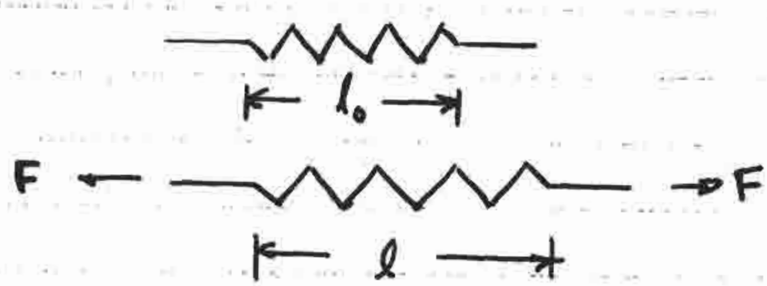
MATERIALS IN NATURE

MATERIAL PROPERTIES

HOOKE'S LAW:



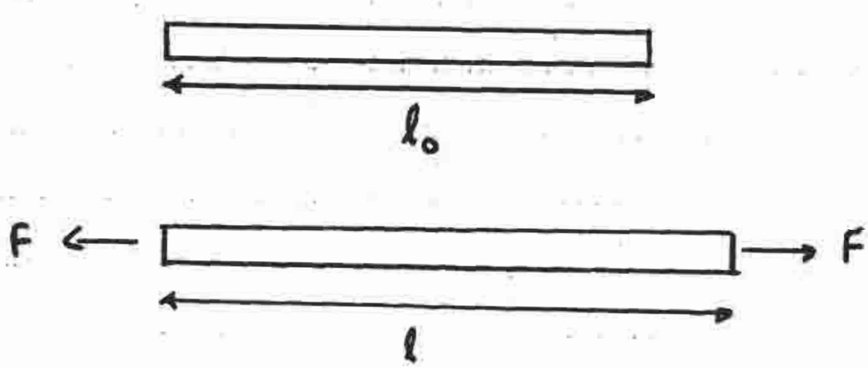
$F = 0$

F

$x = l - l_0$

$F = k\,x$ $\qquad$ K = SPRING CONSTANT

FOR MANY MATERIALS, HOOKE'S LAW APPLIES

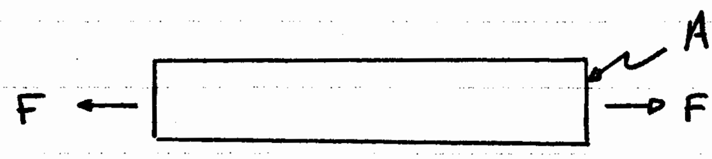


$F = k'\,\delta$ $\qquad$ $\delta = l - l_0$

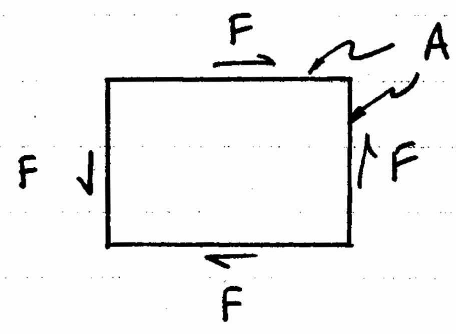
DEFINE STRESS, STRAIN

STRESS = FORCE / AREA

NORMAL STRESS = FORCE / (AREA NORMAL TO FORCE) = σ



SHEAR STRESS = FORCE / (AREA PARALLEL TO FORCE) = τ



UNITS: pounds / square inch = psi

N/m^2 = Pascals = Pa

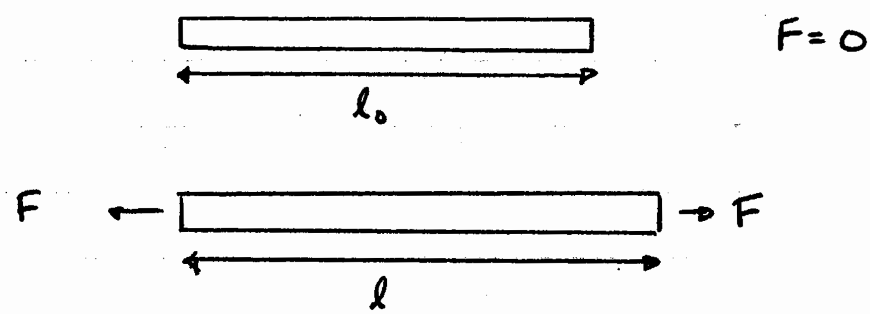
MN/m^2 = 10^6 Pa

GN/m^2 = 10^9 Pa.

