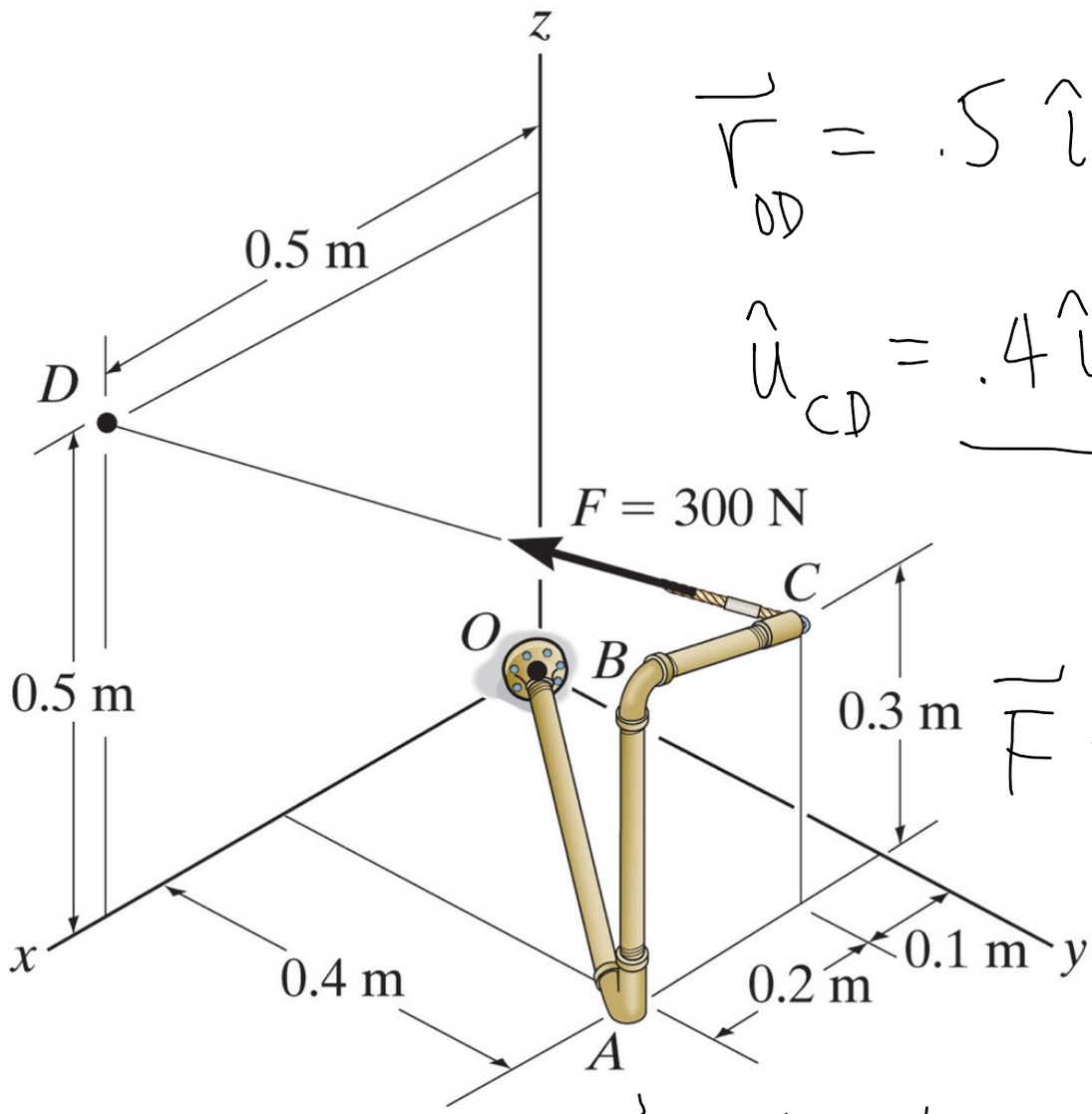


$$\vec{r}_{OD} = .5\hat{i} + .5\hat{k}$$

$$\hat{u}_{CD} = \frac{.4\hat{i} - .4\hat{j} + .2\hat{k}}{.6} = \frac{2}{3}\hat{i} - \frac{2}{3}\hat{j} + \frac{\hat{k}}{3}$$

$$\vec{F} = 200\hat{i} - 200\hat{j} + 100\hat{k}$$

$$\vec{M}_O = \vec{r}_{OD} \times \vec{F} = 100 \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ .5 & 0 & .5 \\ 2 & -2 & 1 \end{vmatrix} = \hat{i}(100) - \hat{j}(-50) + \hat{k}(-100)$$

