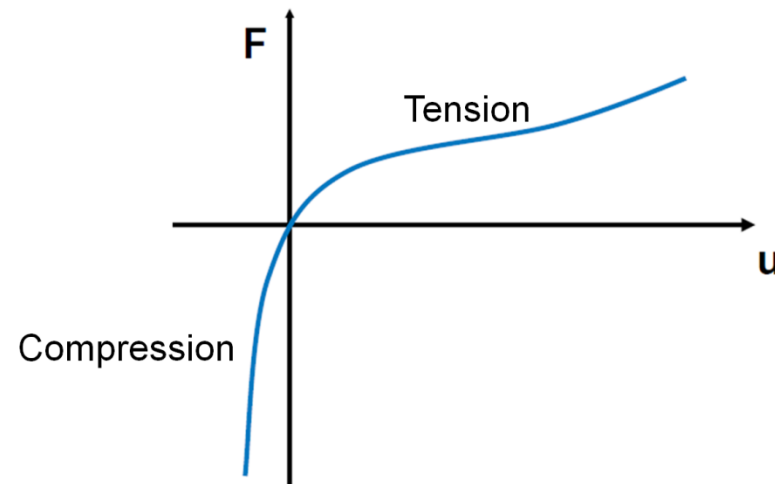
Non-linear and multiphysics problems

Presenter: Doc. dr. Damijan Zorko, Faculty of Mechanical Engineering

Date: 11-02-2022

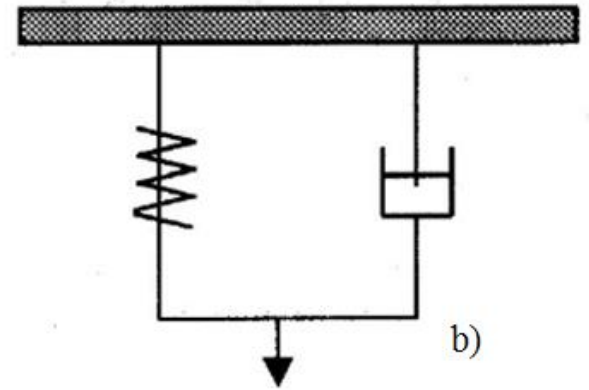
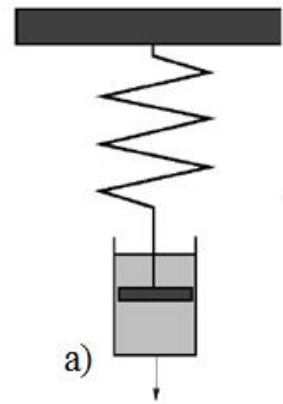
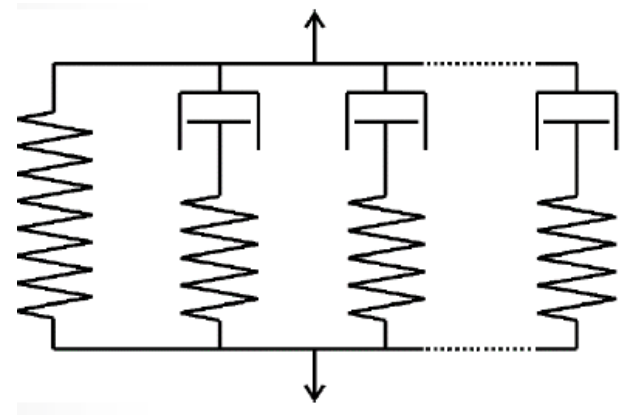
Overview of nonlinearities

- Geometric
- Material
- Contact



Viscoelasticity (Rheological models)

