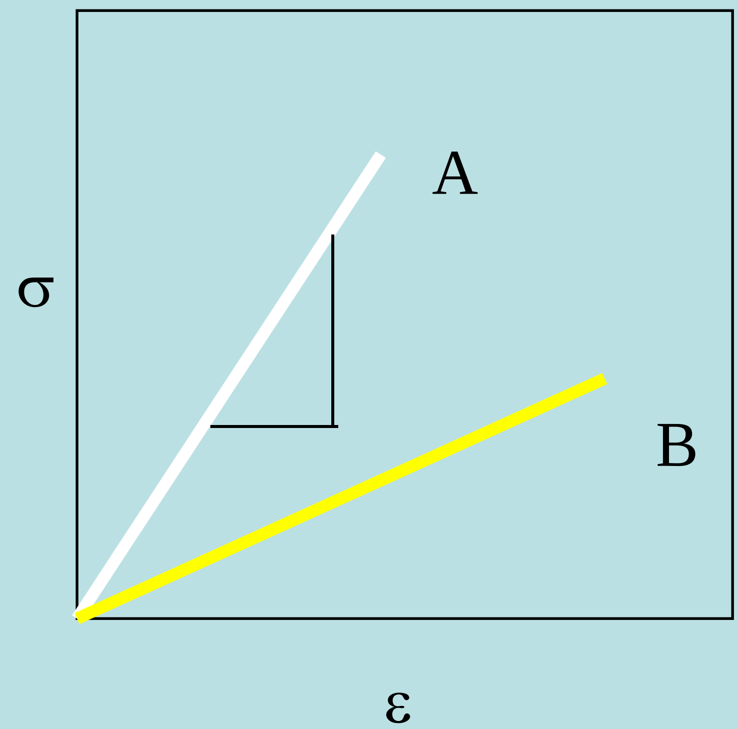
Section 14: Mechanics of Materials – Material Properties

Stress &Strain

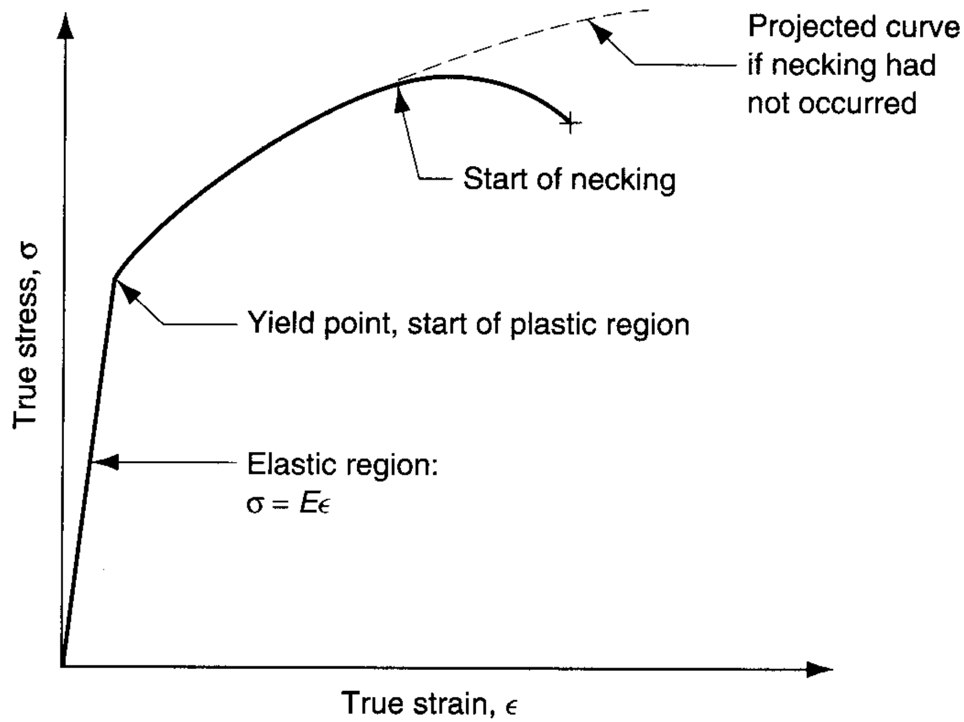
- Stress-strain ratio: stiffness or compliance of the material
  - $E = \sigma / \varepsilon$
- Linear material
  - Hooke' law: $\sigma = E \cdot \varepsilon$
- Biological material non-linear due to its tissue fluid component (viscoelastic properties)



