BASIC CONCEPTS EXTENSION

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- material behavior = response to load & deformation
  - instantaneous
  - time dependent
- creep in different materials
- master curves
- examples

mechanical models

elastic = spring (Hookeian)

viscous = dashpot (Newtonian)

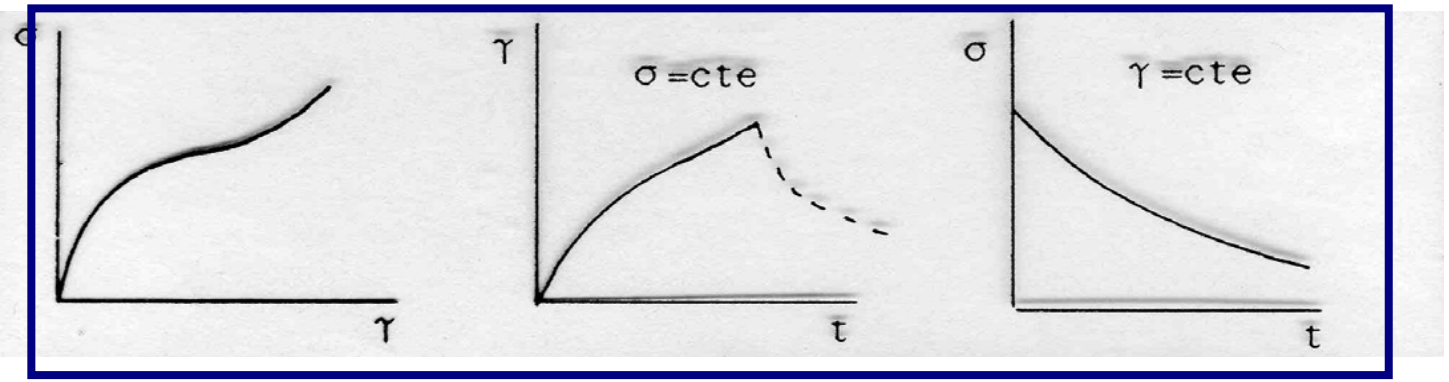
viscoelastic = combination

creep test

response to constant load

relaxation test

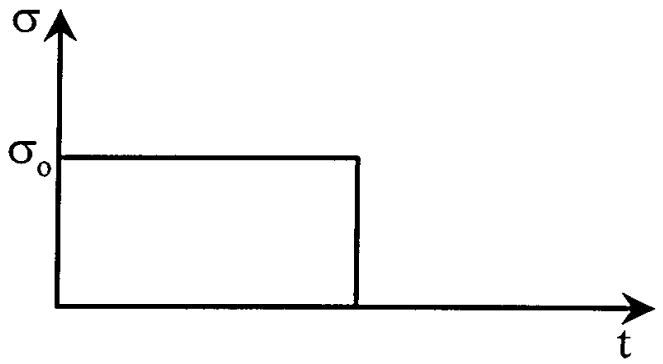
response to constant deformation

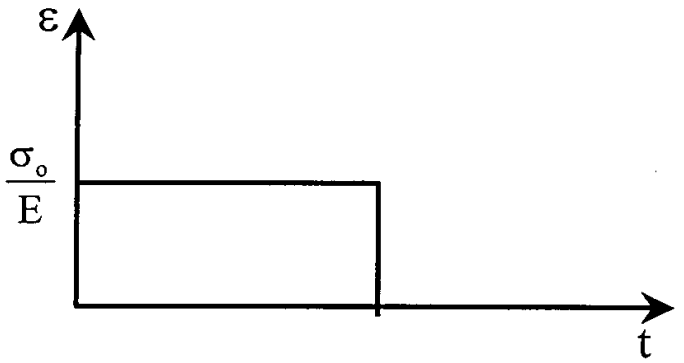


Material Behavior / Models (ELASTIC)

