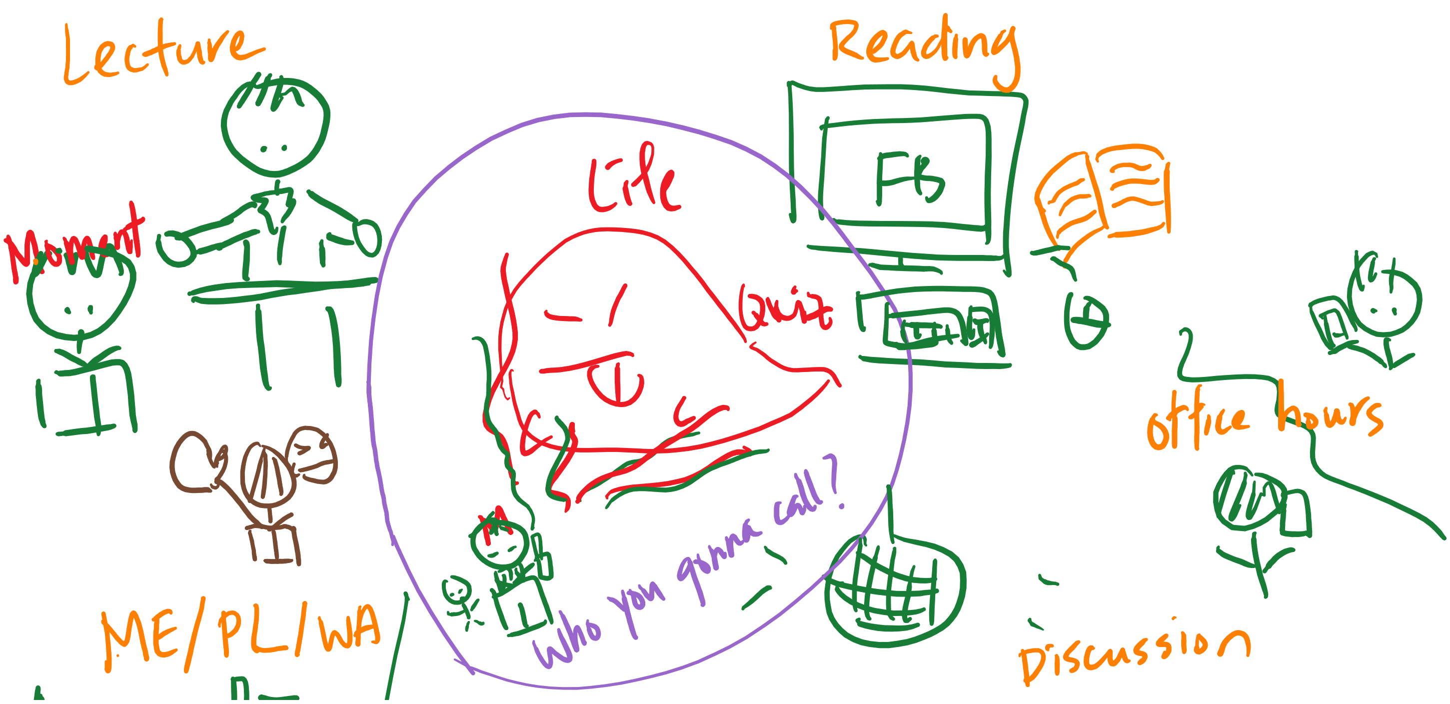
Announcements

- No quiz next week ☺
- Have you been on Piazza lately?