From: Noffal

1. General mechanics principle

• The underlying mechanics principle for metal forming is the stress-strain relationship; see Figure 1.



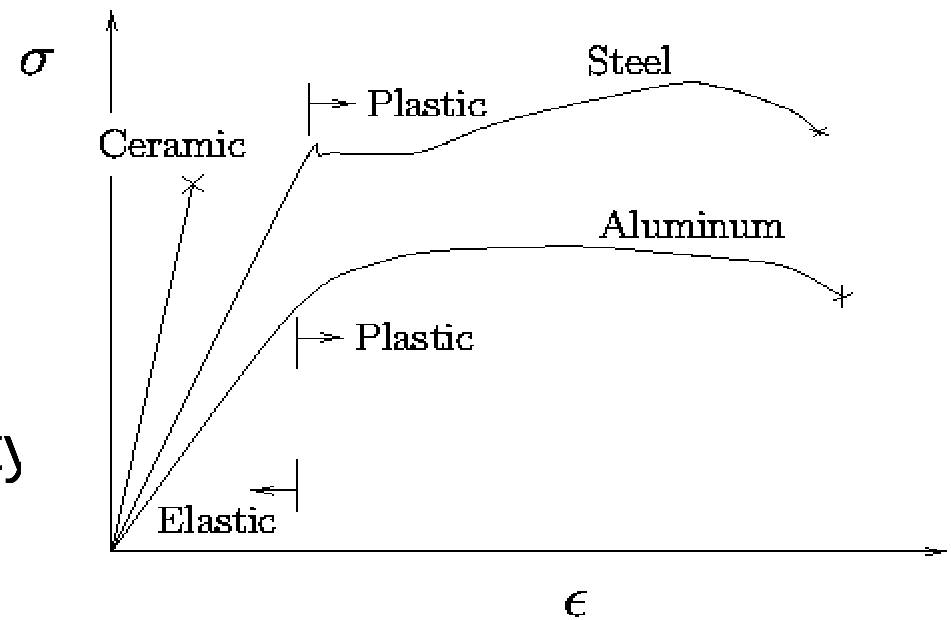
From: Zhang

Stress vs. Strain

Strain: $\varepsilon = \frac{\delta}{l}$ Stress: $\sigma = \frac{F}{A}$

Hooke's law:

$$\sigma = E\varepsilon$$



Where:

E = Modulus of Elasticity

σ = stress

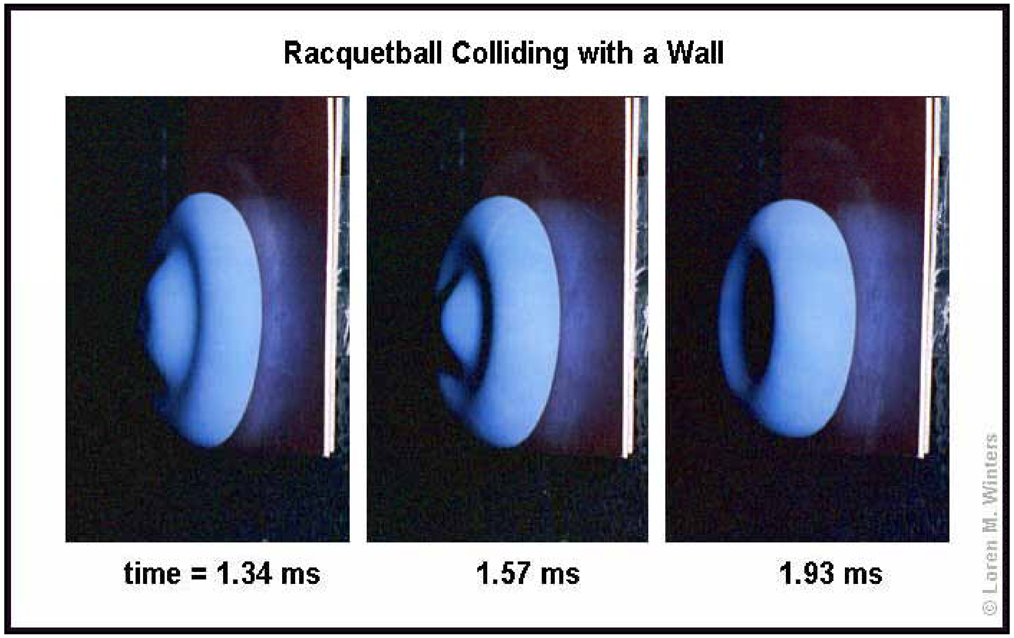
ε = strain

For the bike fork material $E = 29.0 \times 10^6$ psi.

From: Gateway Engineering Education Coalition

Strain

- Change in shape or deformation (ε)
- Absolute strain
- Relative strain
  - $\Delta L/L_o$



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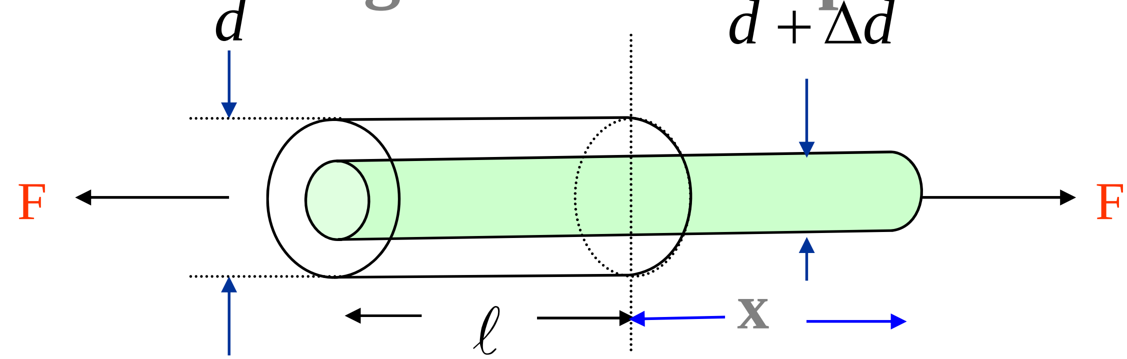
Poisson's ratio :

For a homogeneous isotropic material



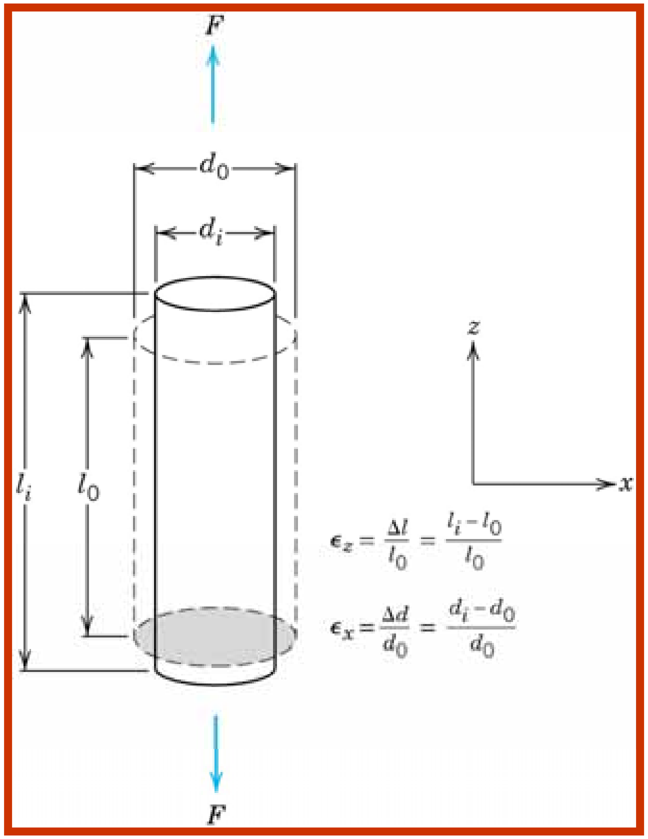
- normal strain : $\varepsilon = \dfrac{x}{\ell}$
- lateral strain : $\varepsilon_L = \dfrac{\Delta d}{d}$
- Poisson's ratio : $\nu \equiv -\varepsilon_L / \varepsilon$
- value of ν : 0.2 - 0.5

