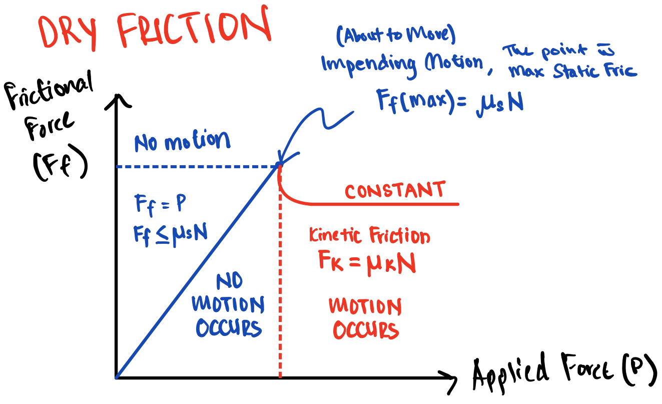
STATICS

BY RIFDY, FOR ZAMIR

DRY FRICTION



NORMAL STRAIN

$$\text{Strain} = \frac{\Delta \text{ length}}{\text{Original length}} = \frac{\delta \text{ (m)}}{L \text{ (m)}}$$

enlongation → Δ length

Strain has no units

NORMAL STRESS

$$\text{Stress} = \frac{\text{Force (N)}}{\text{Area } (m^2)}$$

← ⊥ AREA

MODULUS OF ELASTICITY

$$\text{Modulus} = \frac{\text{Stress}}{\text{Strain}}$$

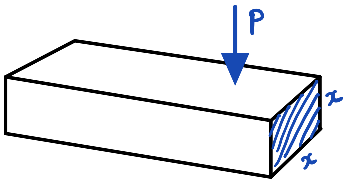
HOOKE'S LAW

$\sigma = E\varepsilon$

$E = \sigma/\varepsilon$

E: Young's Modulus
σ: Stress
ε: Strain

SHEAR STRESS



$$\sigma = \frac{\text{FORCE}}{/\!/ \text{ AREA}} = P/x^2$$

- SHEAR MODULUS – MODULUS OF RIGIDITY

$$G = \frac{\text{Stress}}{\text{Strain}} = \sigma_s/\varepsilon_s$$

DIFFERENT FORMS OF EQNS

$$E = \frac{\sigma}{\varepsilon} = \frac{(P/A)}{(\delta/L)} = \frac{P}{A} \times \frac{L}{\delta} = \frac{PL}{A\delta}$$

Change in length (Deformation) : $\delta = PL/AE$

OA (HOOKE'S LAW)

- Gradient of line measure the stiffness of material
- A is limit of proportionality
- Point used to find Young's Modulus

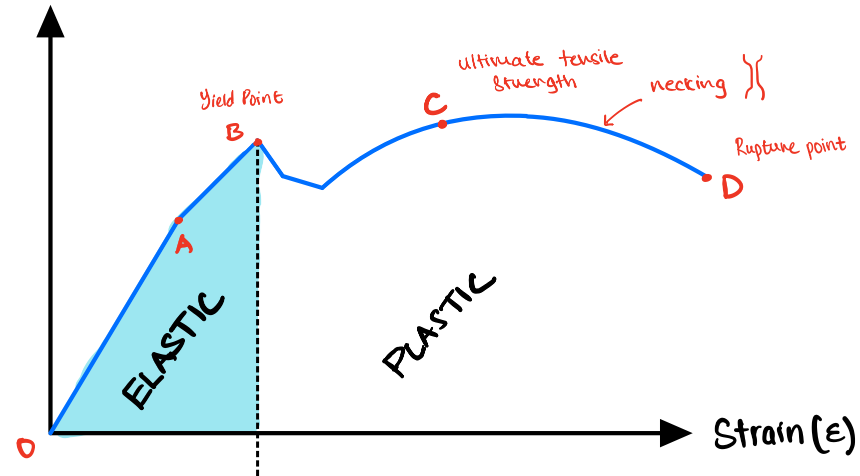
$E = \sigma/\varepsilon$

AB

- Elastic limit lie between it
- B is yield point
- yeild stress or yield strength
- After point B it will go into plastic region, Plastic → length of material will not go back to original length, Permanent deformation

BC

- Plastic Extension w̄ increasing Load
- C is ultimate point, ultimate tensile stress
- C, tensile sample begin to neck



CD

- CD is plastic extension w̄ decreasing load
- D is fracture | rupture point

HIGHER E → STIFFER
(higher gradient)

