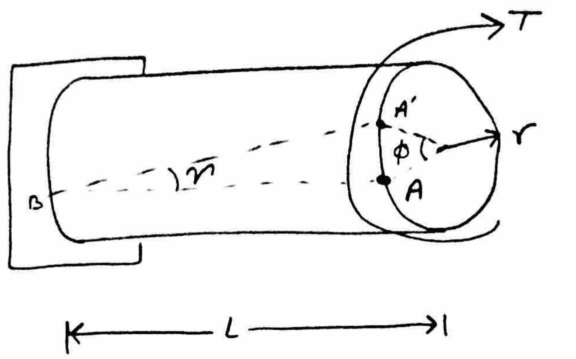
* Torsion Test

T: Torque (N.m)
L: Length (m)
r: Radius (m)



Shear stress (τ)

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

, J : Polar moment of inertia (m^4) $J = \frac{1}{2}\pi r^4$

Angle of twist (ϕ)

$$\phi = \frac{TL}{GJ}$$

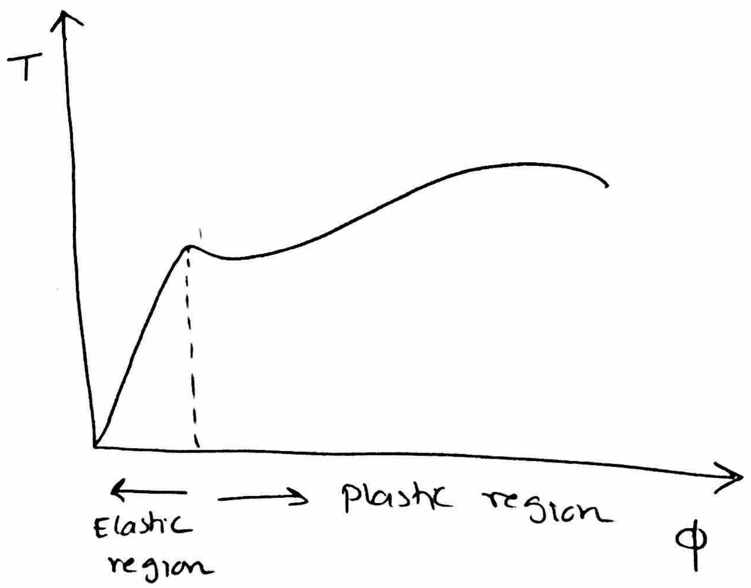
, G: Shear modulus.

shear strain (γ)

$$\gamma = \frac{r\phi}{L}$$

Load-defection Curve

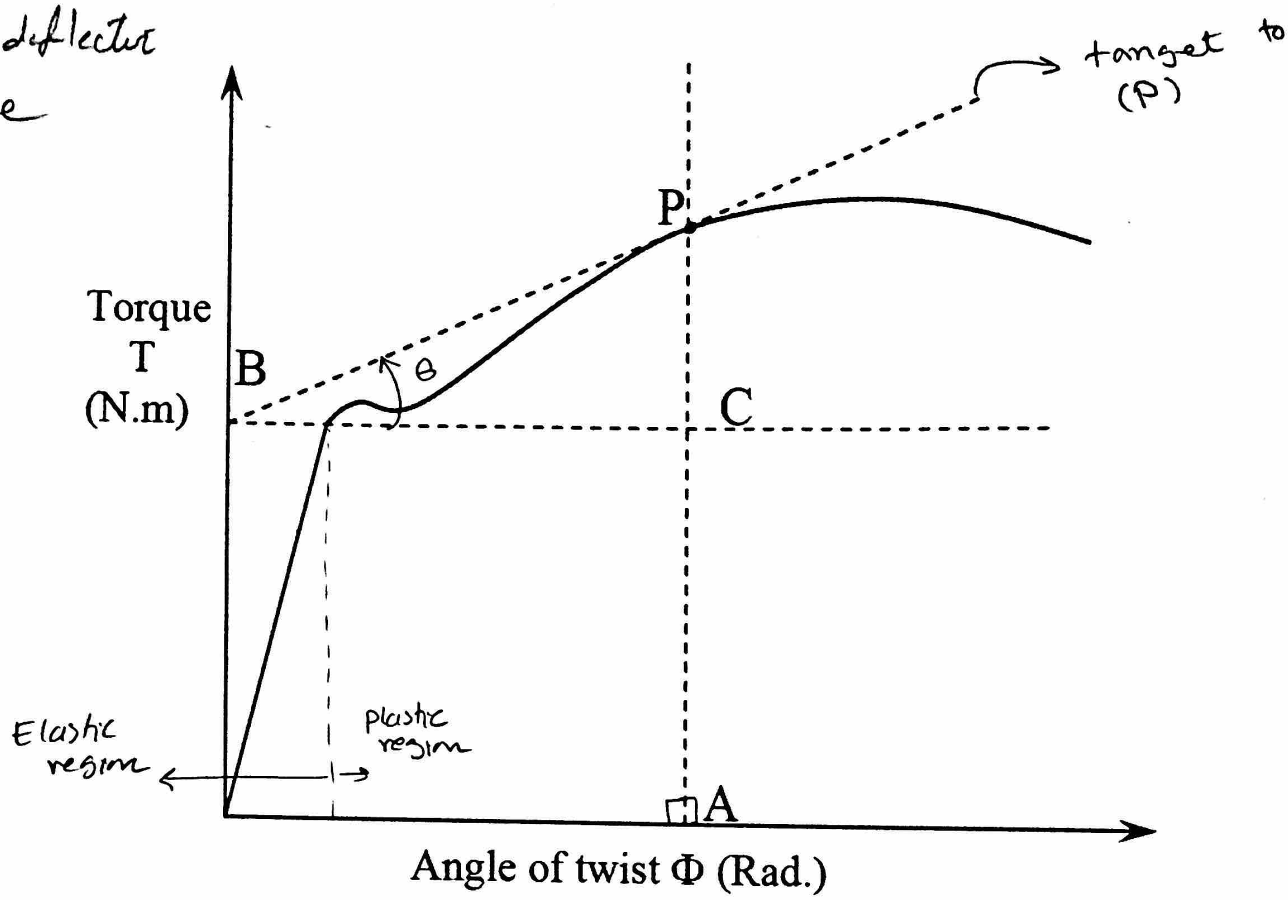
Increase T
$\Rightarrow$ $\phi \uparrow$