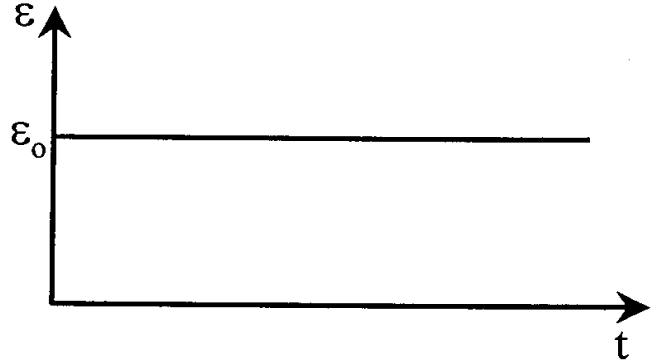
$$\sigma = E\varepsilon$$

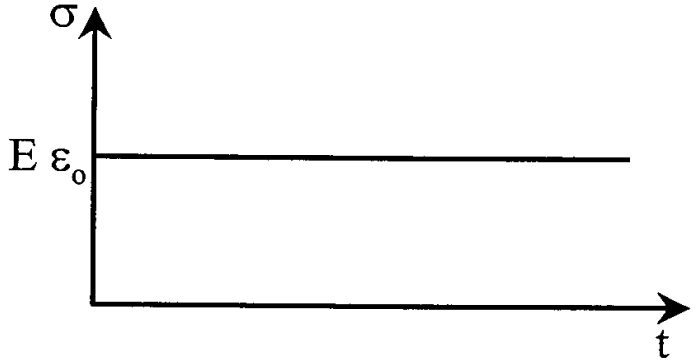
Creep Test



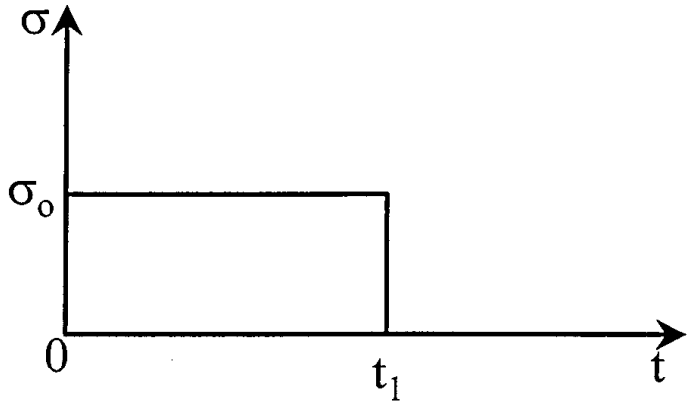


Relaxation Test



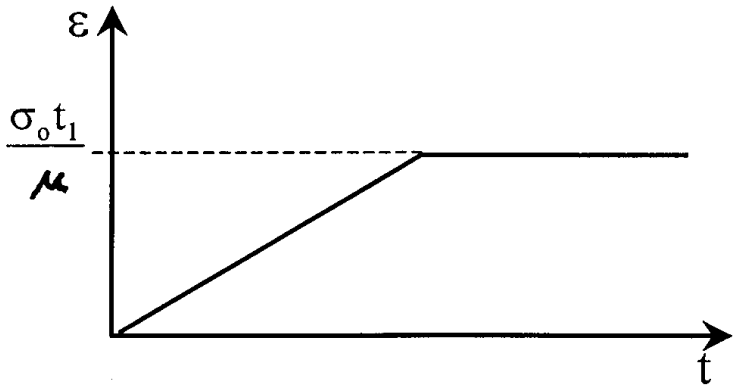


Creep Test



$$\sigma = \dot{\varepsilon}\mu$$

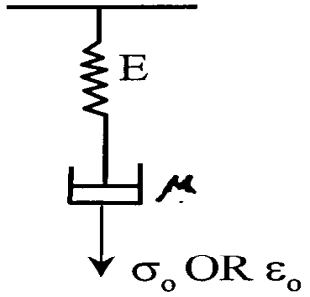
$$\tau = \dot{\gamma}\eta$$



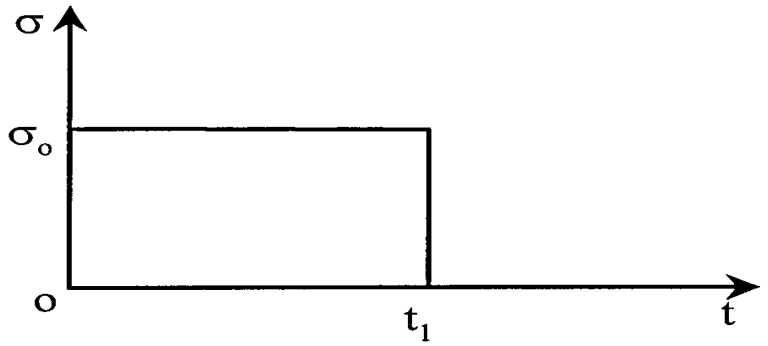