DEFINE STRESS, STRAIN

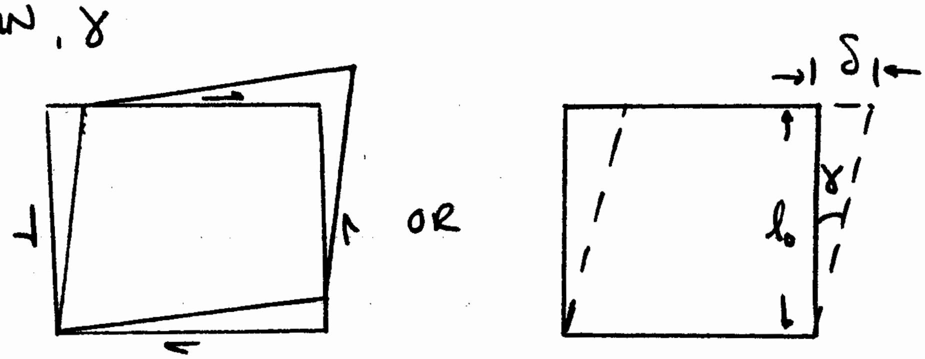
STRAIN = DEFORMATION PER UNIT ORIGINAL LENGTH.
$= \delta / l_0$

NORMAL STRAIN, ϵ



$$\epsilon = \frac{l - l_0}{l_0} = \frac{\delta}{l_0}$$

SHEAR STRAIN, γ



$$\tan \gamma = \frac{\delta}{l_0}$$

$$\gamma = \frac{\delta}{l_0}$$ (SMALL γ, $\tan\gamma = \gamma$)

UNITS (-)

YOUNG'S MODULUS

HOOKE'S LAW FOR LINEAR ELASTIC SOLIDS:

$$F = k x$$

$$\frac{F}{A} = k' \frac{\delta}{l_0}$$

$\sigma = E \epsilon$ $\quad$ E = YOUNG'S MODULUS

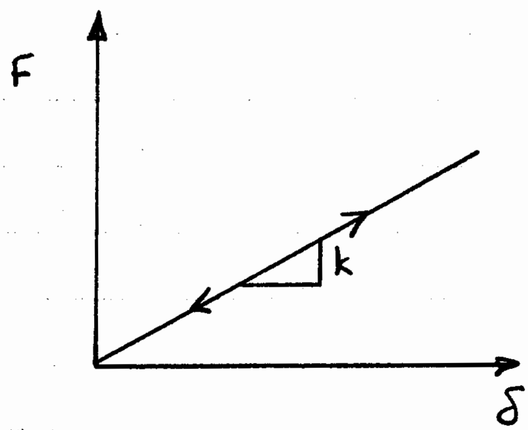
OR $\tau = G \gamma$ $\quad$ G = SHEAR MODULUS

E, G UNITS: 10^6 psi, GPa

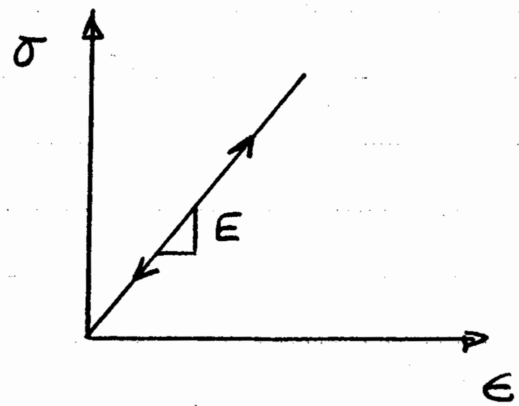
eg.	Steel	30×10^6 psi	210 GPa
	Aluminum	10×10^6 psi	70 GPa
	Glass	10×10^6 psi	70 GPa
	Wood	1×10^6 psi	7 GPa.

YOUNG'S MODULUS IS A MEASURE OF A MATERIAL'S <u>STIFFNESS</u>.