- Kelvin-Voight
- Maxwell
- Generalized Maxwell



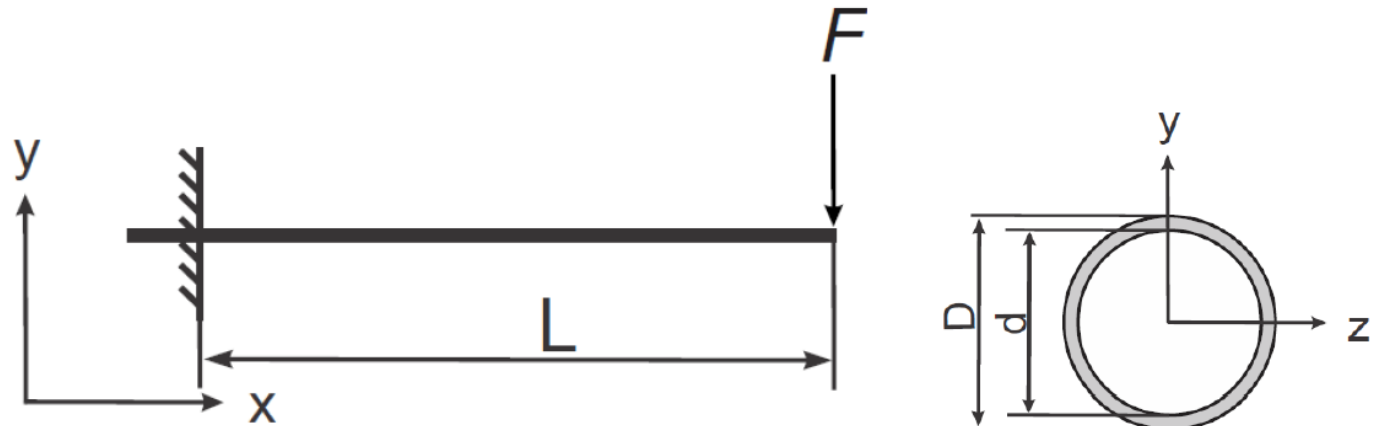
$$G(t) = G_{\infty} + \sum^N G_i e^{-\frac{t}{\tau_i^G}}$$

$$G(t) = G_0 \left[\alpha_{\infty}^G + \sum_1^N \alpha_i^G e^{-\frac{t}{\tau_i^G}} \right]$$

$$K(t) = K_0 \left[\alpha_{\infty}^K + \sum_1^M \alpha_i^K e^{-\frac{t}{\tau_i^K}} \right]$$

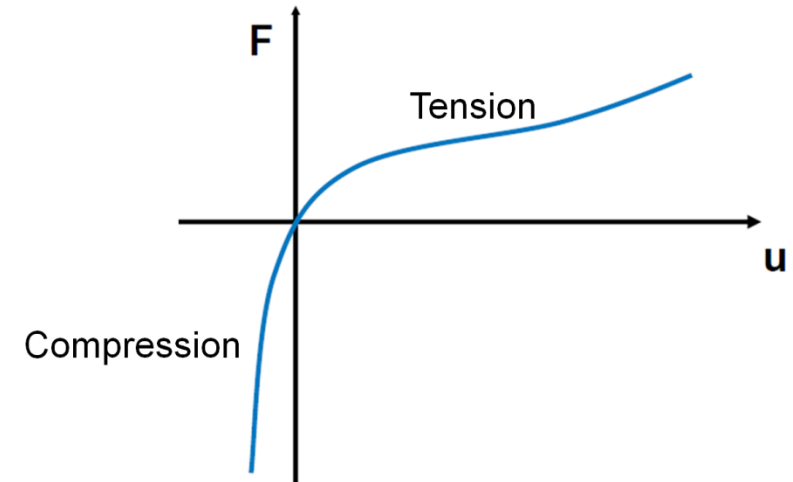
Example I (Viscoelasticity)

- $D = 30 \text{ mm}$
- $d = 24 \text{ mm}$
- $L = 200 \text{ mm}$
- $F = 250 \text{ N}$
- $\sigma = ?$, $y(L) = ?$



Hyperelasticity (assumptions)

- Isotropic, isotherm and elastic response
- Fully incompressible material
- Ideal rubbery behavior



$$\lambda = \frac{L}{L_0} = \frac{L_0 + \Delta L}{L_0} = 1 + \epsilon_E$$

$$S_{ij} = \frac{dW}{dE_{ij}} \quad \begin{matrix} W(\lambda_1, \lambda_2, \lambda_3) \\ W(I_1, I_2, I_3) \end{matrix}$$

$$I_1 = \lambda_1^2 + \lambda_2^2 + \lambda_3^2$$

$$I_2 = \lambda_1^2 \lambda_2^2 + \lambda_2^2 \lambda_3^2 + \lambda_3^2 \lambda_1^2$$

$$I_3 = \lambda_1^2 \lambda_2^2 \lambda_3^2$$

Hyperelasticity (assumptions)

