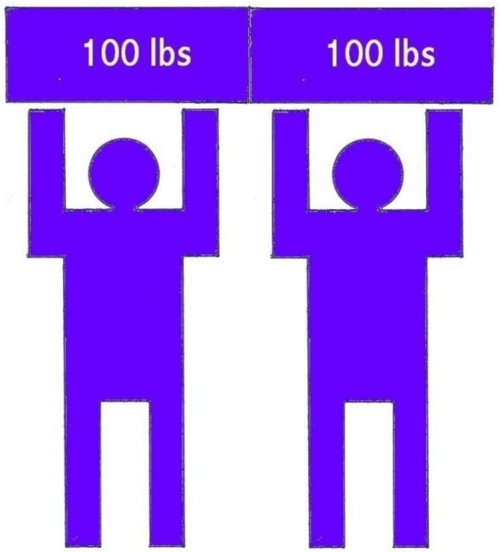
Objectives

1. Define stress & strain.
2. Utilize Hooke's Law to calculate unknown stresses and strains.
3. Determine material parameters from a stress-strain curve.
4. Recognize elastic and plastic components of deformation in a material.
5. Identify the regions of behavior on a stress-strain diagram.

Stress

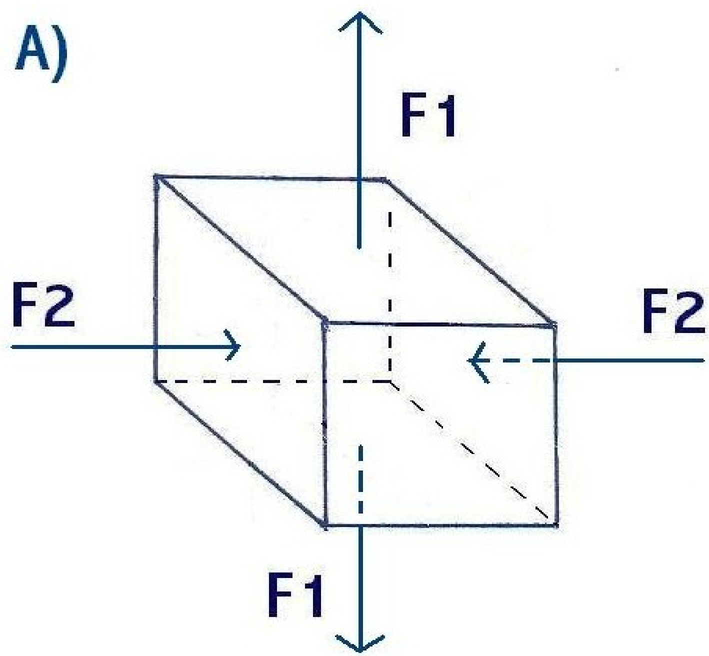
Intensity of Force

Stress = _____ /_____



Types of Stress

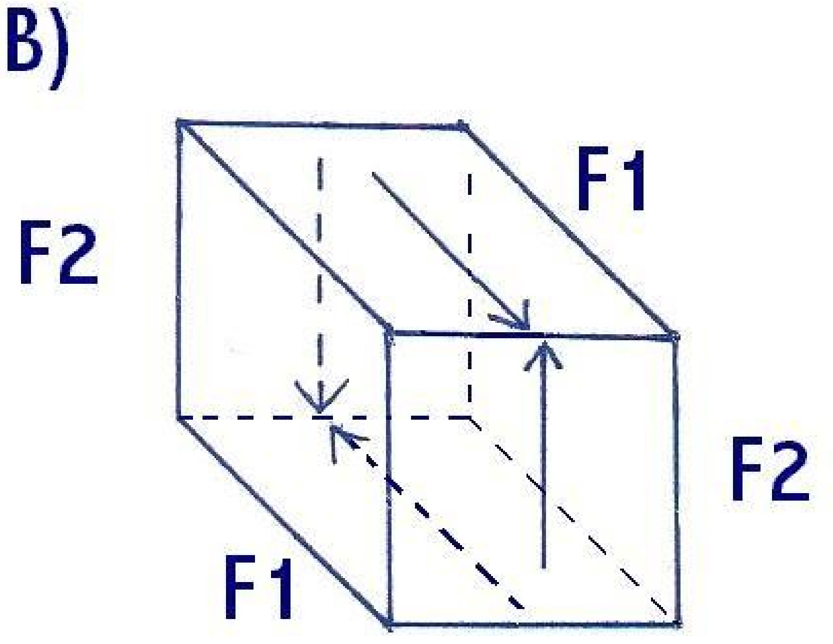
Normal : load perpendicular to area



Types of Stress

a) Normal