❑ Upcoming deadlines:

- Thursday (9/21)
  - ME HW7
- Friday (9/22)
  - Writing Assignment 1 (FBD only)
- Tuesday (9/26)
  - PL HW8

1




ME/PL/WA
Who
Discussion
Piazza

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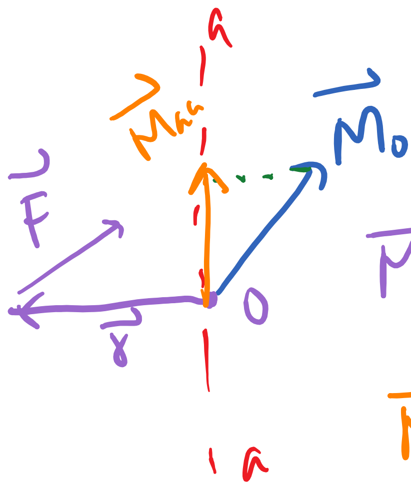
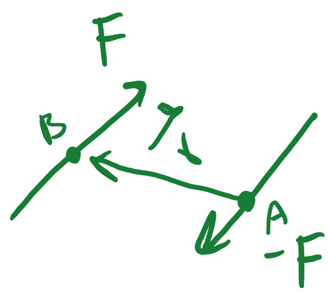
Recap

- Moment of a force
  - About a point
  - About an axis
  - Couple moment



$$\vec{M}_o = \vec{r} \times \vec{F}$$

$$\vec{M}_a = \hat{u}_{aa} \cdot (\vec{r} \times \vec{F})$$



$$\vec{M}_F = \vec{r}_{AB} \times \vec{F}$$

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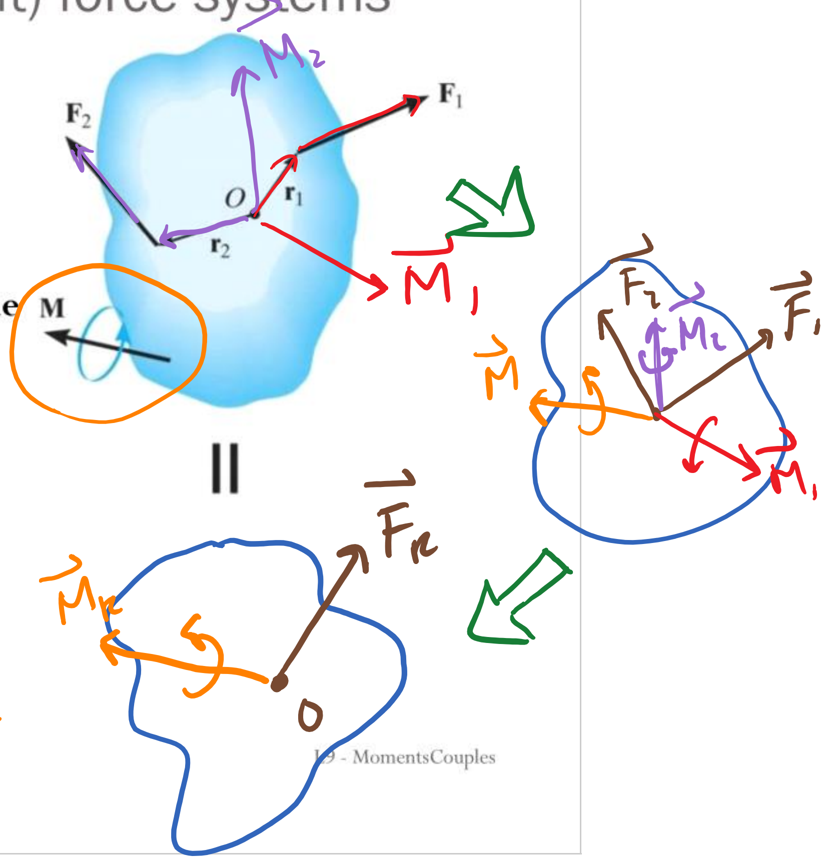
Equipollent (or equivalent) force systems

A force **system** is a collection of **forces** and **couples** applied to a body.