MEASURE OF DUCTILITY

$$\% \text{ Elongation} = \frac{\delta}{L_o} \times 100\%$$

$$\% \text{ Reduction in Area} = \frac{A_o - A_f}{A_o} \times 100\%$$

Area under graph → Toughness

Area ▬ → Resilience

Stiffness : higher gradient → stiffer material

Elasticity : 0 → yeild pt : return to original length

Ductility : look at where it rupture

m1 more Ductile → rubber

m2 more Brittle → glass

Malleability : ability to flatten material

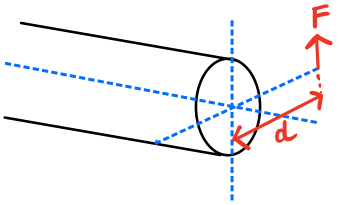
Brittle : Break w/o warning

Toughness : Area under graph → material able to endure high impact

TORSION

For equilibrium, the internal resisting torque = external torque

EXTERAL TORQUE



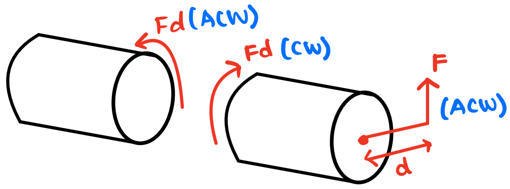
TORQUE = F · d

% Torsional Strength lost

$T_{(all)} \propto J$

$$= \frac{J_S - J_H}{J_S} \times 100\%$$

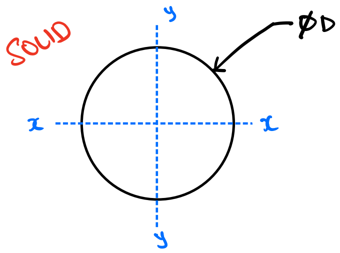
INTERAL TORQUE

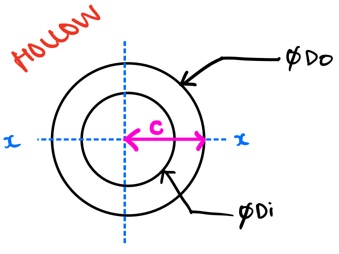


When calculating τ for different ∅ and segment, use internal torque as T in $\tau = Tc/J$

POLAR MOMENT OF INERTIA, J

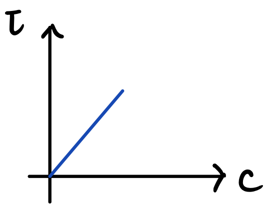
- Larger J, more resistant to torsion



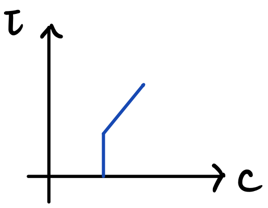


$$J = \frac{\pi D^4}{32}$$

$$J = \frac{\pi (D_o^4 - D_i^4)}{32}$$



SOLID



HOLLOW

TORSIONAL SHEAR STRESS

$$\tau = \frac{Tc}{J}$$

Torsional Shear Stress (Pa)

Applied Twisting Torque (Nm)

Dist from shaft axis to shear area (m)

Polar moment of inertia (m^4)

- $\tau \propto c$
- max shear stress at outer diameter
- $\tau = 0$, when there is no material (hollow area)
- finding d, $d = \sqrt[3]{16T/\pi\tau}$

ANGLE OF TWIST

$\phi = TL / JG$

$\phi = TL / \frac{\pi d^4}{32} G$

$d = \sqrt[4]{\frac{32TL}{\pi \phi G}}$

T: Torque (Nm)
L: length (m)
J: (m^4)
G: Usually GPa

POWER IN TORSION

Power = $T\omega$ OR $2\pi T N_r / 60$

T = torque (Nm) N_r = rpm

ω = angular rotation per second (rad/s)

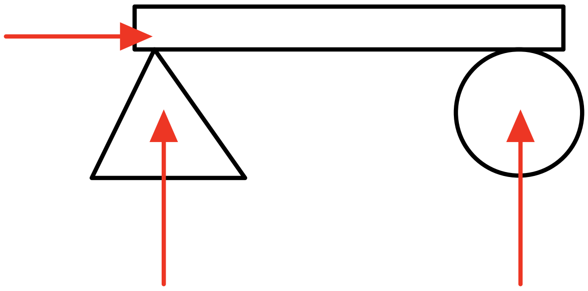
$\omega = \frac{2\pi N_r}{60}$

units : Watts OR J/s

BENDING

Simply Supported Beam

- Shear force = 0, Bending Moment Maximum



Cantilever Beam

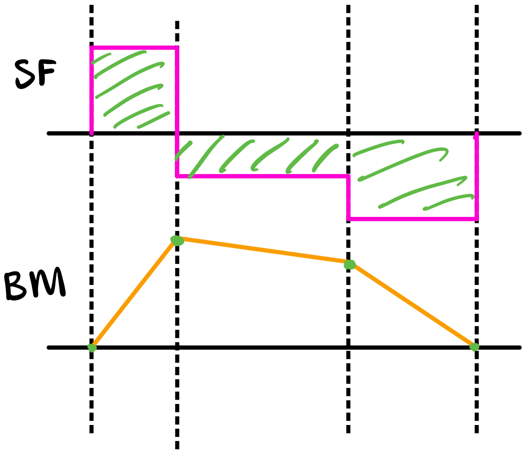
- Shear for maximum at fixed end
- Bending moment maximum at fixed end

SHEAR FORCE DIAGRAM

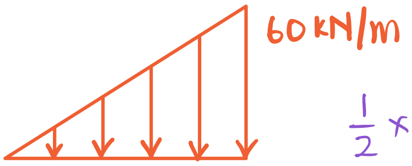
- Follow the Forces of Y components

BENDING MOMENT DIAGRAM

- Area of the Shear force diagram



BENDING STRESS = $\sigma = My / I_x$



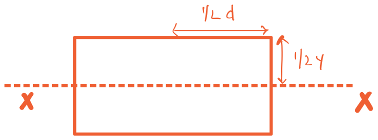
$\frac{1}{2} \times 3 \times 60 = 90KN$

M: moment about centrodial axis

y: ⊥ distance to centroidal axis

I_x: Area moment of inertia about the centrodial axis

↳ measure of the ability of the cross sectional area to resist bending (Larger I, more resistant to bending)



$\frac{bh^3}{12}$ = Centroidal Axis

b → // to x-x, d
h → y