b) Shear : load parallel to area

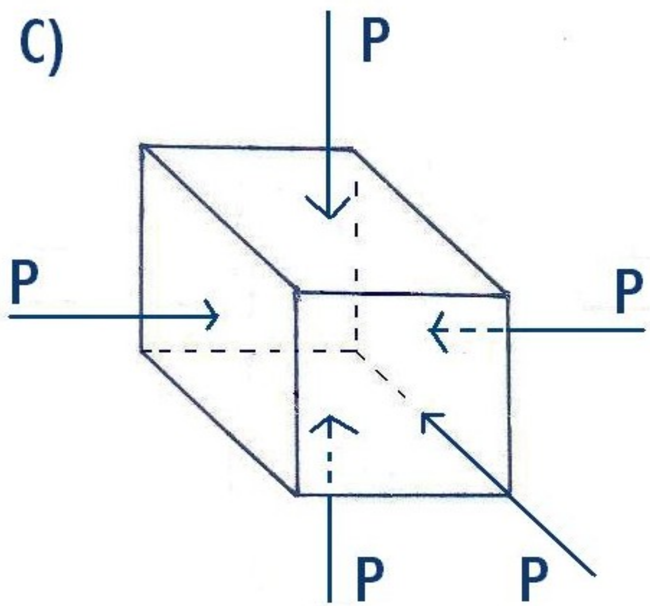


Types of Stress

a) Normal

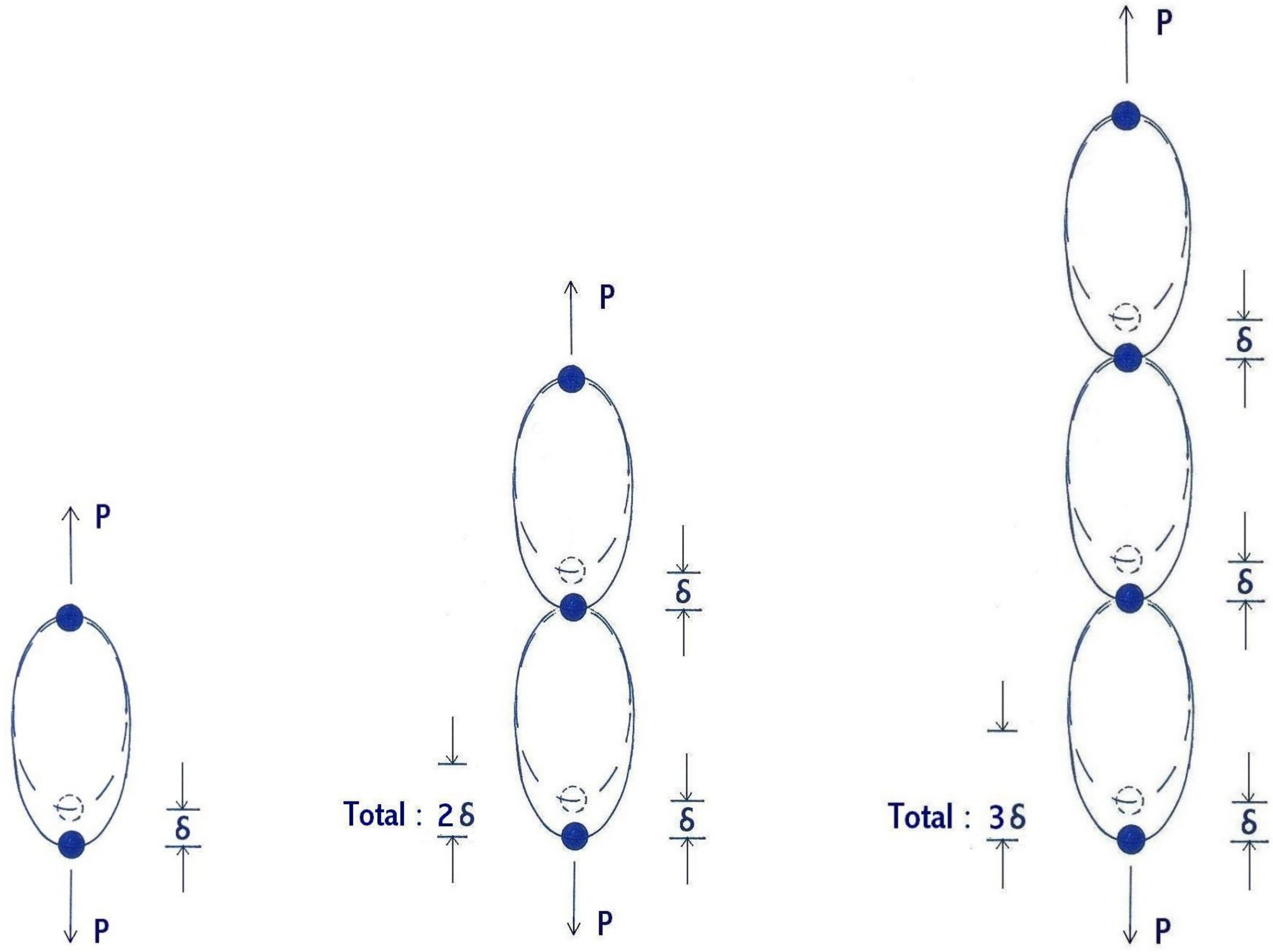
b) Shear

c) Hydrostatic (uniform pressure)



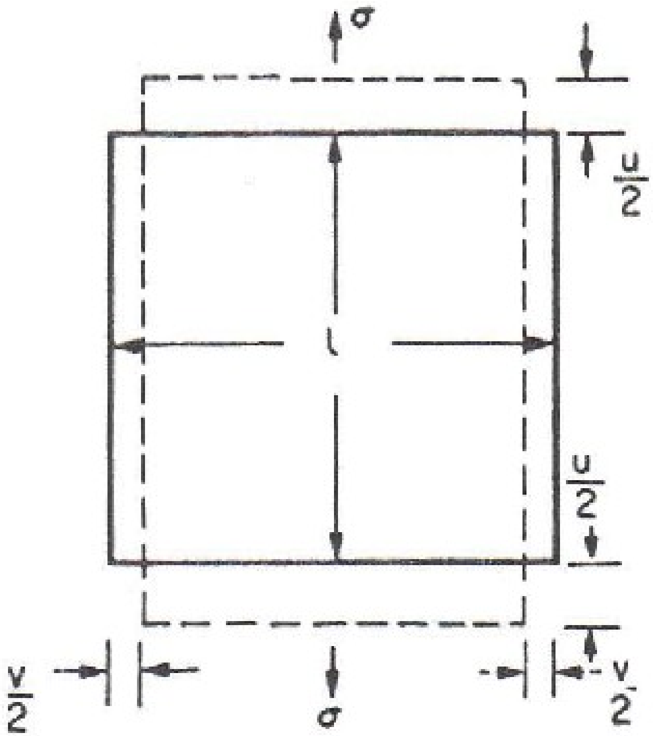
Strain: Intensity of Deformation

$$e = \_\_\_\_ / \_\_\_\_\_ = dl / lo$$



Types of Strain

Normal : deformation in the the direction of length



Longitudinal Strain

e = u / l

Transverse Strain

e = v / l

Transverse Strain

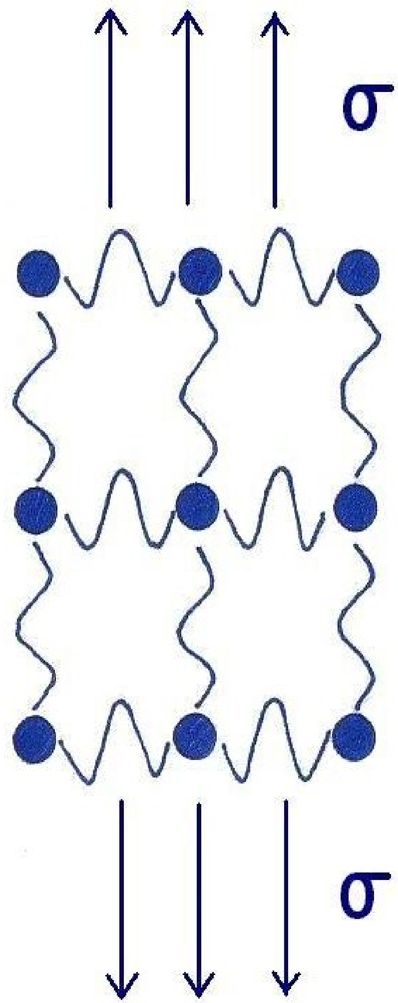
Materials tend to expand/contract in the directions perpendicular to the load application.