$$E = 2(1+\upsilon)G$$

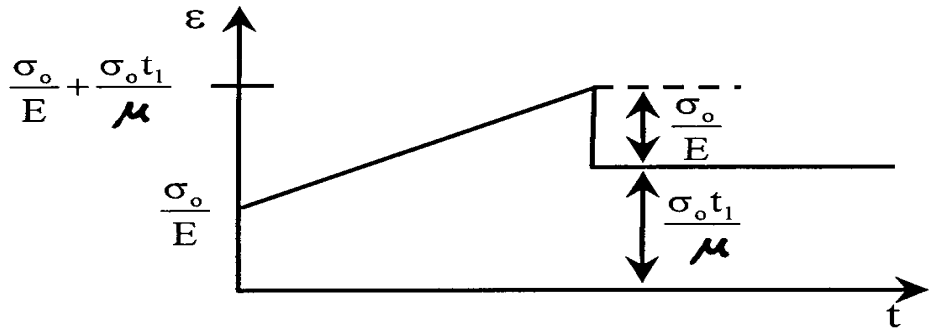
$$\text{for } \upsilon = 0.5;\ \mu = 3\eta$$

Viscoelastic solids (MAXWELL Model)



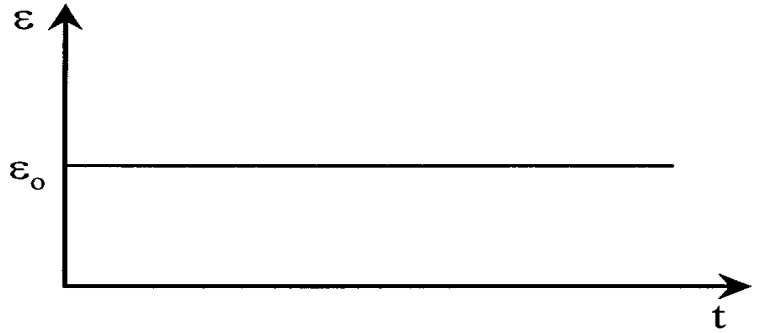
Creep Test

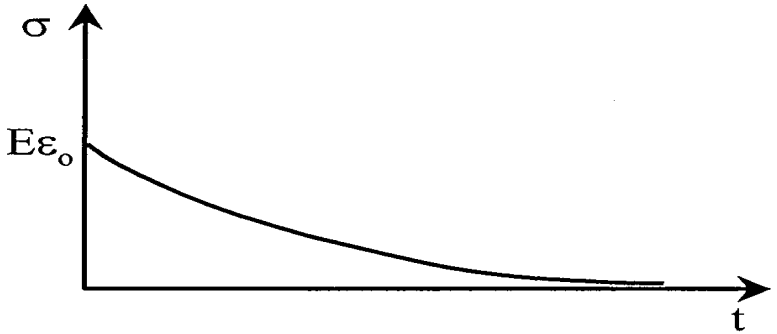




Elements in Series
Same Stress Acts on Both Elements

Relaxation Test





Viscoelastic solids (MAXWELL Model)