YOUNG'S MODULUS



$F = k\delta$



$\sigma = E\epsilon$

LINEAR : FORCE + DISPLACEMENT LINEARLY RELATED

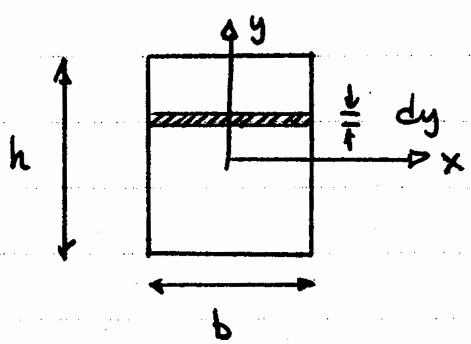
ELASTIC : DISPLACEMENT IS COMPLETELY RECOVERABLE, INSTANTANEOUSLY

SECTION GEOMETRY.

(i) AREA, A

(ii) MOMENT OF INERTIA (SECOND MOMENT OF AREA), I

$$I_{xx} = \int_A y^2 \, dA$$



$$dA = b\,dy$$

$$I_{xx} = \int_{-h/2}^{h/2} y^2 \, b \, dy$$

$$= \frac{by^3}{3} \Big|_{-h/2}^{h/2}$$

$$= \frac{b}{3} \left[\left(\frac{h}{2}\right)^3 - \left(-\frac{h}{2}\right)^3 \right]$$

$$= \frac{b}{3} \left(\frac{h^3}{8} + \frac{h^3}{8} \right)$$

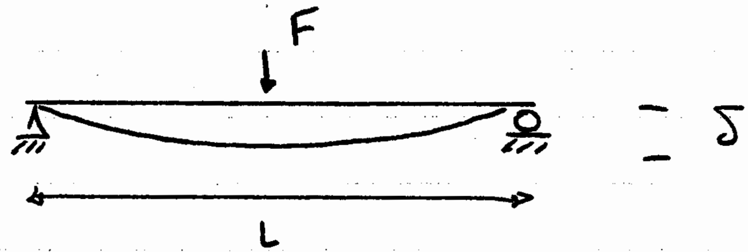
$$I_{xx} = \frac{bh^3}{12}$$

⇒ BEAM BENDING

⇒ COLUMN BUCKLING.

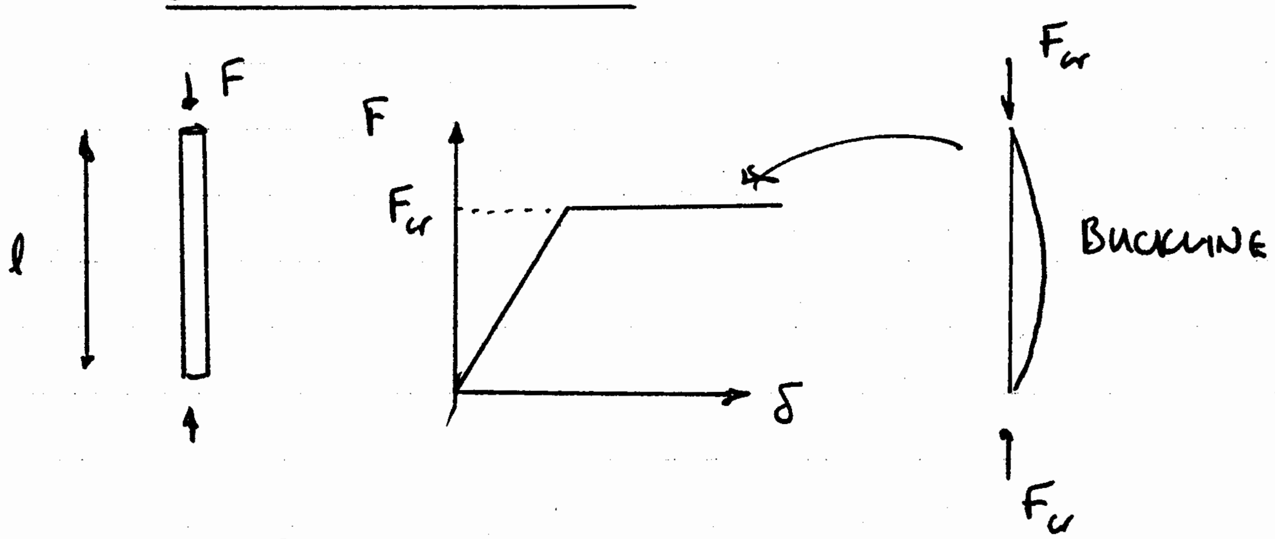
MOMENT OF INERTIA IMPT IN

BEAM BENDING :



$$\delta = \frac{F L^3}{48 E I}$$

COLUMN BUCKLING :



$$F_{cr} = \frac{\pi^2 E I}{l^2}$$