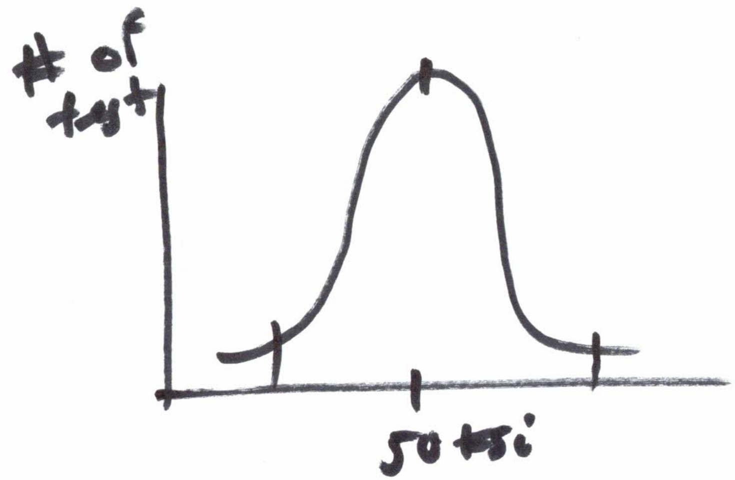
# II Design

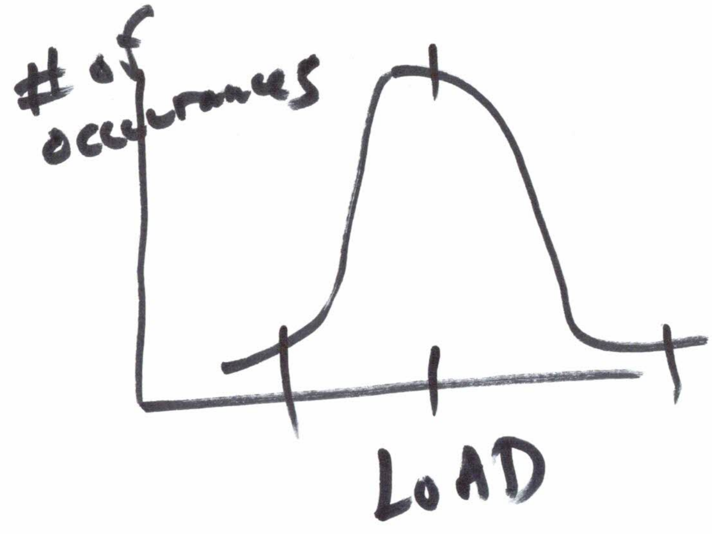
$$\sigma = \frac{F}{A}$$

Design Problem: Find diameter of bar so that it does not yield if $F = 10{,}000$ lbs
$\sigma_{yield} = 50$ ksi

$$A = \frac{F}{\sigma} = \frac{\pi}{4} d^2 = \frac{10{,}000 \text{ lbs}}{50 \times 10^3 \frac{\text{lb}}{\text{in}^2}} = \frac{\pi}{4} d^2$$

$$d = 0.505 \text{ in}$$



Instead of statistical analysis, we will use a 'safety factor' approach to design.

A. Safety factor

1. on stress

$$SF = 2.0 \quad \text{the} \quad \sigma_{allowable} = \frac{\sigma_{failure}}{SF}$$