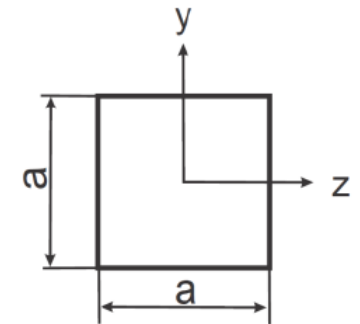
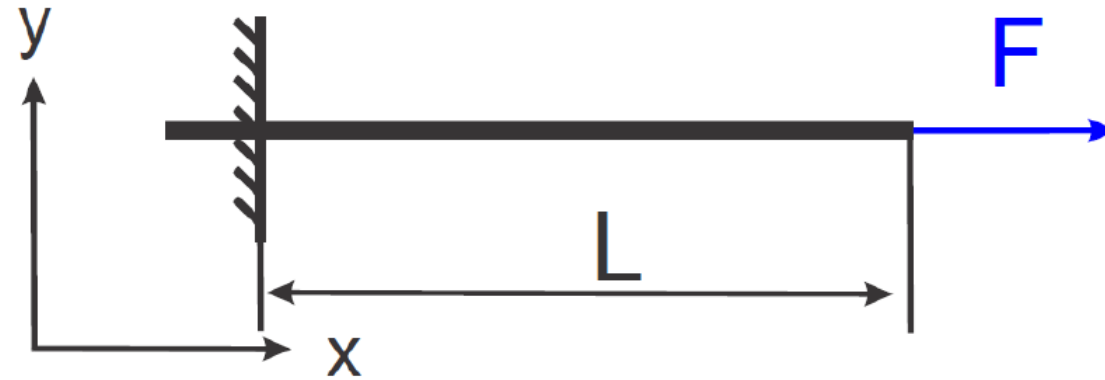
- Functions based on strain invariants
- Functions based on stretch ratios
- Statistical-Mechanical based models

$$W = C_1(I_1 - 3)$$

$$W = C_1(I_1 - 3) + C_2(I_2 - 3)$$

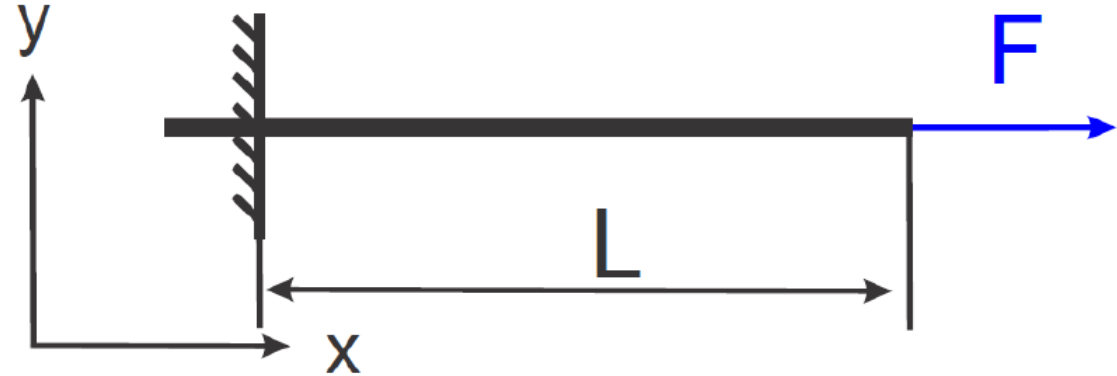
Example II (Hyperelasticity)

- $a = 30 \text{ mm}$
- $L = 200 \text{ mm}$
- $F = 2 \text{ kN}$
- $\sigma = ?$, $\Delta L = ?$



Example II (Structural-Modal)

- Dimensions: $15 \times 30 \times 500$
- $E = 200 \text{ GPa}$
- $\nu = 0,3$
- $F = 1000 \text{ N}$





Thanks!



This project has received funding from the European High-Performance Computing Joint Undertaking (JU) under grant agreement No 951732. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Germany, Bulgaria, Austria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Italy, Lithuania, Latvia, Poland, Portugal, Romania, Slovenia, Spain, Sweden, United Kingdom, France, Netherlands, Belgium, Luxembourg, Slovakia, Norway, Switzerland, Turkey, Republic of North Macedonia, Iceland, Montenegro



EuroHPC
Joint Undertaking