spring + dashpot in series
creep test

$$\varepsilon(t) = \sigma_0 \left(\frac{1}{E} + \frac{t}{\mu}\right)$$

relaxation test

$$\sigma(t) = E\varepsilon_0 e^{-\frac{E}{\mu}t}$$

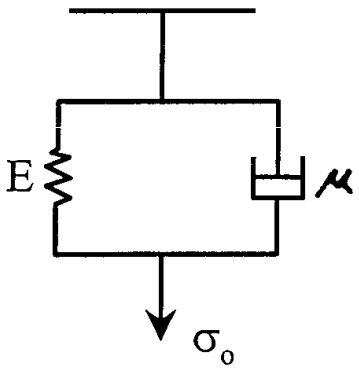
σ_0

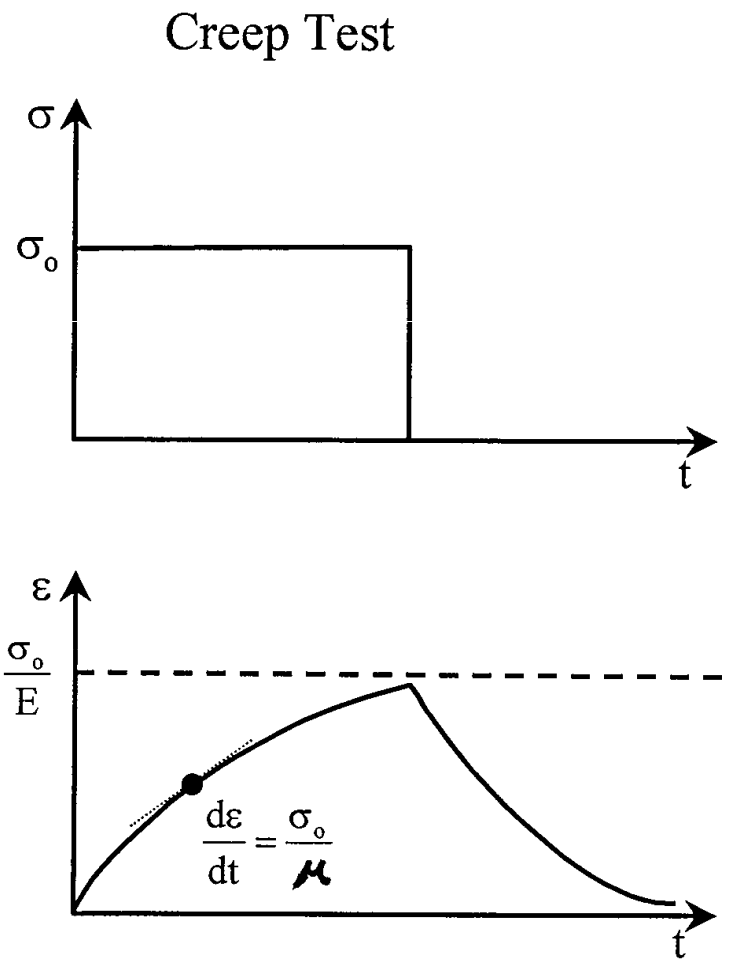
$$\frac{\mu}{E} = \text{relaxation time} = \tau \text{ or } \theta$$

$\sigma=\sigma_0 e^{-t/\theta_1}$ $\theta_1=\eta_1/E_1$ $\varepsilon=(\sigma_0/E_1)+(\sigma_0/\eta_1)t$ $\sigma=0.37\sigma_0$ per $t=\theta_1$

Viscoelastic solids (KELVIN Model)

spring + dashpot in parallel

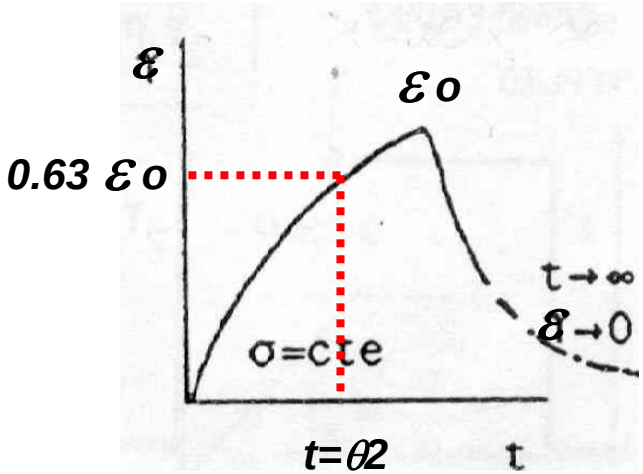




Viscoelastic solids (KELVIN Model)