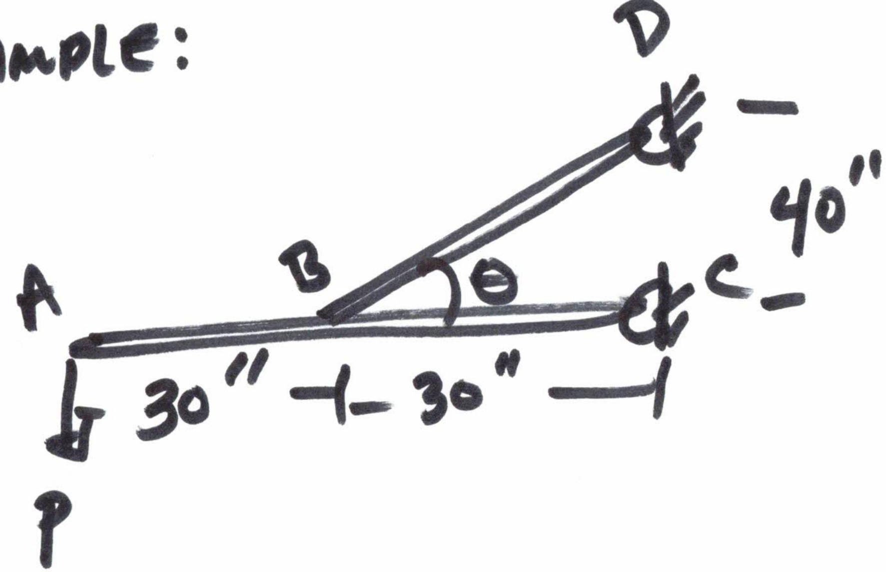
$\sigma_{design}$

$$\sigma_{design} = \frac{50\ ksi}{2.0} = \underline{25\ ksi}$$

$$d = \underline{0.714\ in}$$

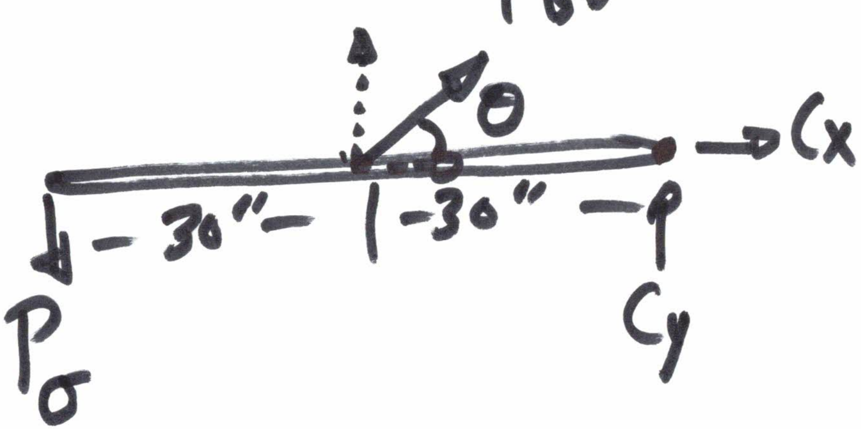
2. safety factor on load

EXAMPLE:

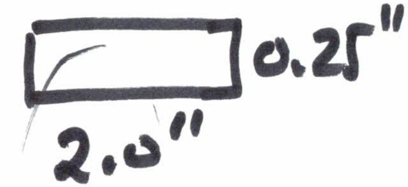



Find max safe load, P

PAR BD




Bar BD




$\sigma_Y = 36$ ksi

$SF_\sigma = 3.0$

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Pin C : Double-shear

$d = 0.375''$

$\tau_{ULT} = 60$ ksi

$SF_C = 3.3$

$$\tan\theta = \frac{40}{30}$$

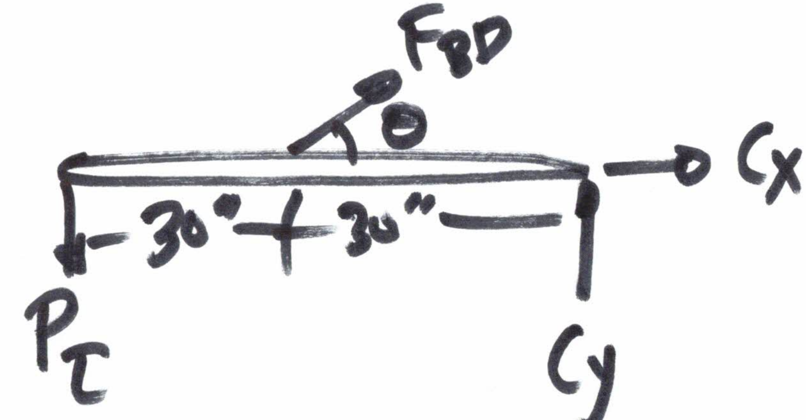
$$\theta = 53.13^\circ$$

$$+\circlearrowleft \Sigma M_C \qquad P_\sigma(60) - F_{BD}\sin\theta\,(30) = 0$$

$$\sigma_{BD} = \frac{F_{BD}}{A_{BD}} = \frac{36\text{ ksi}}{3.0} = \frac{F_{BD}}{(0.25)(2.0)\text{ in}^2}$$