Poissonʼs Ratio

ν = - ________________

axial strain

Why Poisson's Ratio ?



Poissons Ratio Values

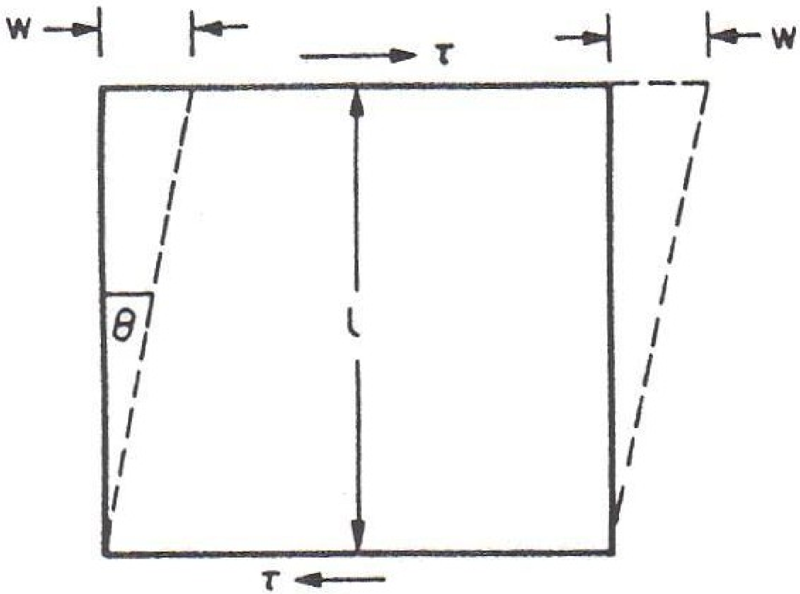
$\nu = 0.5$ constant volume

$\nu = 0.3$ good guess for most materials

Types of Strain

Normal

Shear : deformation normal to length



Engineering shear strain,

$$\gamma = \frac{w}{l} = \tan\theta$$

$\approx \theta$ for small strains

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

for small θ

$\sin\theta \to 0$

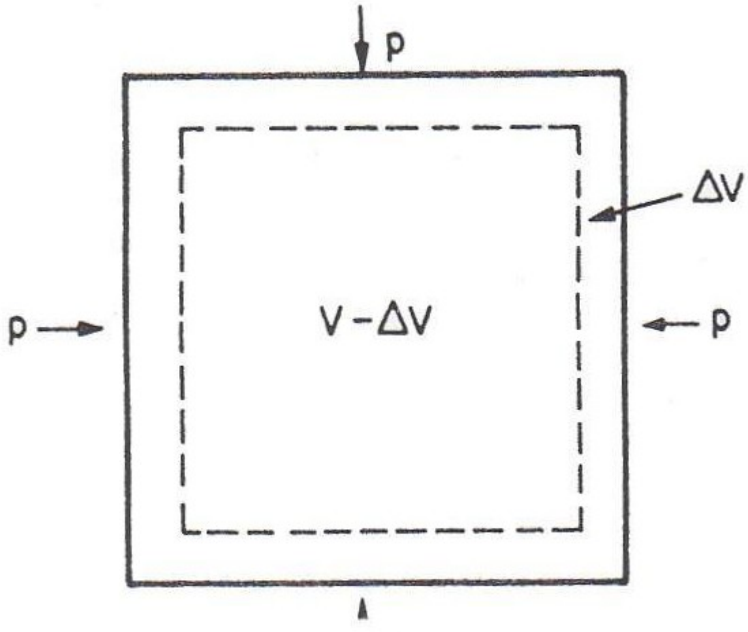
$\cos\theta \to 1$

Types of Strain

Normal

Shear

Dilatational (volume change)



Dilatation (volume strain)

$$\Delta = \frac{\Delta V}{V}$$

Relating Stress and Strain

Called a “Constitutive Model”

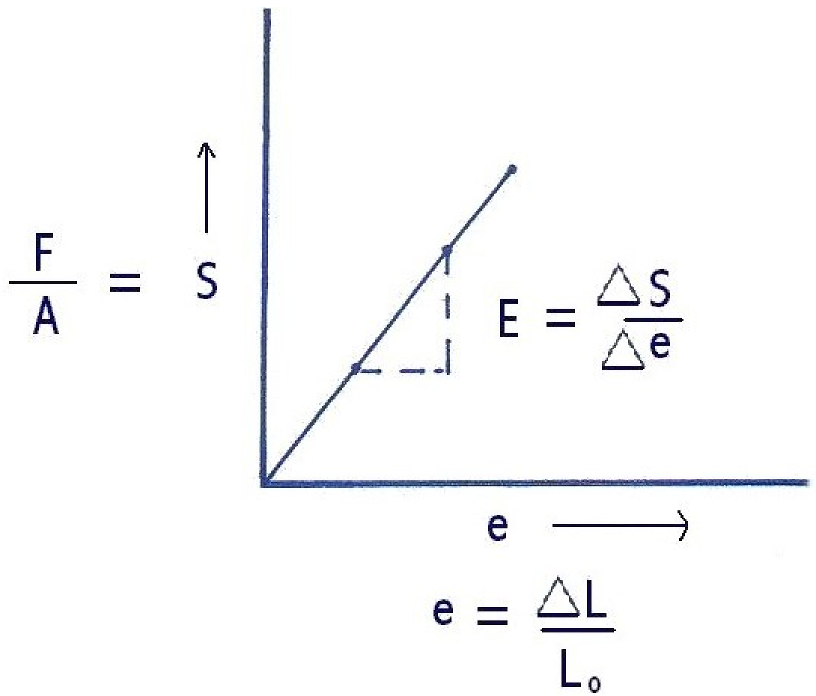
Simple Linear Model:

“Hooke’s Law”

Relating Stress and Strain Normal

$S = E\,e$

Stress = Young's modulus x strain



Relating Stress and Strain
Shear

Hooke's Law

$$\tau = G\,\gamma$$

τ = shear stress

G = shear modulus

γ = shear strain

Shear Modulus

$$G = E \,/\, [2\,(1 + \nu)]$$

Relating Stress and Strain Dilatational (hydrostatic)

Hooke's Law

$P = K\,\Delta$

$K = E/3(1-2\nu)$

P = pressure

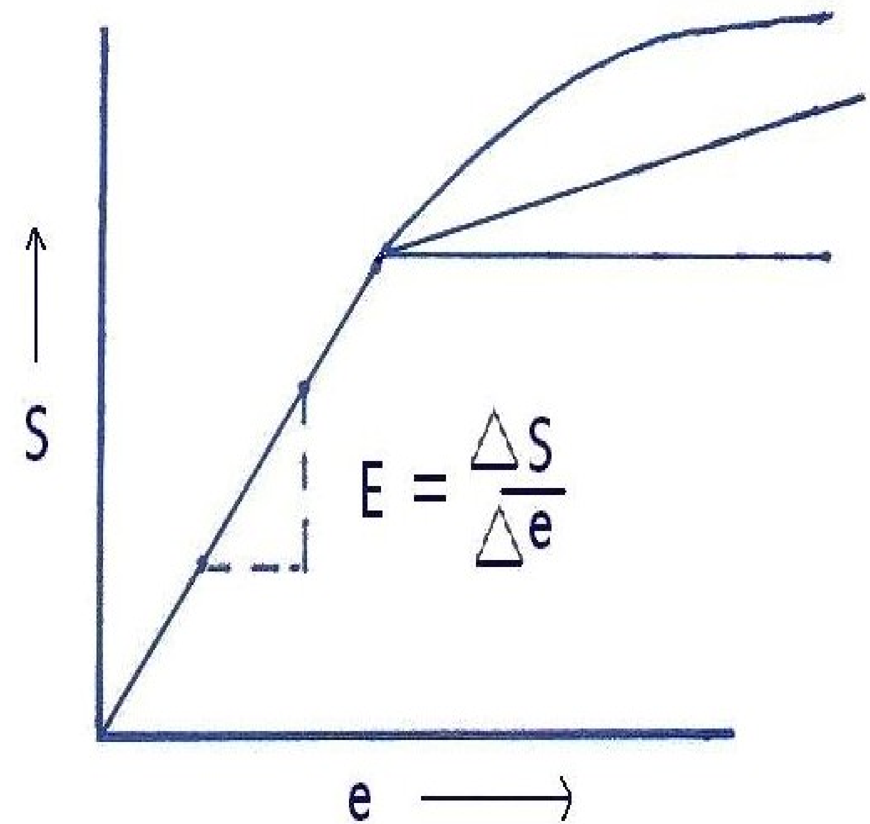
K = bulk modulus

$\Delta = \Delta V / V_o$

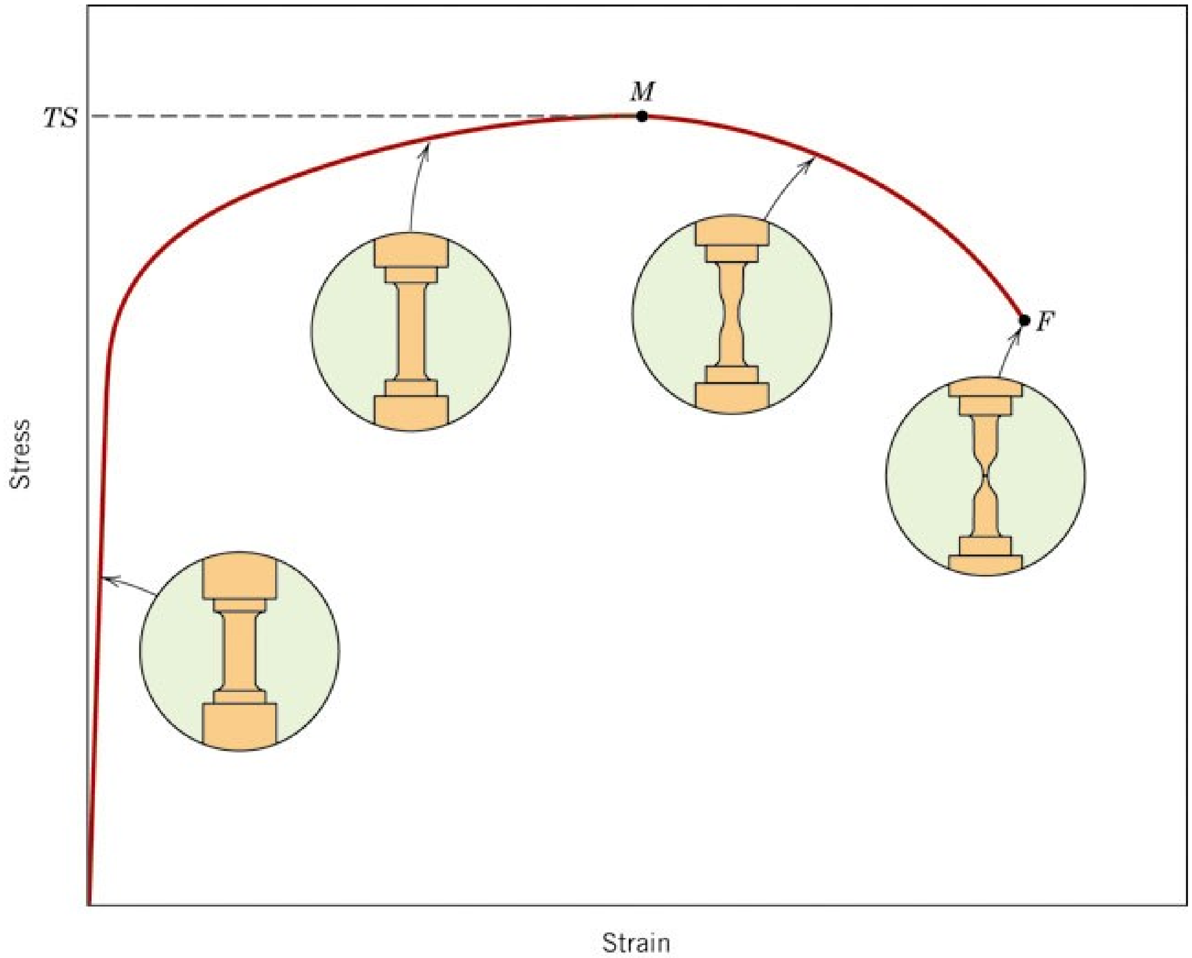
Real Material Behavior

-Hookean to a limiting strain
-Proportional limit : Deviation from linear
-After PL