$$\vec{M}_O = 100\hat{i} + 50\hat{j} - 100\hat{k} \quad N\cdot m$$

$\vec{M}_{OA}$ = moment about line OA

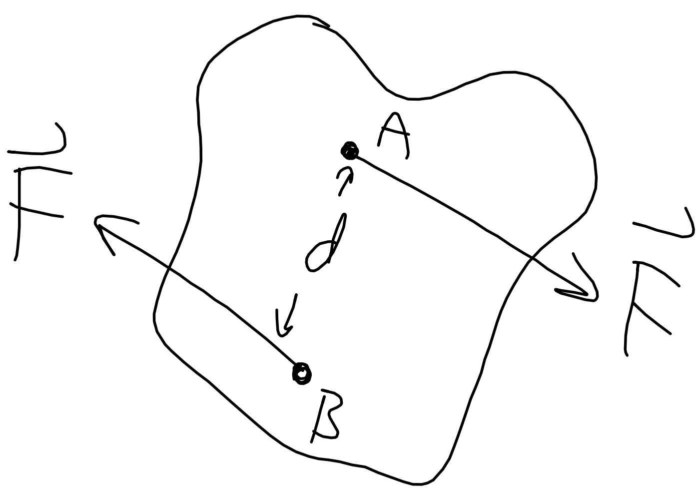
$$= \left[\vec{M}_O \cdot \hat{u}_{OA}\right]\hat{u}_{OA} > 0 \therefore \text{loosening}$$

$$\hat{u}_{OA} = \frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}$$

$$\vec{M}_{OA} = \left[60 + 40\right]\left[\frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}\right]$$