$$P_\sigma(60) - \frac{36{,}000}{3.0}(0.25)(2.0)\sin\theta\,(30) = 0$$

$$\underline{P_\sigma = 2400\text{ lbs}}$$




need to find $C_x$ & $C_y$ in terms of $P_\tau$ & then find Resultant

$\xrightarrow{+}$ $\Sigma F_x$ $\quad C_x + F_{BD}\cos\theta = 0$

$+\uparrow$ $\Sigma F_y$ $\quad -P_\tau + F_{BD}\sin\theta + C_y = 0$

$\Sigma M_C$ $\quad P_\tau\, 60 - F_{BD}\sin\theta\,(30) = 0$

$F_{BD} = 2.5P_\tau \,;\; C_x = -1.5P_\tau \,;\; C_y = -P_\tau$

$$\tau = \frac{V}{A} = \frac{\sqrt{C_x^2 + C_y^2}}{2\frac{\pi}{4}d^2} = \frac{60{,}000\text{ psi}}{3.3}$$

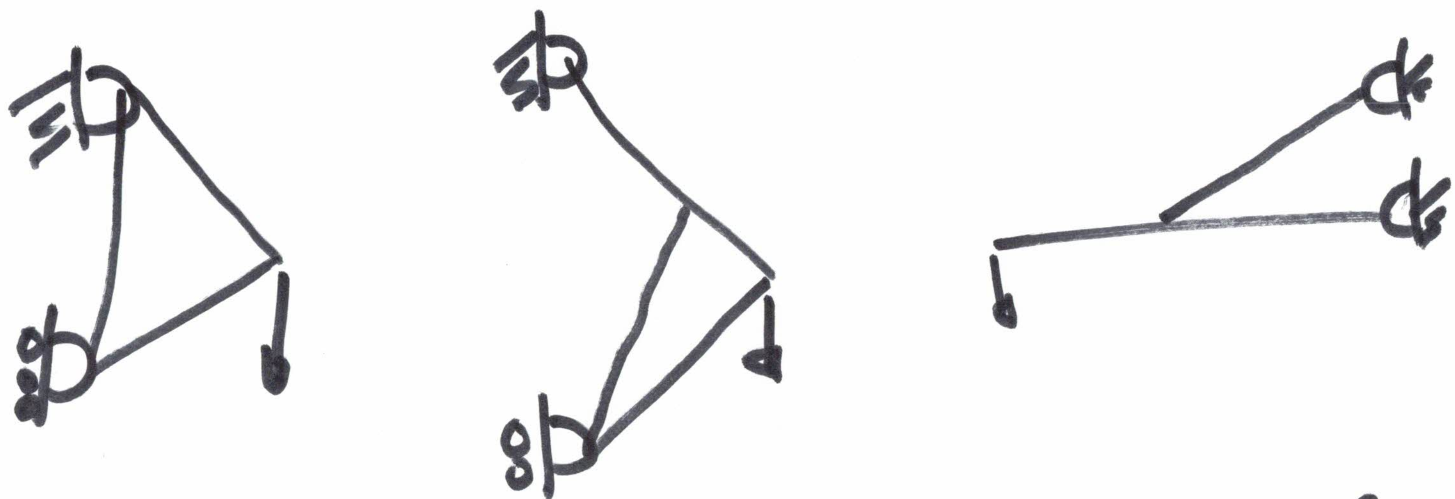
double shear

0.375 in

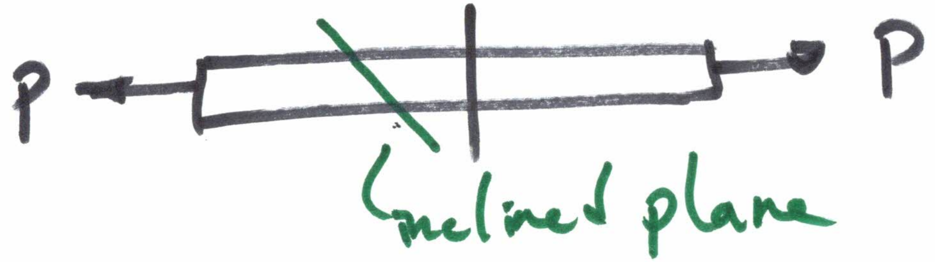
$P_\tau = 2230$ lbs

$P = \text{MIN}\ \{2400, 2230\}$ lbs

$= 2230$ lbs, safe for both cases



B. Stress on an inclined plane (axial loading)




$$\sigma_{axial} = \frac{P}{A_{x\text{-section}}}$$