*Linear
*Flat
*Non linear



Tensile Test



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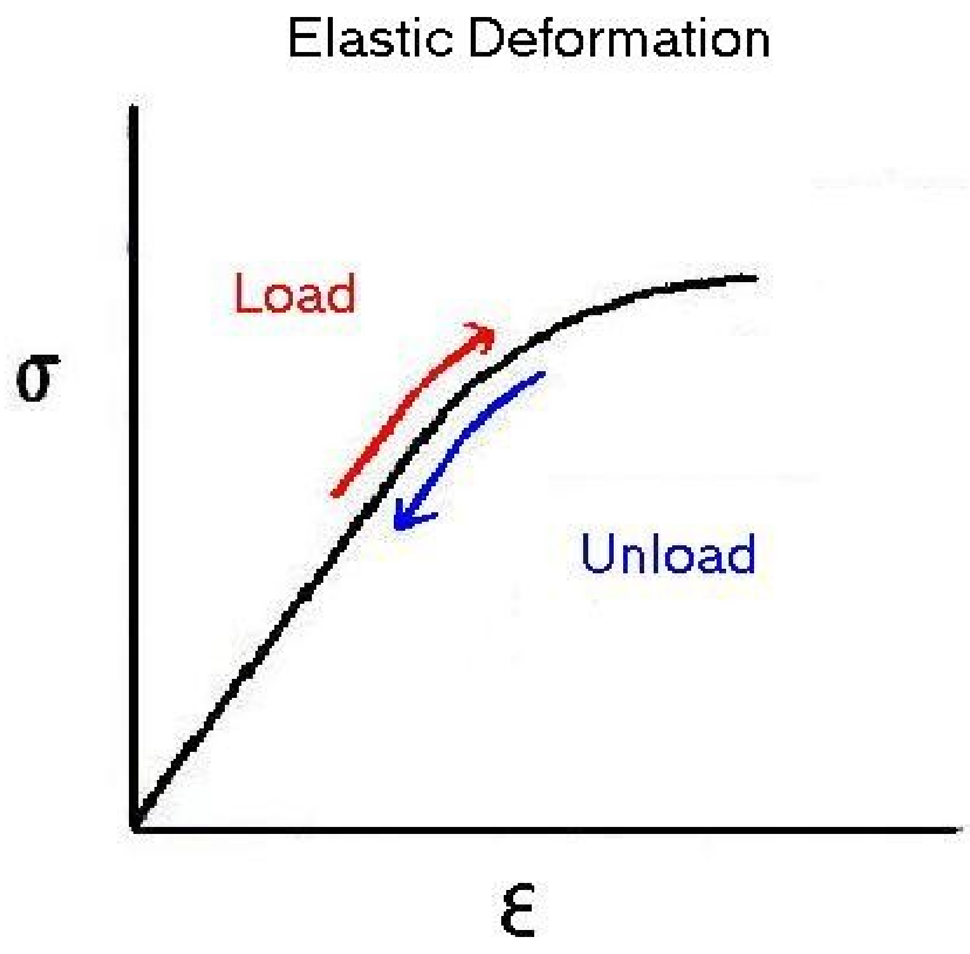
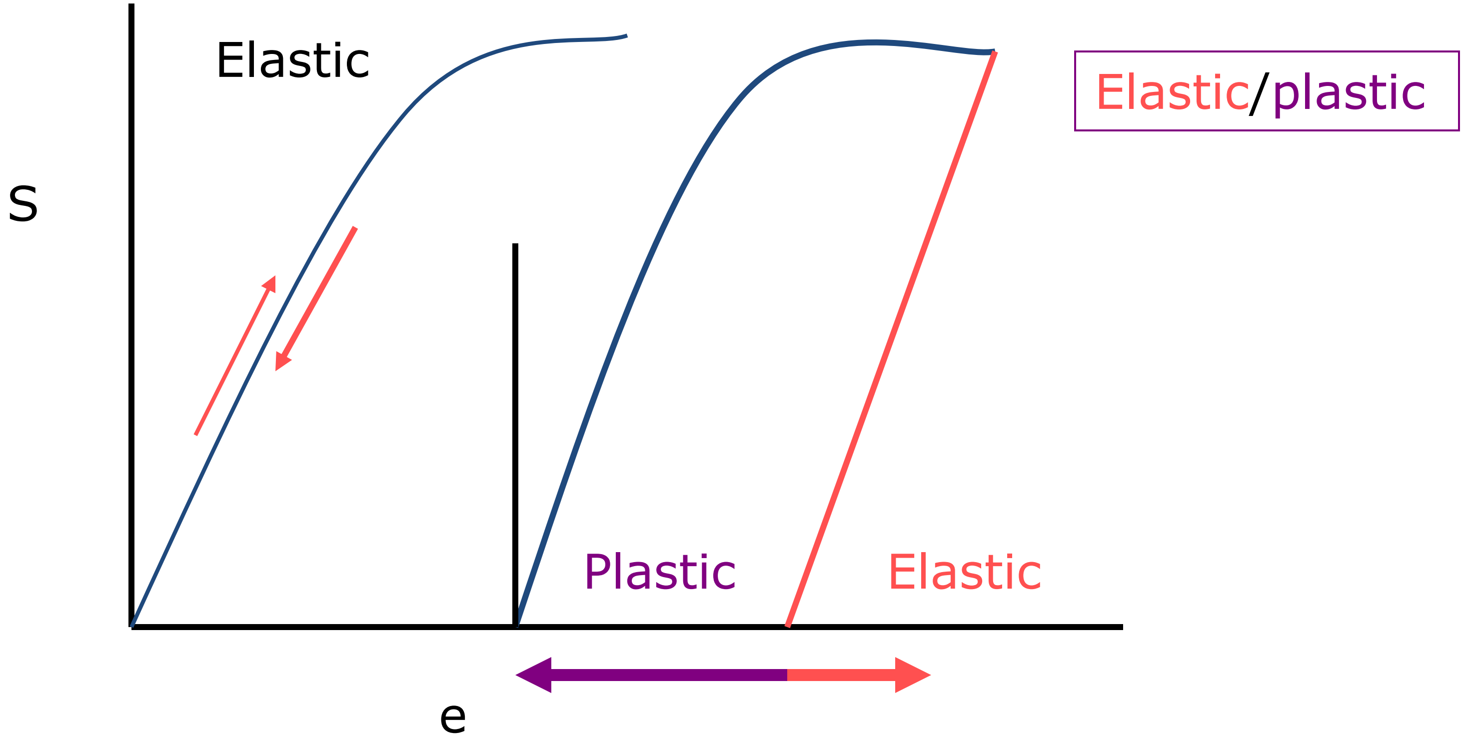
What is Elastic Deformation?