Two force systems are said to be **equipollent** (or equivalent) if they have the **same resultant force** AND the **same resultant moment** with respect to any point P.



$$\begin{cases} \sum \vec{F} = \vec{F}_R \\ \sum \vec{M}_c + \underbrace{\sum \vec{M}_o} = \vec{M}_R \end{cases}$$

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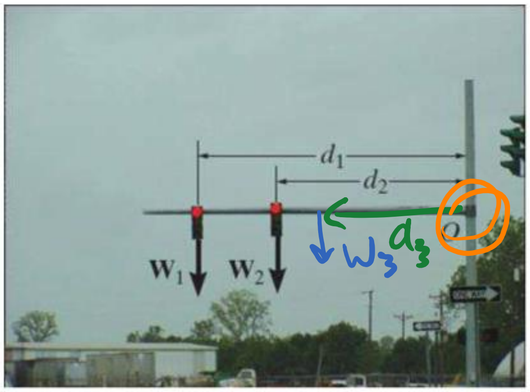
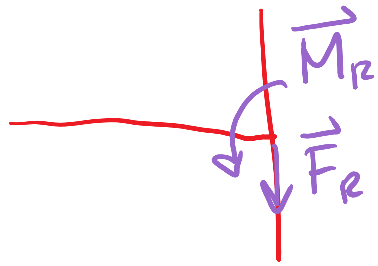
1-9 - MomentsCouples

What is the equivalent system?





$$\vec{F}_R = \vec{W}_1 + \vec{W}_2 + \vec{W}_3$$

$$\vec{M}_R = (W_1 d_1 + W_2 d_2 + W_3 d_3)(+\hat{k})$$

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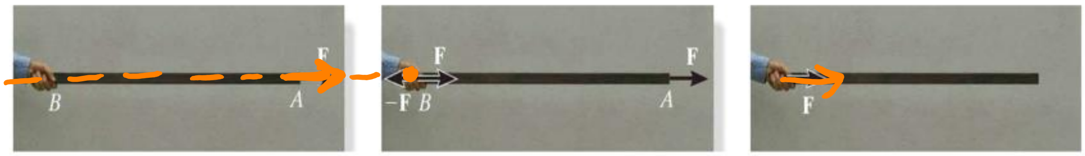
Moving a force on its line of action



Moving a force from A to B, when both points are on the vector's line of action, does not change the **external effect**.

Hence, a force vector is called a **sliding vector**.

However, the **internal effect** of the force on the body does depend on where the force is applied.

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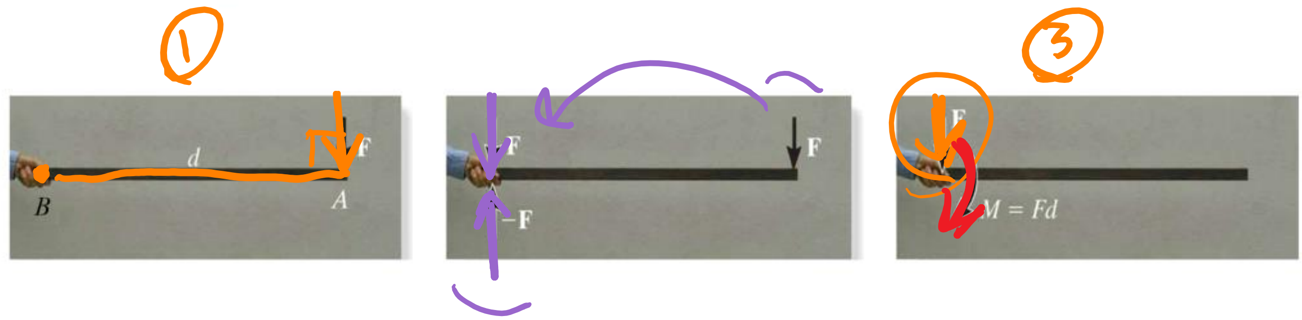
Moving a force off of its line of action