$$= 60\hat{i} + 80\hat{j}$$

Couple : 2 equal + opp forces separated by a distance d



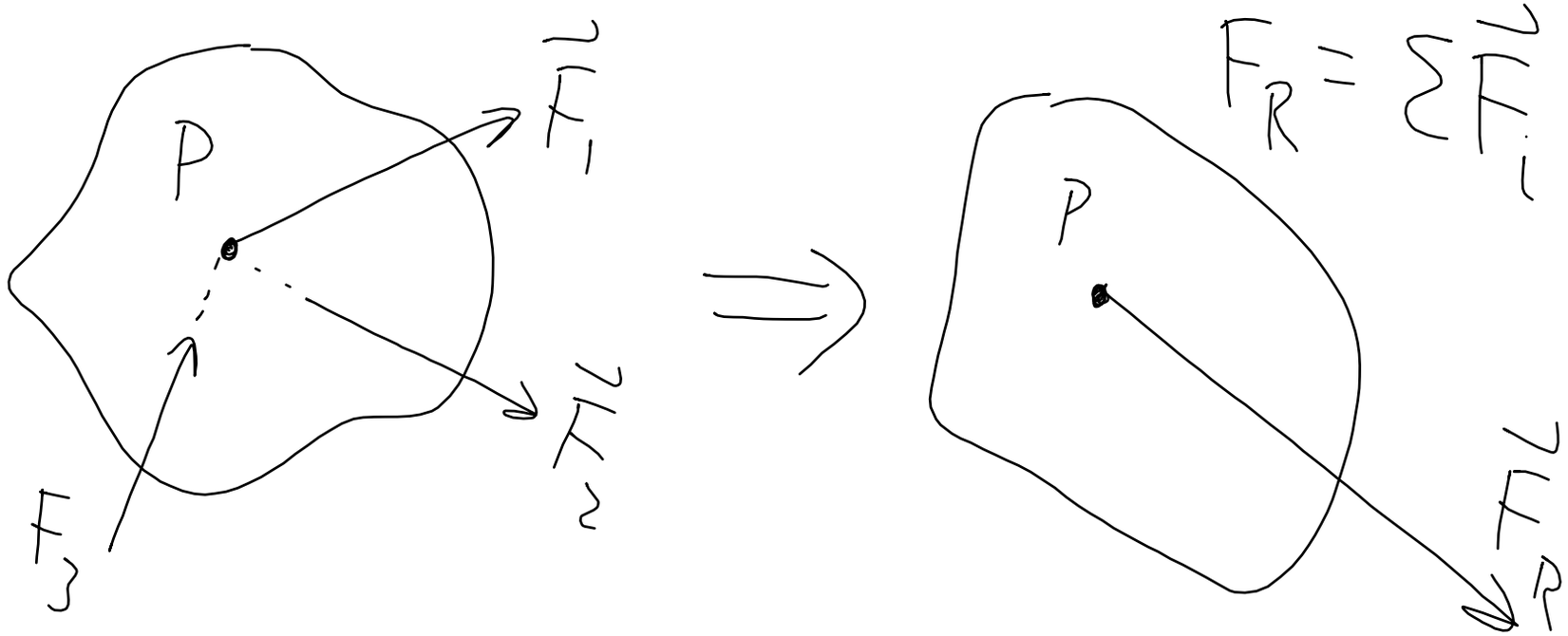
$\sum \vec{M}_A = Fd$ ⊗ into board

$\sum \vec{M}_B = Fd$ ⊗ into board

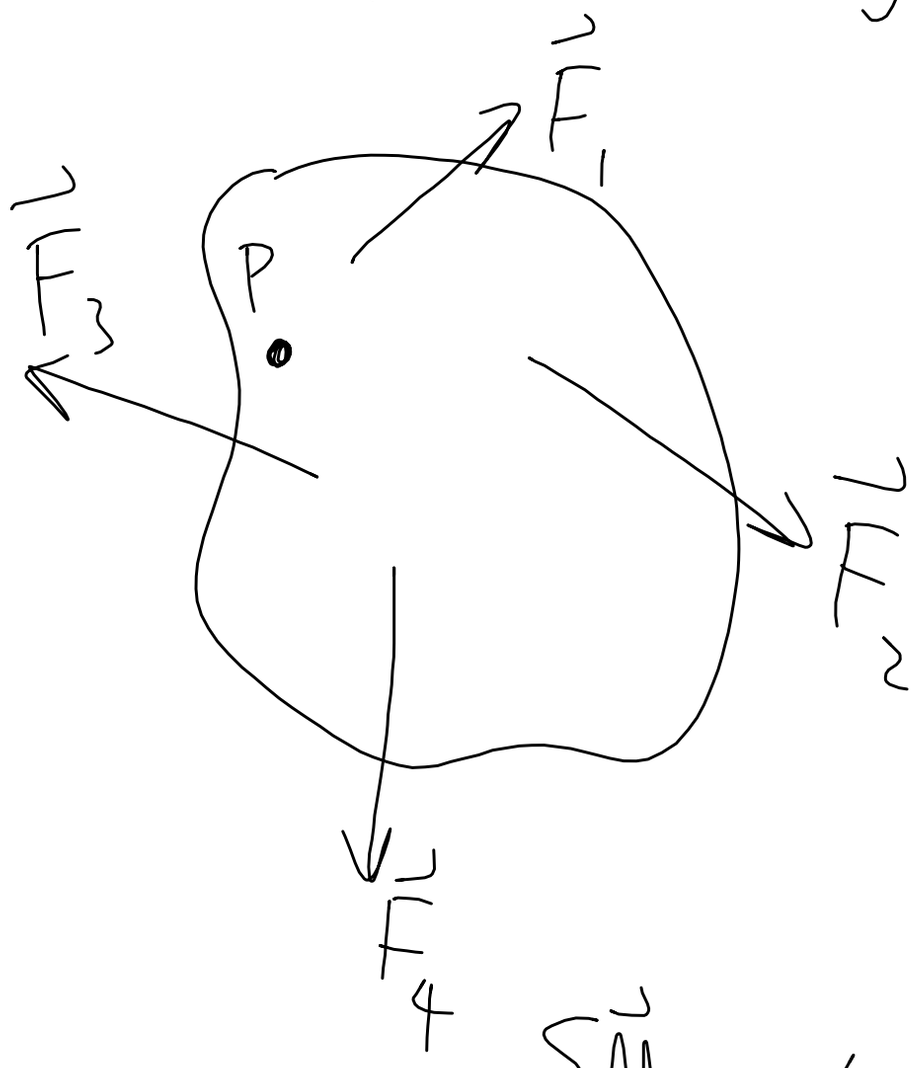
• P $\sum \vec{M}_P =$ " " "