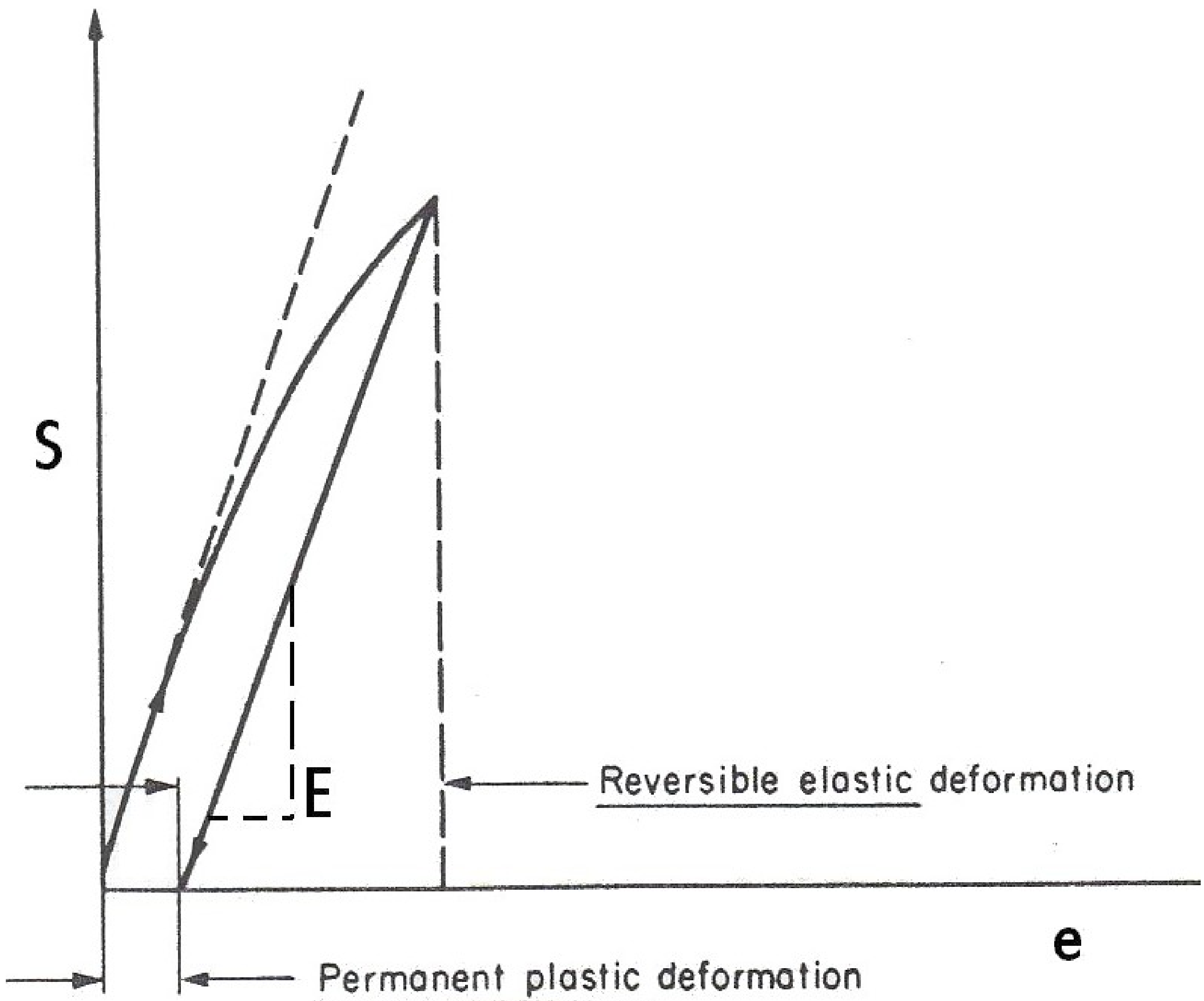
Real Material Behavior

*Recoverable strain (elastic)