- How to transform to τ, γ curve

In elastic region, $\tau = \frac{Tr}{J}$ and $\gamma = \frac{r\phi}{L}$

Load-deflection curve



In plastic region

Shear stress

$$\tau = \frac{1}{2\pi r^3}\left(\phi \frac{dT}{d\phi} + 3T\right)$$

, $\frac{dT}{d\phi}$ Torque change with respect to ϕ

At point P, for example

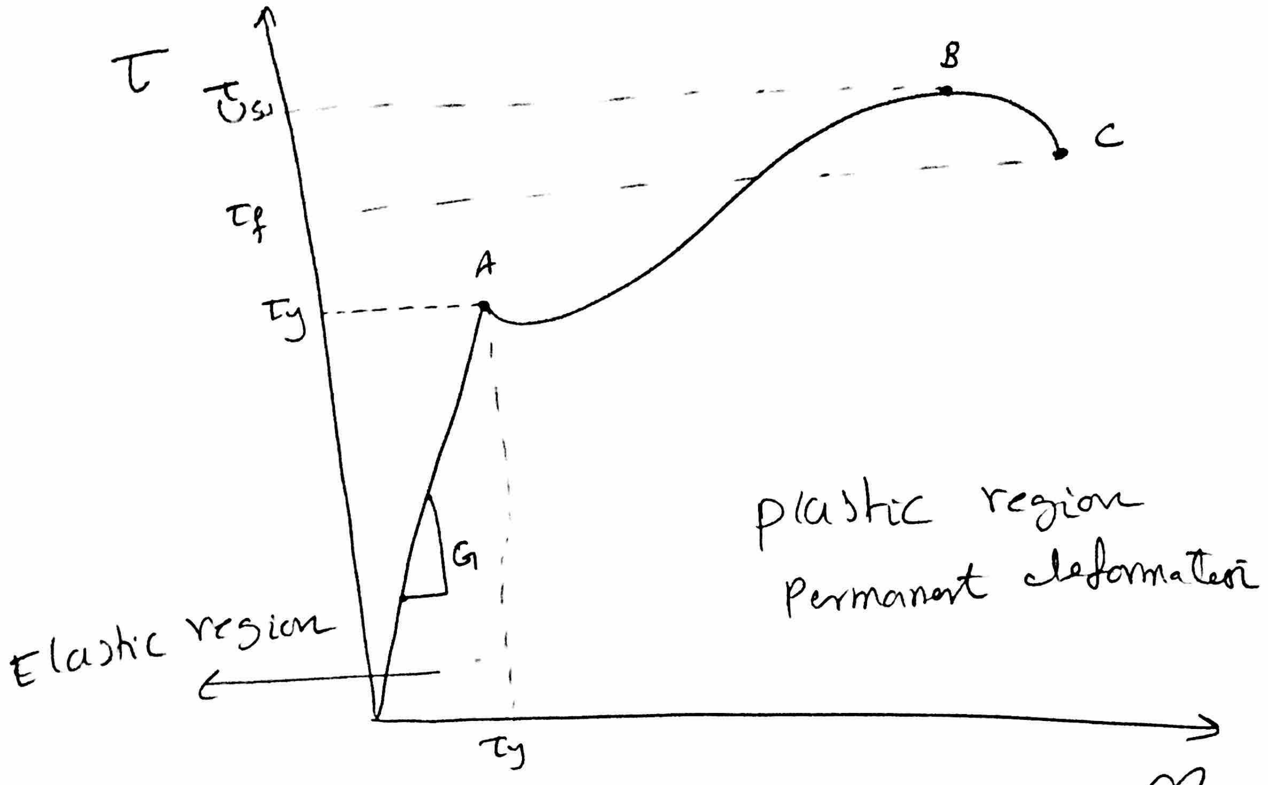
$\phi = BC$, $T = AP$, $\frac{dT}{d\phi} = ?$