- spring + dashpot in parallel
- creep test
- no relaxation test

$$\varepsilon(t) = \frac{\sigma_0}{E}(1 - e^{-\frac{E}{\mu}t})$$

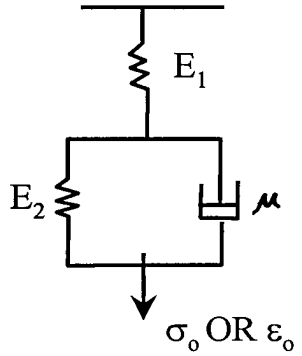


$\varepsilon = 0.63\ \varepsilon o$ per $t = \theta 2$

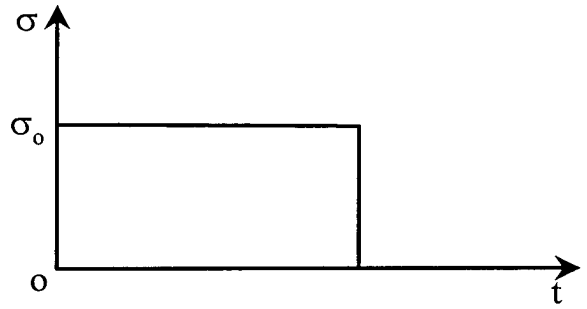
$$\frac{\mu}{E} = \text{retardation time} = \tau \text{ or } \theta$$

Viscoelastic solids (STANDARD Model)

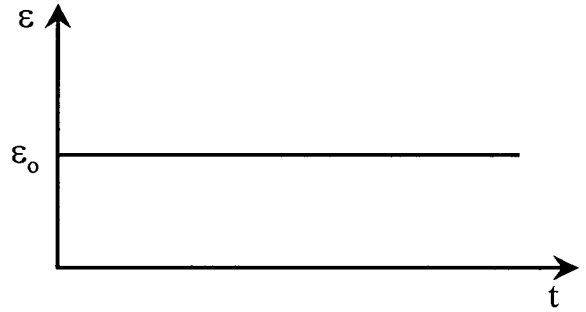
spring + dashpot in parallel
+ spring series