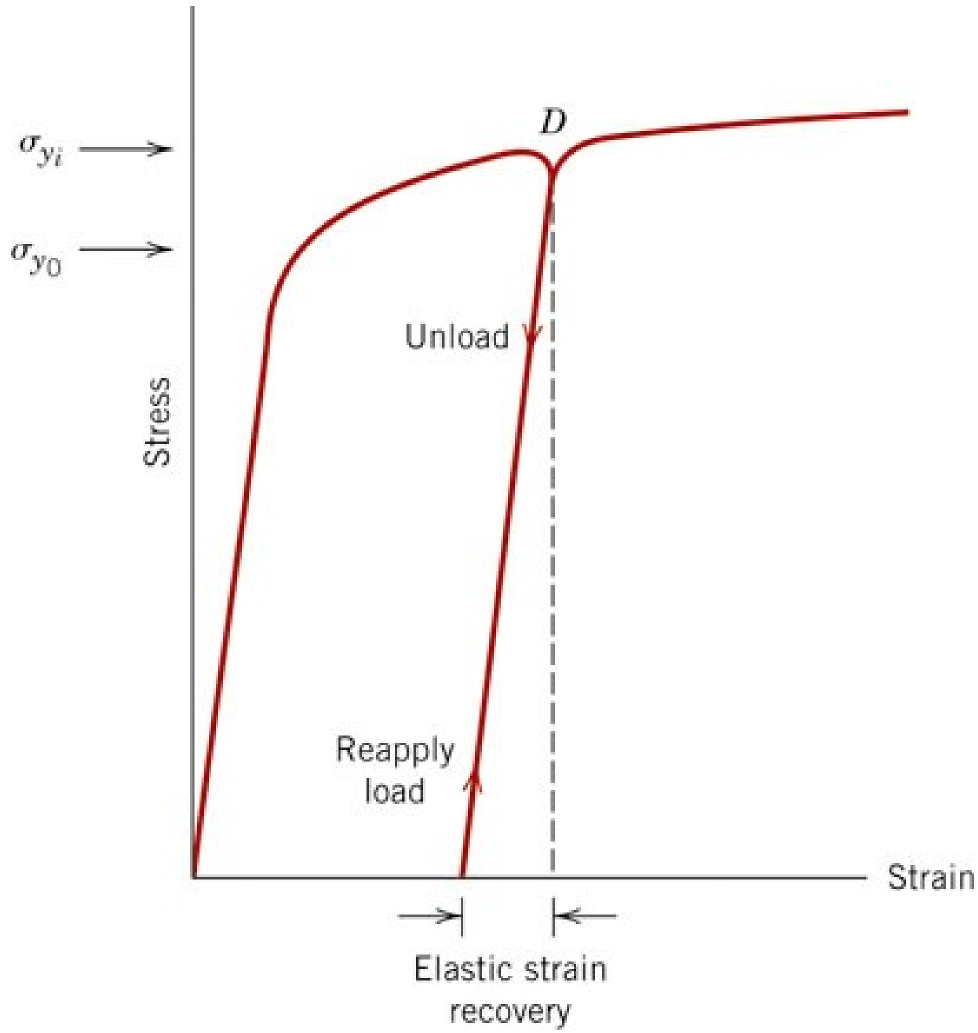
*Nonrecoverable strain (plastic)



Slope of Recovery Line



Unload/Reload



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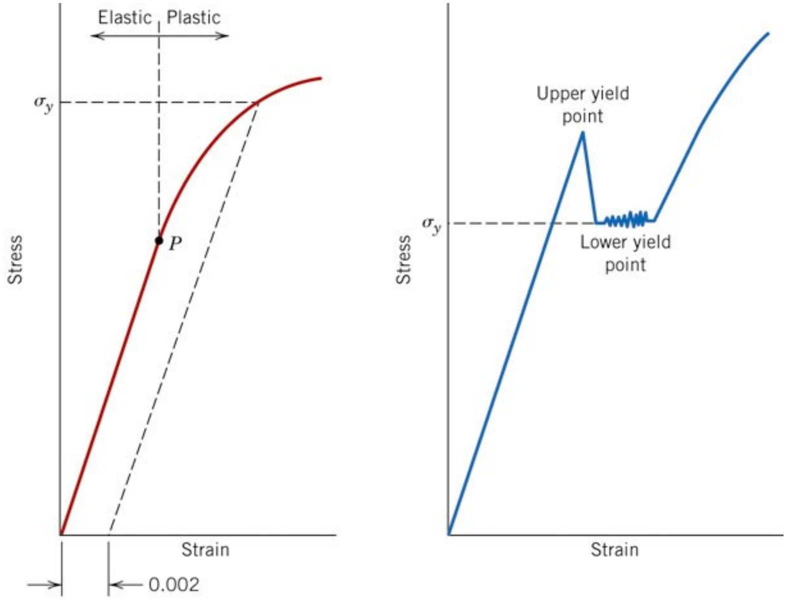
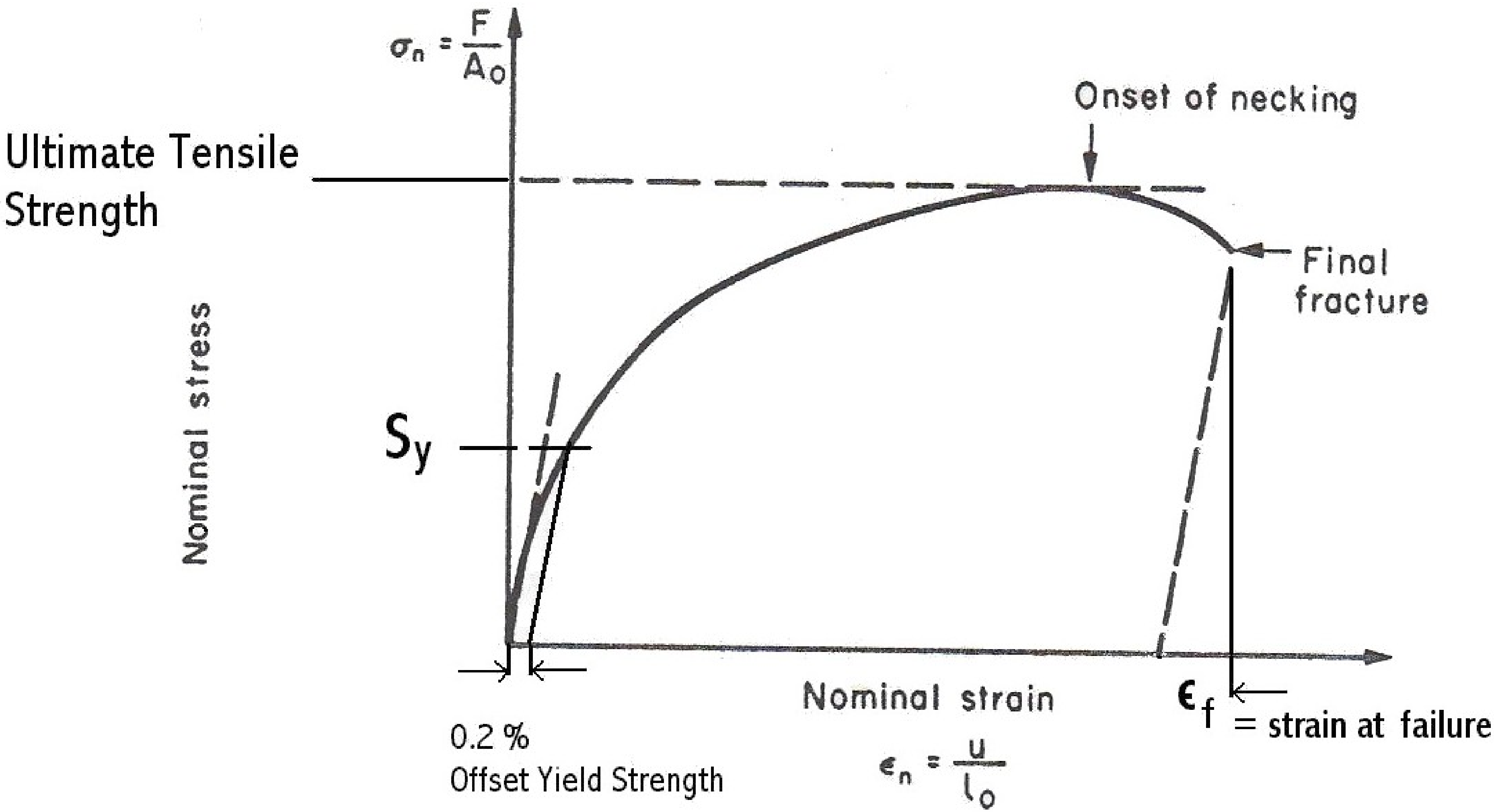
Yield Strength from S-e Curve



