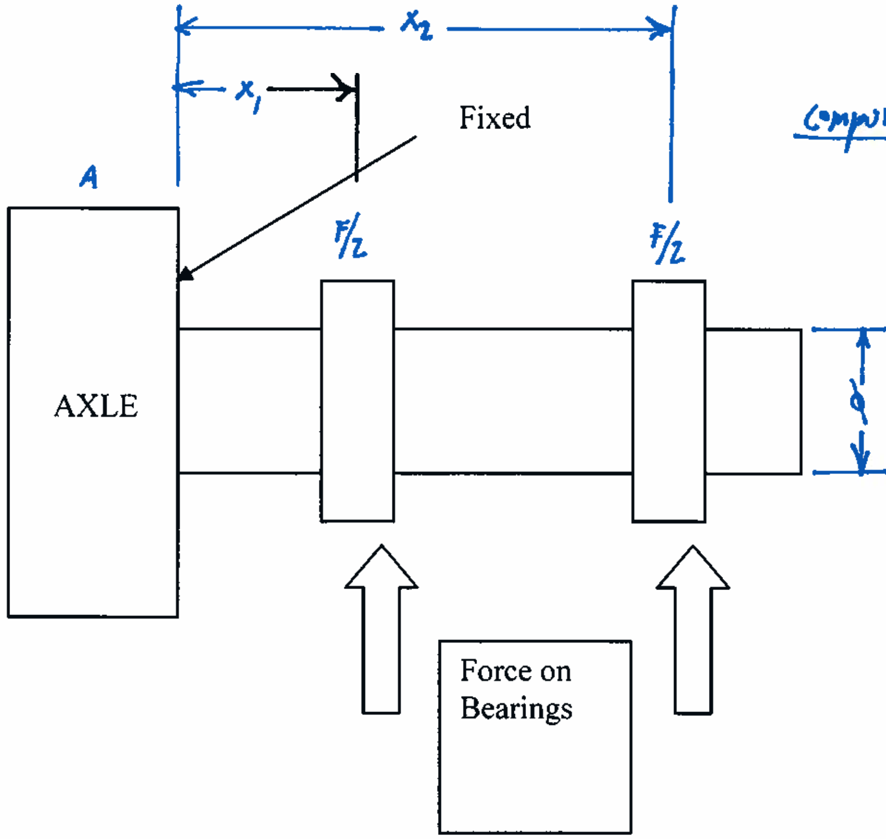
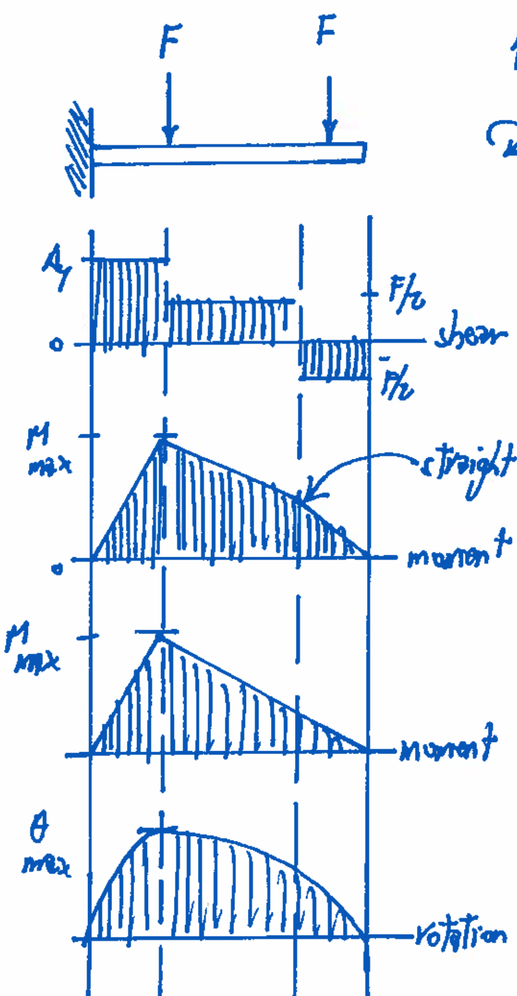
compute stress and size the shaft ϕ





$$\uparrow \Sigma F_y = 0 = A_y - \frac{F}{2} - \frac{F}{2} \Rightarrow \underline{\underline{A_y = F\,(\downarrow)}}$$