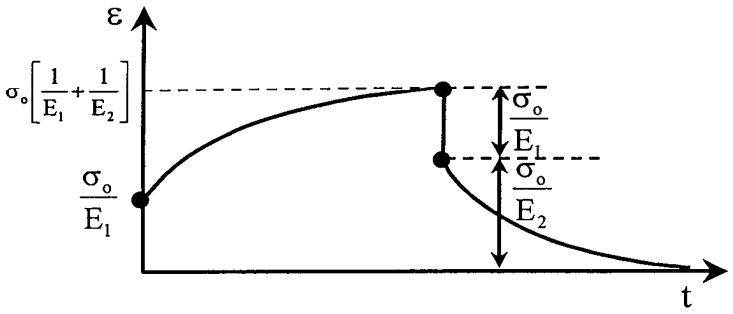


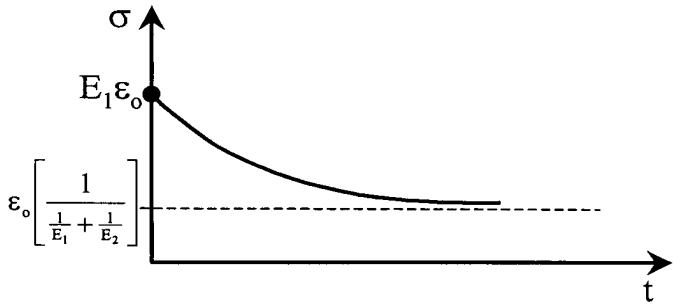
Creep Test



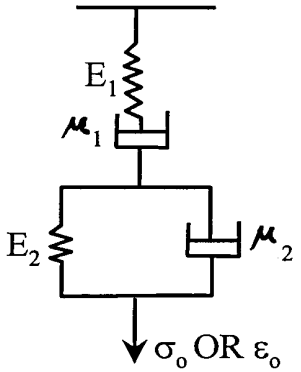
Relaxation Test







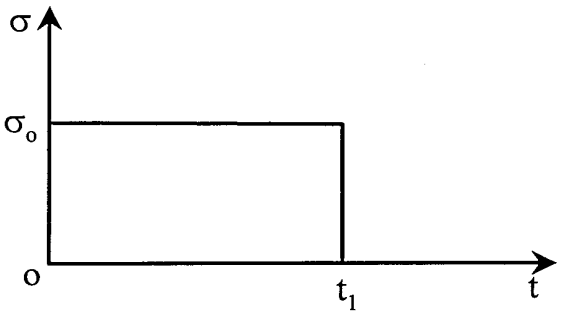
Viscoelastic solids (BURGERS Model)



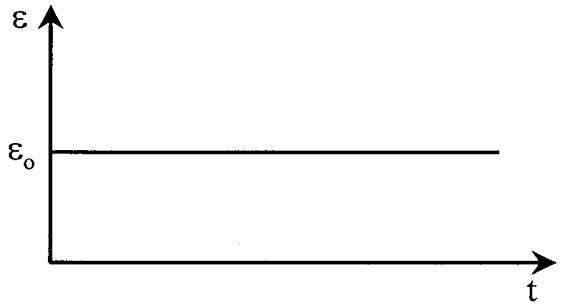
$$\sigma = \sigma o(e^{-t/\theta 1} + e^{-t/\theta 2})$$

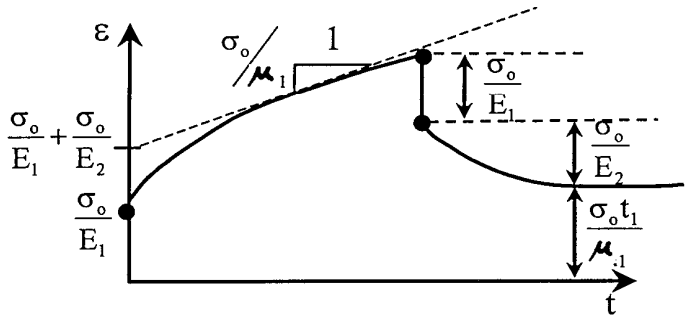
$$\varepsilon = (\sigma o/E1) + (\sigma o/\eta 1)t + (\sigma o/E2)(1 - e^{-t/\theta 2})$$

