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Equilibrium and Elasticity

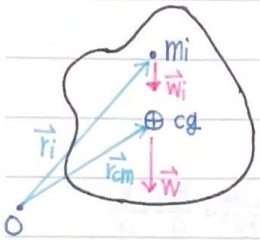
Conditions for Equilibrium

First condition for equilibrium $\Sigma \vec{F} = 0$

Second condition for equilibrium $\Sigma \vec{\tau} = 0$

Center of Gravity

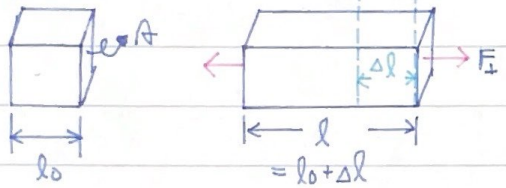
$x_{cm} = \frac{\Sigma m_i x_i}{\Sigma m_i}$ $y_{cm} = \frac{\Sigma m_i y_i}{\Sigma m_i}$ $z_{cm} = \frac{\Sigma m_i z_i}{\Sigma m_i}$, $\vec{r}_{cm} = \frac{\Sigma m_i \vec{r}_i}{\Sigma m_i}$



$\vec{\tau}_i = \vec{r}_i \times \vec{w}_i = \vec{r}_i \times m_i \vec{g}$, $\vec{\tau} = (\sum_i m_i \vec{r}_i) \times \vec{g} = \frac{\Sigma m_i \vec{r}_i}{\Sigma m_i} M\vec{g}$ which $\sum_i m_i = M$

$= \vec{r}_{cm} \times M\vec{g}$ $= \vec{r}_{cm} \times \vec{w}$

Stress, Strain, and Elastic Moduli



tensile stress $= \frac{F_\perp}{A}$

tensile strain $= \frac{l - l_0}{l_0} = \frac{\Delta l}{l_0}$

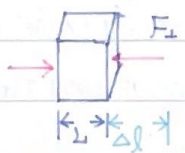
$Y = \frac{\text{tensile stress}}{\text{tensile strain}} = \frac{F_\perp / A}{\Delta l / l_0} = \frac{F_\perp}{A} \frac{l_0}{\Delta l}$

Young's modulus

stress: strength of the forces causing the defomation

strain : resulting deformation

under compressive stress



compressive stress $\frac{F_\perp}{A}$

compressive strain $\frac{\Delta l}{l_0}$

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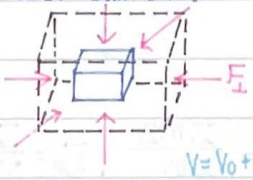
bulk stress (volume stress) and bulk strain (volume strain)

pressure in a fluid = $\frac{F_\perp}{A}$

bulk strain = $\frac{\Delta V}{V_0}$

initial

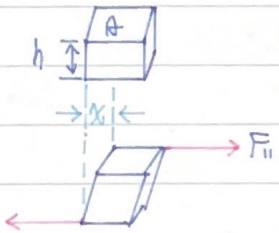
under bulk stress



B, bulk modulus $= -\frac{\Delta P}{\frac{\Delta V}{V_0}}$

$k = \frac{1}{B} = -\frac{1}{V_0}\frac{\Delta V}{\Delta P}$ compressibility

shear stress and strain

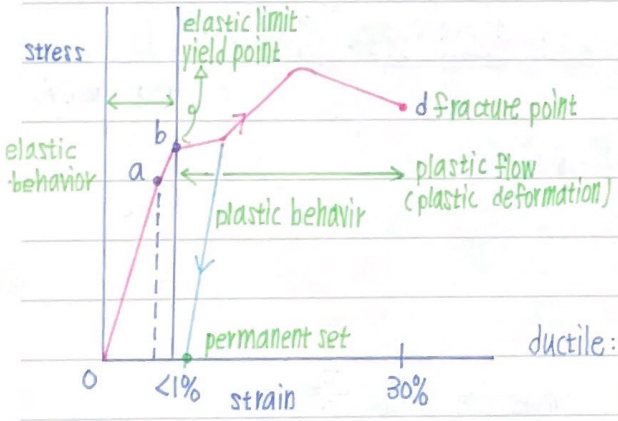


shear stress = $\frac{F_\parallel}{A}$

shear strain = $\frac{x}{h}$

shear modulus, $S = \frac{F_\parallel / A}{x/h} = \frac{F_\parallel}{A}\frac{h}{x}$

Elasticity and Plasticity



ductile: a large amount of plastic deformation take place between the elastic limit and the fracture point

brittle: fracture occurs soon after the elastic limit is passed

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