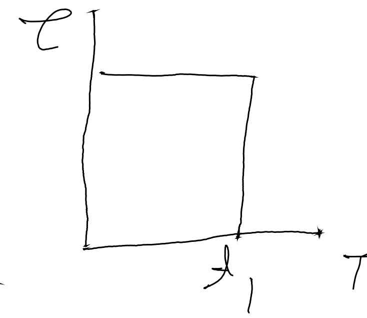
Viscoelastic

elastic + viscous



Newton's law viscosity

Newton's law of viscosity.

$$\tau \propto \frac{\partial u}{\partial y}$$ — shear strain

shear stress

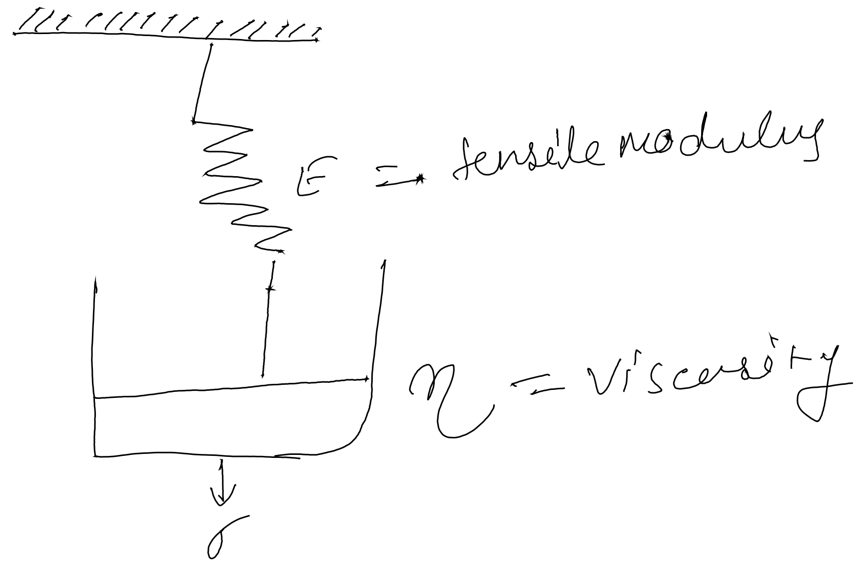
$$\tau = \mu \frac{du}{dy}$$

Newton's law of viscosity / dynamic viscosity

Kinematic viscosity → $\frac{\rho}{\mu}$ = stoke

Viscosity & elasticity in solids

$$\tau = \eta \frac{dy}{dt}$$



$$\sigma = \sigma_a = \sigma_d$$

where σ_s and σ_d are stresses on the spring and dashpot

$$\varepsilon_T = \varepsilon_s + \varepsilon_d \quad — (1)$$

$$\varepsilon_T = \varepsilon_s + \varepsilon_d \quad — (2)$$

But $\varepsilon_s = \frac{\sigma}{E}$ and $\varepsilon_d = \sigma/\eta$ — (3)

where ε_T is the total strain rate while ε_s and ε_d spring and dashpot

3 in (2)

$$\varepsilon_T = \frac{1}{E}\sigma + \frac{1}{\eta}\sigma \quad — (4)$$

Creep experiments.

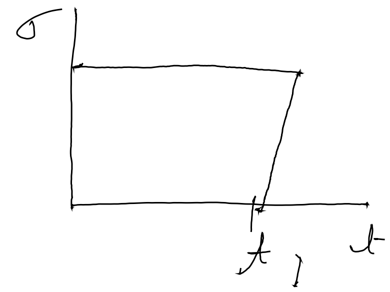
$$\varepsilon_T = \frac{1}{E}\sigma + \frac{1}{\eta}\sigma$$

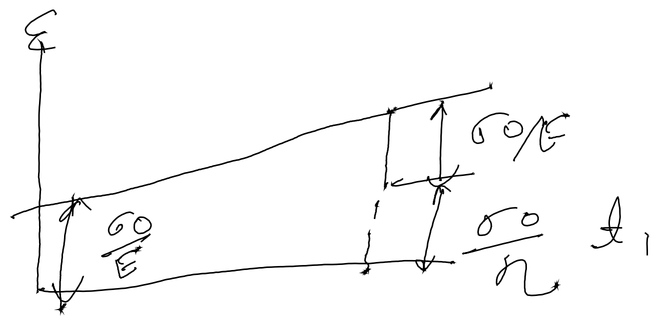
$$\varepsilon_T = \frac{1}{\eta}\sigma_0$$

$$\varepsilon(t) = \frac{\sigma_0}{E} + \frac{\sigma_0}{\eta}t$$

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

Stress Relaxation Experiment





$$\varepsilon_T = \frac{1}{E}\sigma + \frac{1}{\eta}\sigma$$

$$\varepsilon_T$$

$$\frac{1}{E}\sigma + \frac{1}{\eta}\sigma = 0$$

$$\sigma = E\varepsilon_0 \text{ at } t = 0$$

$$\sigma = \sigma_0 \exp\left(-\frac{E}{\eta}t\right)$$

$$\sigma = \sigma_0 \exp(-t/\tau) \quad — \; X$$

$1/e$ or 37%

$$\frac{\sigma(t)}{\varepsilon_0} = \frac{\sigma_0}{\varepsilon_0} e^{-t/\tau}$$

$$E_{re}(t) = E e^{-t/\tau}.$$