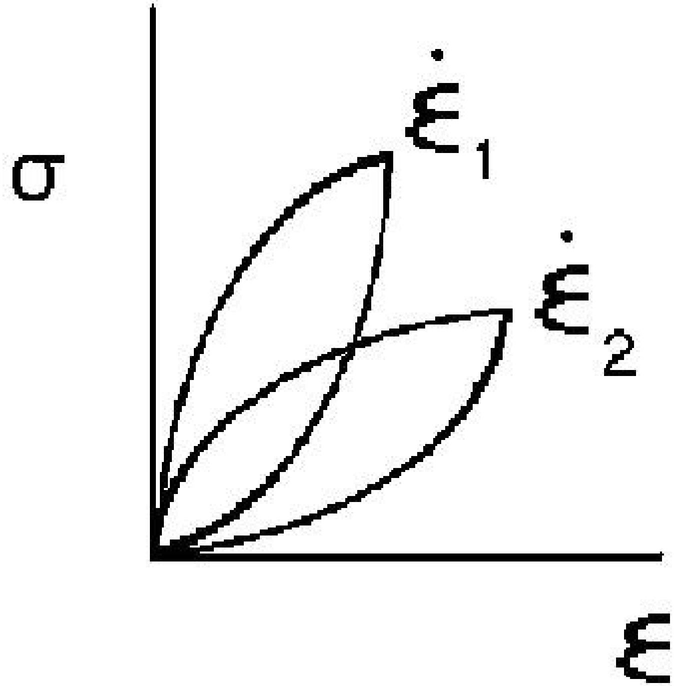
(a) (b)

Everything Together



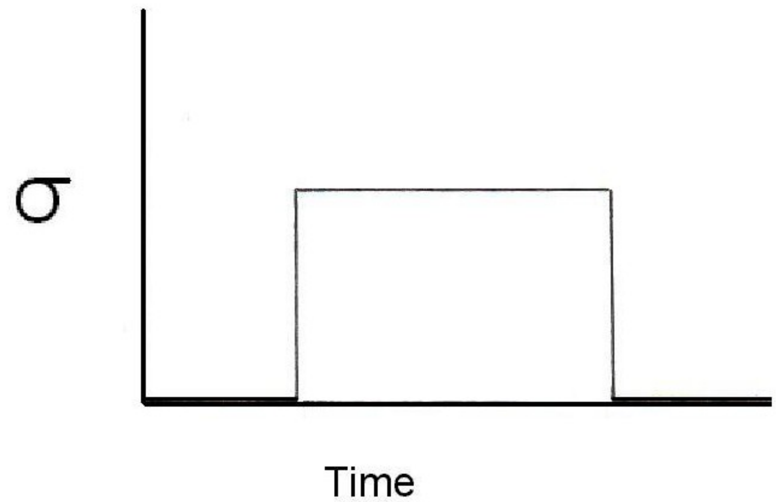
What is Viscoelastic Deformation?

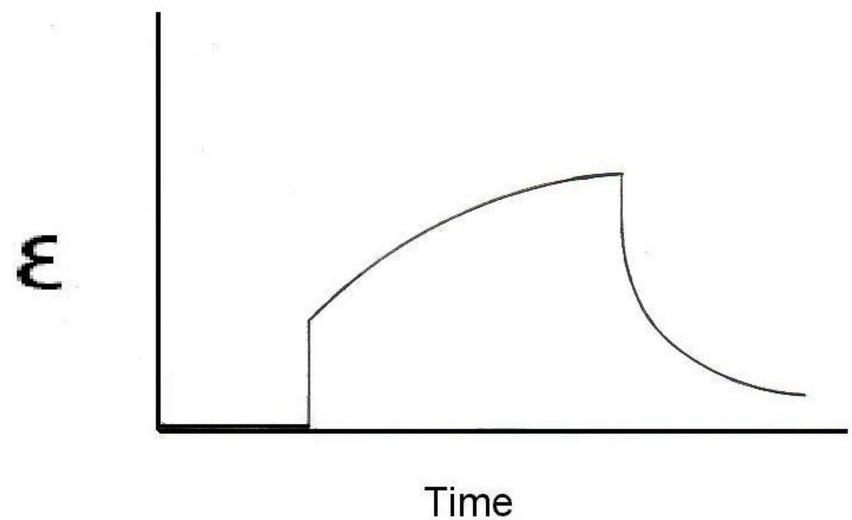
Viscoelastic : Time
Dependant



$\dot{\varepsilon}_1 > \dot{\varepsilon}_2$

Creep Test Viscoelasticity





Deformation Types

Name	Math Model	Time Dependency	Type
Elastic	Linear/Nonlinear	None	Recoverable
Plastic	Linear/Nonlinear	None	Nonrecoverable
Viscoelastic	Linear/Nonlinear	Strong	Recoverable
Viscoplastic	Nonlinear	Strong	Nonrecoverable

Representative Modulii

Material	Modulus (psi)
Aluminum	10x10^6
Steel	30x10^6
Polycarbonate	300 x 10^3