$$\circlearrowleft \Sigma_A M = 0 = M_A - x_1\left(\frac{F}{2}\right) - x_2\left(\frac{F}{2}\right) \Rightarrow M_A = (x_2 - x_1)\frac{F}{2}$$

$$\sigma = \frac{Mc}{I} \;\forall\; I = \frac{1}{64}\pi\phi^4 \;\wedge\; c = \frac{\phi}{2}$$

$$\sigma = \frac{(x_2 - x_1)\,F/2 \cdot \phi/2}{\frac{\pi}{64}\phi^4} = \frac{16(x_2 - x_1)F}{\pi\phi^3}$$

$$\therefore \sigma = \frac{16(x_2 - x_1)F}{\pi\phi^3}$$ stress at axle support

- Compare this to material strength, σ_y which is a known.
- factor of safety: $FoS = \frac{\sigma_y}{\sigma}$.
- you can set FoS to compute σ and given σ_y, size the shaft.

$$\frac{\sigma_y}{FoS} = \frac{16(x_2 - x_1)F}{\pi\phi^3} \Rightarrow \phi = \sqrt[3]{\frac{16(x_2 - x_1)F}{\pi\sigma_y} \cdot FoS}.$$

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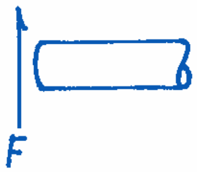
shear

$$\tau = \frac{F}{A} = \frac{F}{\frac{\pi}{4}\phi^2} \equiv \frac{4F}{\pi\phi^2}. \qquad \therefore \ \tau = \frac{4F}{\pi\phi^2}$$

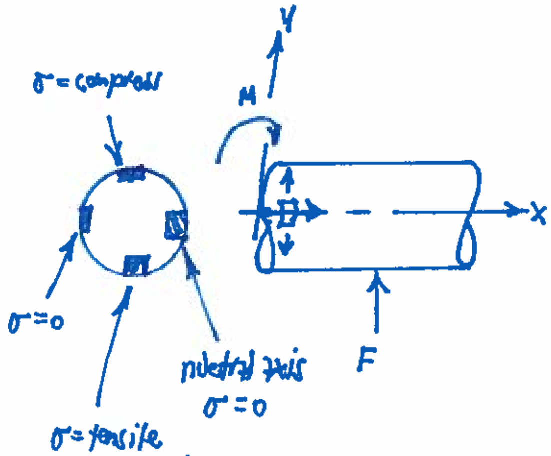


- simple shear acts to cut the shaft at the support, one plane only!

Mohr's Circle

$$\sigma_{min\ max} = \frac{\sigma_x+\sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

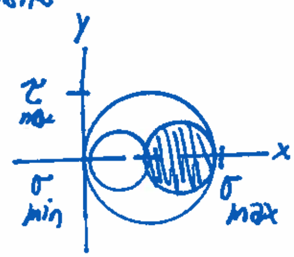
$$\tan 2\theta = \frac{\sigma_x-\sigma_y}{2\tau_{xy}}.$$



$\sigma_y = 0$, $\sigma_x = \frac{16(x_2-x_1)F}{\pi\phi^3}$, $\tau_{xy} = \frac{4F}{\pi\phi^2}$, are input values.

$$\sigma_{max\ min} = \frac{16(x_2-x_1)F}{2\phi^3\pi} \pm \sqrt{\left(\frac{16(x_2-x_1)F}{\pi\phi^3}\right)^2 + \left(\frac{4F}{\pi\phi^2}\right)^2} \qquad \underline{\text{equation A}}$$

$$2\theta = \tan^{-1}\left(\frac{-16(x_2-x_1)F}{\pi\phi^3} \cdot \frac{\pi\phi^2}{2\cdot 4F}\right)$$



$$m\angle\theta = \frac{1}{2}\tan^{-1}\left(\frac{-2(x_2-x_1)F}{F\cdot\phi}\right) \qquad \underline{\text{equation B}}$$

- So you can get σ_{min} as the "−" and σ_{max} as the "+" from eq^{n} A
- the deformation of wall element is $m\angle\theta$; gives an idea of shear role in the problem.
- at the neutral axis, stress is zero but shear is max/min.
- 90° off the neutral axis, the wall element experiences compression or tension; but the shear is zero. <u>this is the principle stress.</u>