From: Ong

Definition of Strain and Poisson's Ratio:

$$\varepsilon = \frac{(l_i - l_o)}{l_o} = \frac{\Delta l}{l_o}$$

- This is the definition of **engineering** strain.
- In this definition, l_0 is the **initial** length of the specimen; l_i is the **instantaneous** length of the specimen; Δl is the difference between the two.

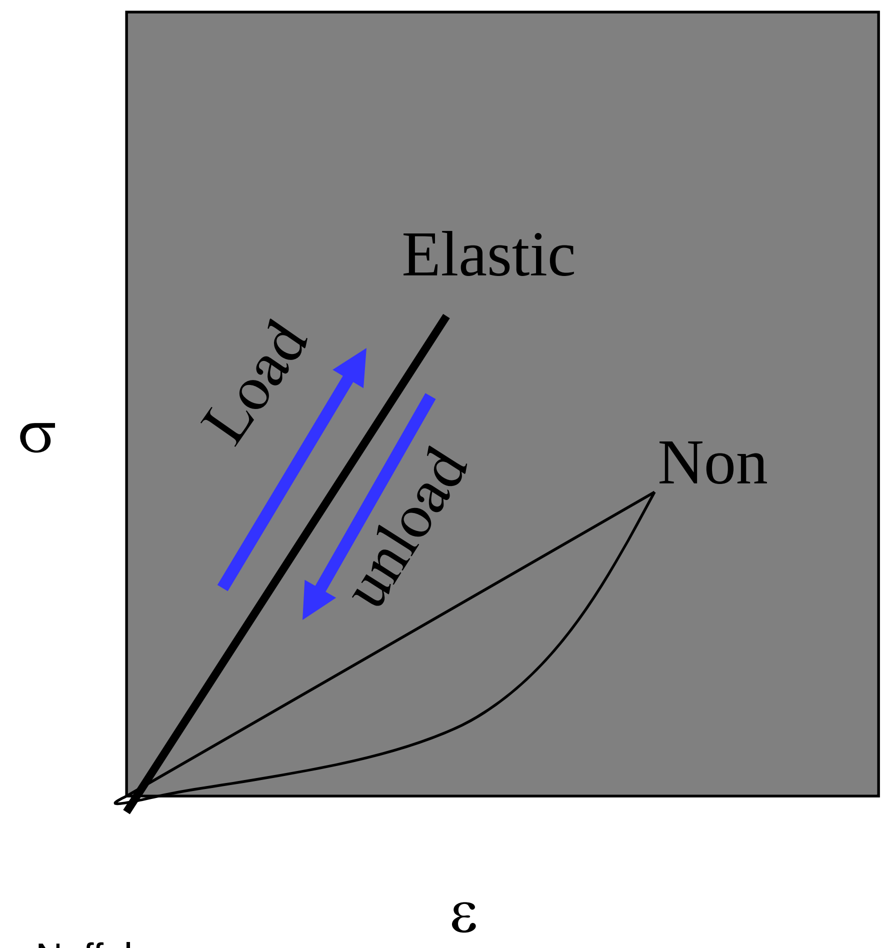


$\nu = \varepsilon_x / \varepsilon_z$

From: Wei

Viscoelasticity