Reducing force/couple systems to simplest resultant

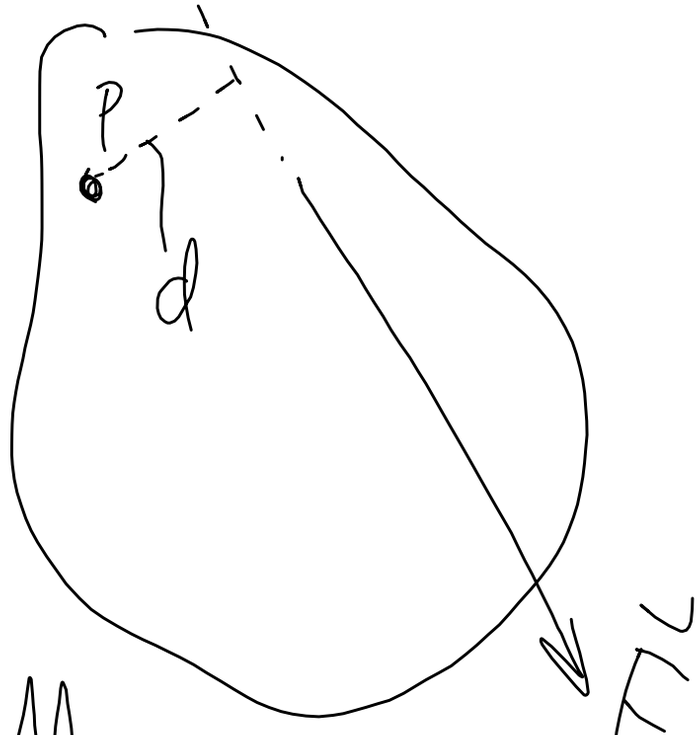
1. Concurrent system



2. Coplanar system



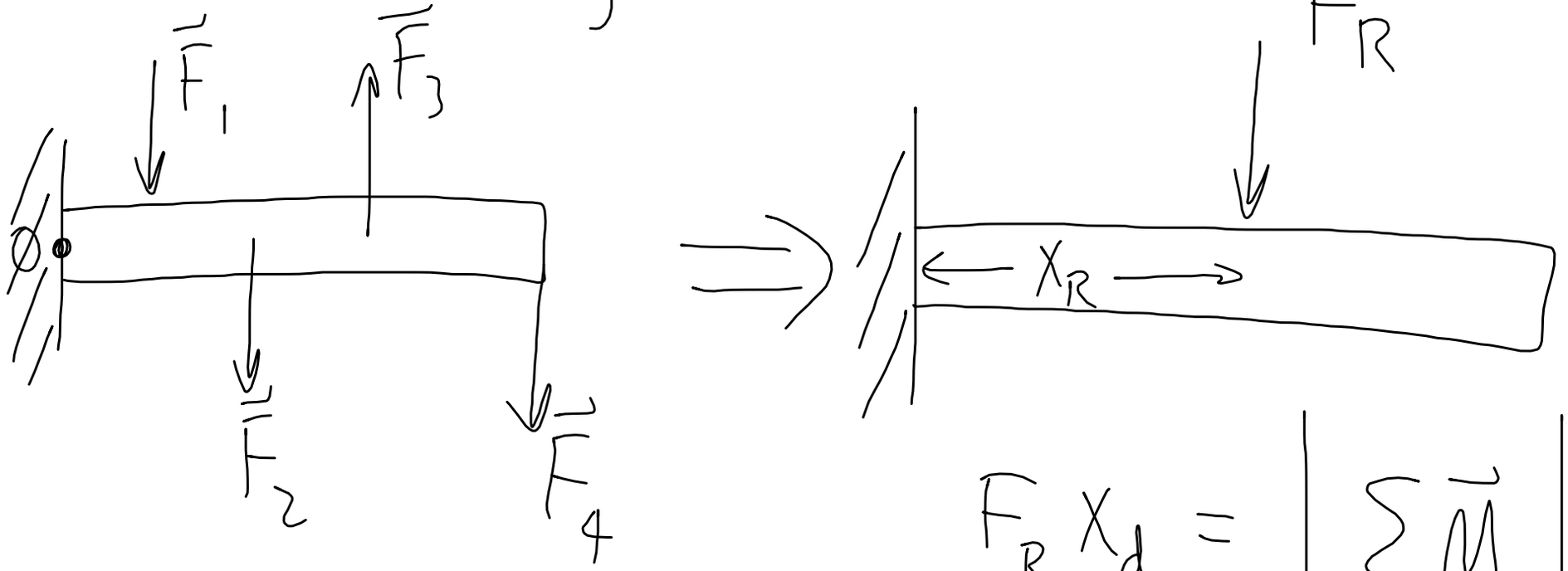
Still need $\vec{F}_R = \sum \vec{F}$



$\Sigma \vec{M}_P \iff Fd = M_P$

Get sign of M_P correct

3. Parallel system



$$F_R X_d = \left| \sum \vec{M}_O \right|$$

get sign correct

$$X_R = \frac{\Sigma M}{F_R}$$

In general (3-d also), single force resultant is possible whenever $\vec{F}_R \cdot \Sigma \vec{M}_P = 0$

Just put $\vec{F}_R$ at posn $\vec{r}$

so that $\vec{r} \times \vec{F}_R = \Sigma \vec{M}_P$

If all else fails $\Rightarrow$ screwdriver

Find $\vec{F}_R$

$$\left[\vec{M}_{total} \cdot \hat{u}_{F_R}\right] \hat{u}_{F_R} \Rightarrow \vec{M}_{||}$$

$$\vec{M}_{\perp} = \vec{M}_{total} - \vec{M}_{||}$$

Place $\vec{F}_R$ at $\vec{r}$ so that $\vec{r} \times \vec{F}_R = \vec{M}_{\perp}$ + put $\vec{M}_{||}$ there too