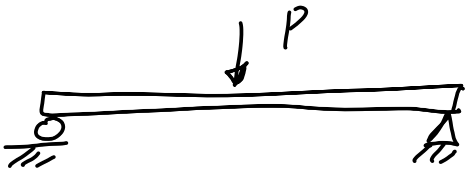
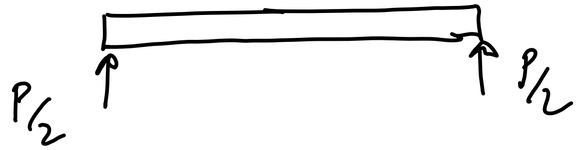
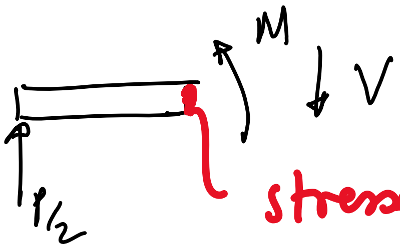
Stress



FBD



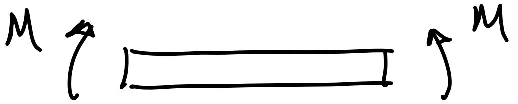
FBD for
M, V



stresses here?

V — induces shear stress

M — induces normal stress (?)

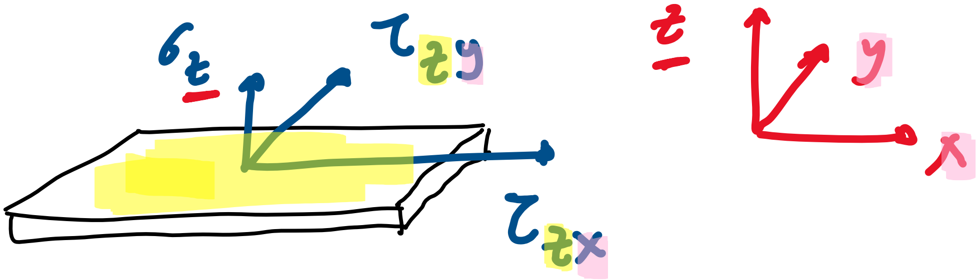


same units

{ σ — normal stress (due to M)
{ τ — shear stress (due to V)

SI — N/m²
FPS — pounds per sq. inch (psi)