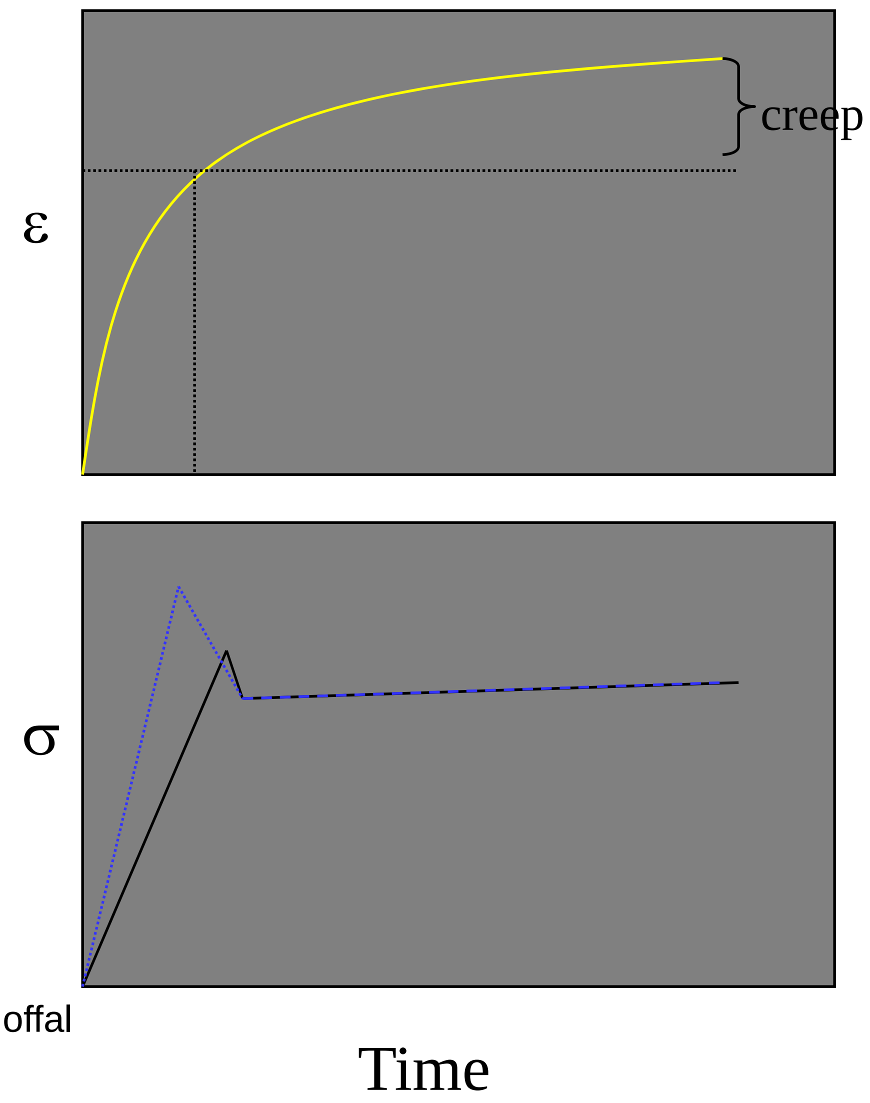
- Pure elastic material
  - strain energy returned
  - no energy loss
- Viscoelastic tissues
  - lose energy due to heat
  - energy is not returned immediately
  - Resilient
  - Dampened
- Hysteresis: area representing energy lost



From: Noffal

Viscoelasticity

- Creep response
- Stress-relaxation response
- Effects of strain-rate on stress relaxation



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