$M = Fd$

or

$\vec{M} = \vec{r} \times \vec{F}$

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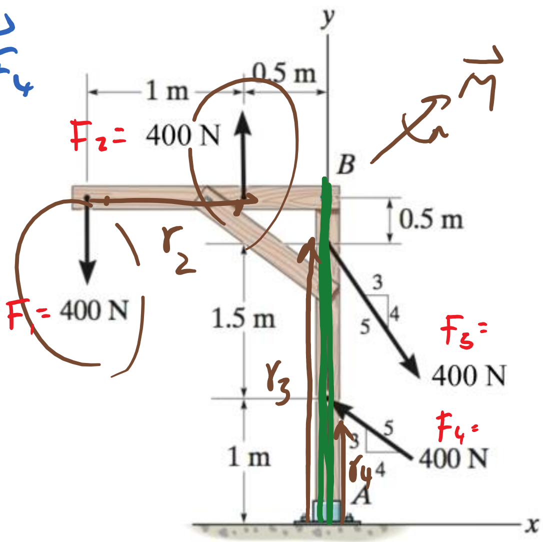
Example – 2D Equivalent System

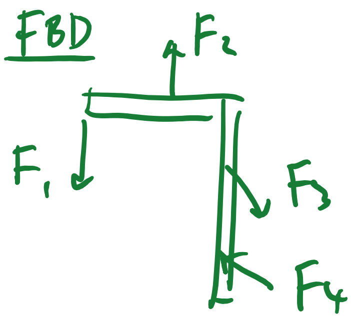
Replace the loading on the frame by a single resultant force. Specify where its line of action intersects a vertical line along member *AB*, measured from *A*.

Given: $\vec{F}_1, \vec{F}_2, \vec{F}_3, \vec{F}_4$

Find: $\vec{F}_R$, d



FBD



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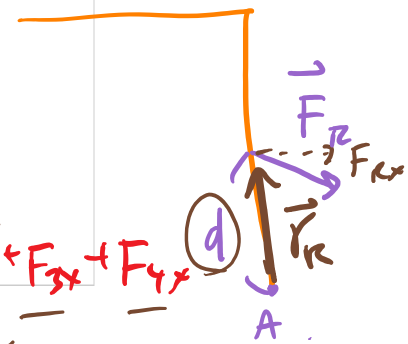
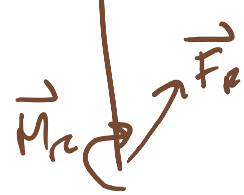


$F_{Rx} = \cancel{F_{1x}} + \cancel{F_{2x}} + F_{3x} + F_{4x}$

$F_{Ry} = \cancel{F_{1y}} + \cancel{F_{2y}} + F_{3y} + F_{4y}$

$\vec{F}_R = \cancel{\vec{F}_1} + \cancel{\vec{F}_2} + \vec{F}_3 + \vec{F}_4$

$\vec{M}_R = \underbrace{\vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2}_{\vec{r}_1 \times \vec{F}_2 = Fd(+\hat{k})} + \vec{r}_3 \times \vec{F}_3 + \vec{r}_4 \times \vec{F}_4$



We want $\vec{M}_R = \vec{r}_R \times \vec{F}_R$

$$M_R = dF_{Rx} \Rightarrow d = \frac{M_R}{F_{Rx}}$$

$F_{Rx} = F_3\left(\frac{3}{5}\right) - F_4\left(\frac{4}{5}\right) = -80\text{ N}$ $\boxed{\vec{F}_R = -80\hat{i} - 80\hat{j}\text{ N}}$

$F_{Ry} = -F_3\left(\frac{4}{5}\right) + F_4\left(\frac{3}{5}\right) = -80N$

$M_R = r_2 F_2 - r_3 F_{3x} + r_4 F_{4x}$

$= (1m)(400N) - (2.5m)(400N) + (1m)(400N)$

$\boxed{\vec{M}_R = -200 N\cdot m\, \hat{k}}$

$d = \frac{M_R}{F_{Rx}} = \frac{200 N\cdot m}{80N}$

$\boxed{d = 2.5m}$