$$\frac{dT}{d\phi} = \text{slope} = \tan\theta = \frac{PC}{BC}$$

$$\tau = \frac{1}{2\pi r^3}\left(BC\,\frac{PC}{BC} + 3AP\right) \Rightarrow \tau = \frac{PC + 3AP}{2\pi r^3}$$

Shear strain (γ)

$$\gamma = \frac{r\phi}{L}$$



Shear stress - strain curve

point (A) → Yield shear point (Yield shear stress = τ_y)

point (B) → Ulimate shear stress (τ_{uss})

point (C) → Fracture (rupture) shear stress τ_f

Slope linear part → G: Shear modulus

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

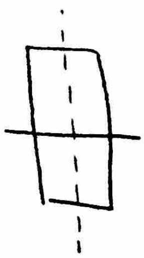
Modulus of resilience (U_{RS}) = area under elastic region

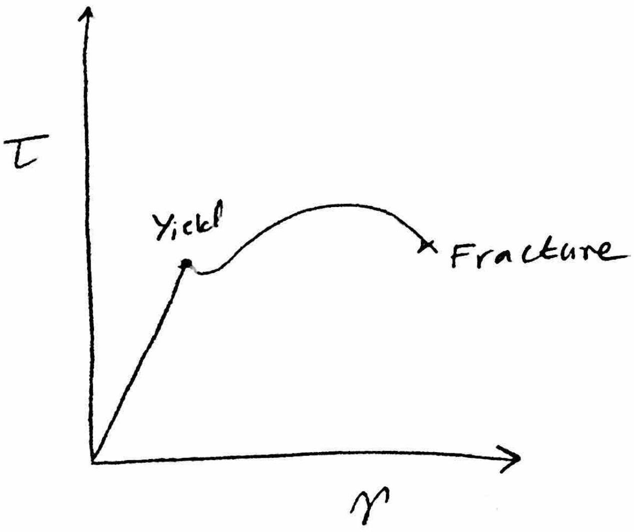
Modulus of Toughness (U_{TS}) = area under τ-γ curve

Ductile / Brittle materials

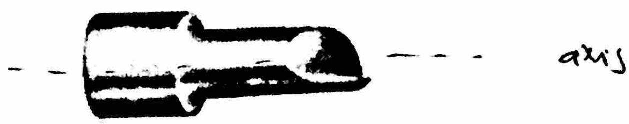
Ductile

Surface 90°
From axis

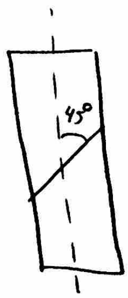


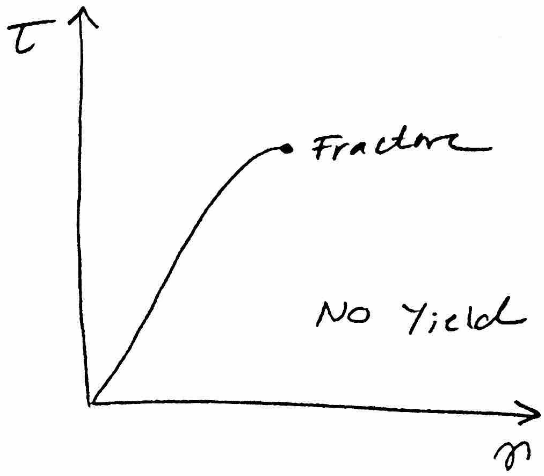


Brittle



Surface 45°
from axis





*** What will we do in the lab?**

Torsion test → T, ϕ data → τ, γ data (elastic / plastic regions)

Find

1. τ_y
2. τ_{uss}
3. τ_f
4. U_{RS}, U_{RT}
5. Shear modulus (G)