Cartesian stresses

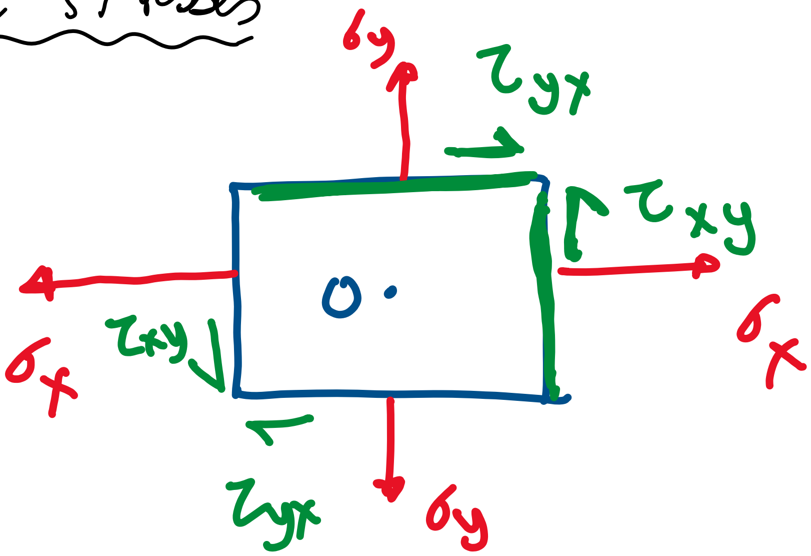


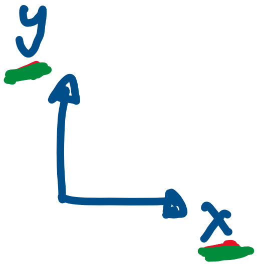
$$\tau_{ij}$$

direction of shear force/stress

normal to the plane

Plane ~~st~~resses





It can be shown that $\boxed{\tau_{xy} = \tau_{yx}}$

Complementary Shear

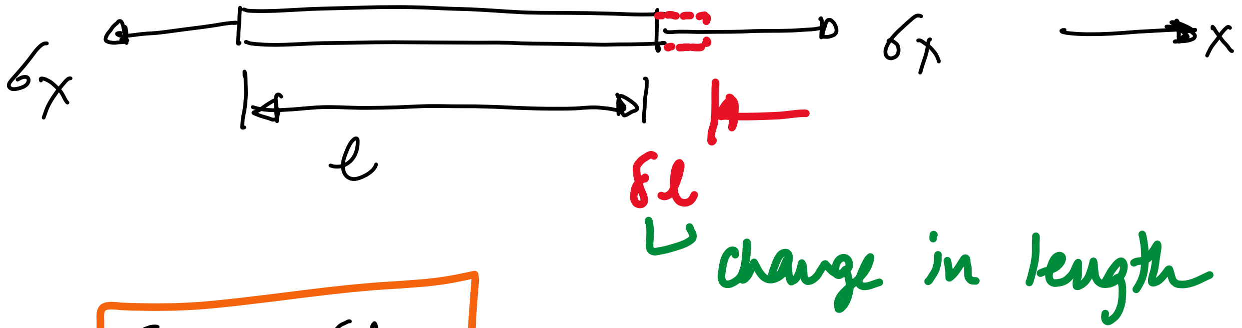
For a plane stress element

$$\boxed{\sigma_x, \; \sigma_y, \; \tau_{xy} = \tau_{yx}}$$

Only 3 stresses NOT 4

Elastic Strain (ε)

1-D stress case



$$\boxed{\begin{aligned} \varepsilon_x &= \frac{\delta l}{l} \\ \sigma_x &= E\ \varepsilon_x \end{aligned}}$$

E = Young's modulus
(material constant)

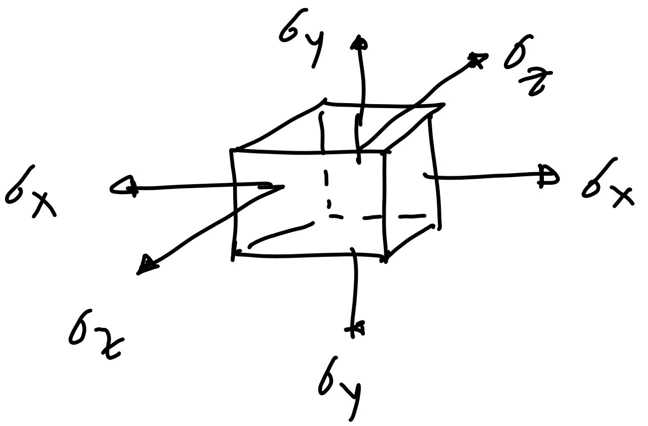
$$\boxed{\begin{aligned} \varepsilon_y &= -\nu\ \varepsilon_x \\ \varepsilon_z &= -\nu\ \varepsilon_x \end{aligned}}$$

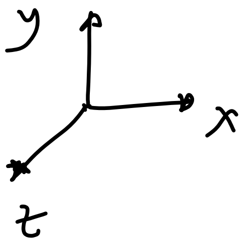
ν - Poisson's Ratio
(non-dimensional constant)

If the material stretches in the x-direction, it will contract in the y and z direction

Generalization to 3D

3D stress case



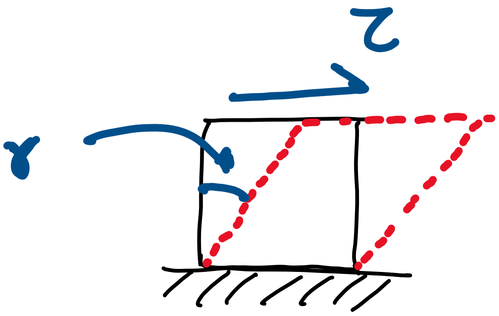


σ — normal stress
ε — strain

$$\boxed{\begin{aligned}\varepsilon_x &= \frac{1}{E}\left\{\sigma_x - \nu(\sigma_y+\sigma_z)\right\}\\ \varepsilon_y &= \frac{1}{E}\left\{\sigma_y - \nu(\sigma_x+\sigma_z)\right\}\\ \varepsilon_z &= \frac{1}{E}\left\{\sigma_z - \nu(\sigma_x+\sigma_y)\right\}\end{aligned}}$$

E — Young's modulus
ν — Poisson's ratio

Shear strain



γ - shear strain

$$\boxed{\gamma = \frac{\tau}{G}}$$

G = modulus of rigidity
or
Shear modulus

$$\boxed{E = 2G(1 + \nu)}$$