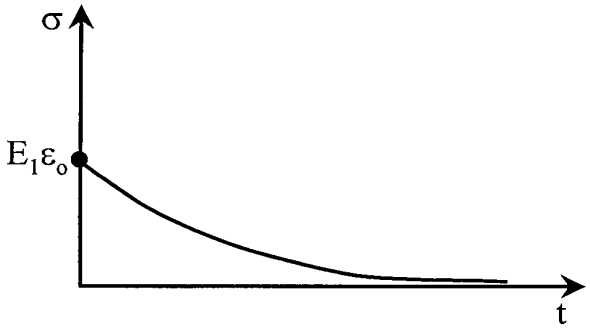
Creep Test



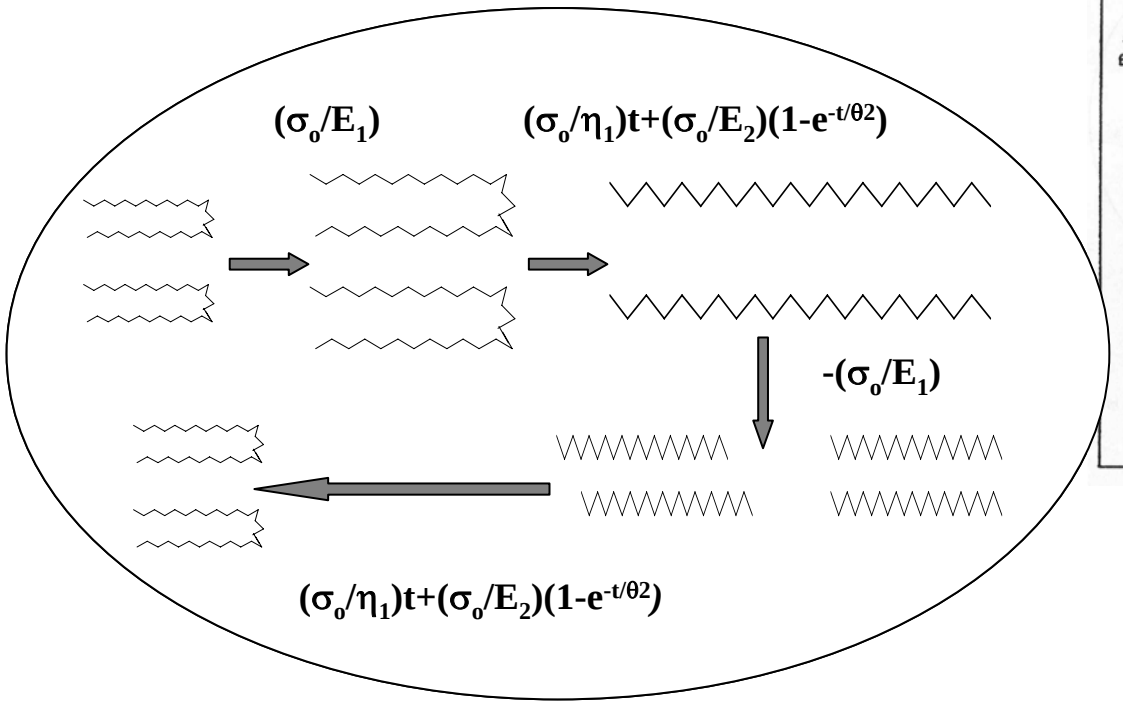
Relaxation Test

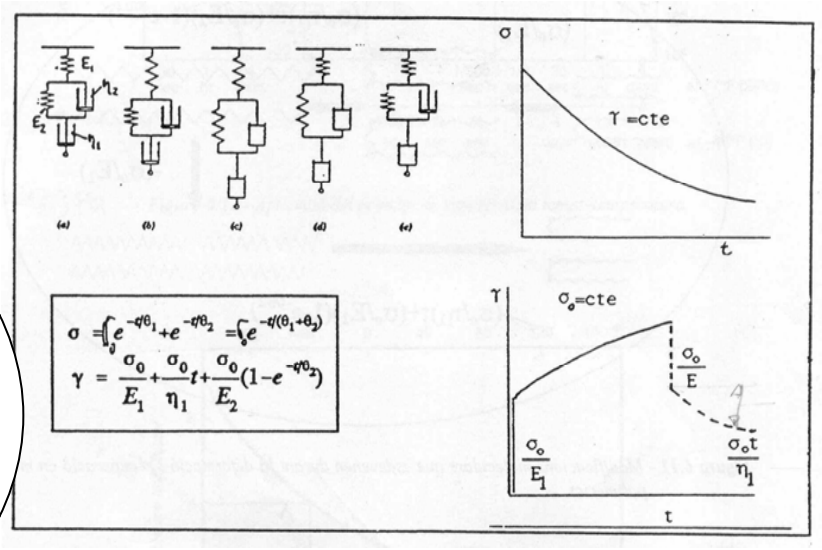






Viscoelastic solids (BURGERS Model)





$$\sigma = \sigma o(e\text{-}t/\theta 1 + e\text{-}t/\theta 2)$$

$$\varepsilon = (\sigma o/E1) + (\sigma o/\eta 1)t + (\sigma o/E2)(1\text{-}e\text{-}t/\theta 2)$$

3 Stages f (stress level, temperature)

Stage 1: transient / primary

Stage 2: steady state / secondary

Stage 3: tertiary