Announcements

- Happy Monday
- No Wed morning office hour this week (9/19)

- Upcoming deadlines:
- Tuesday
  - PL HW
- Friday
  - Writing Assignment

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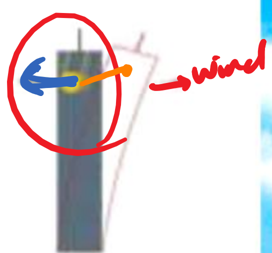
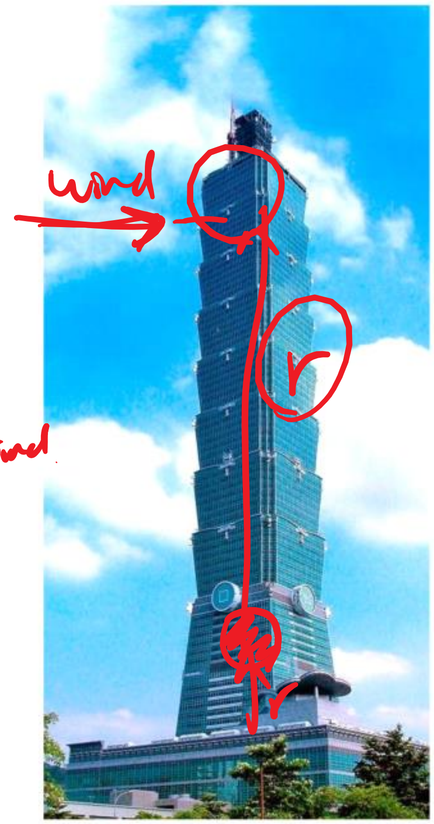
Objective

- Moment of a Couple
- Equivalent Systems





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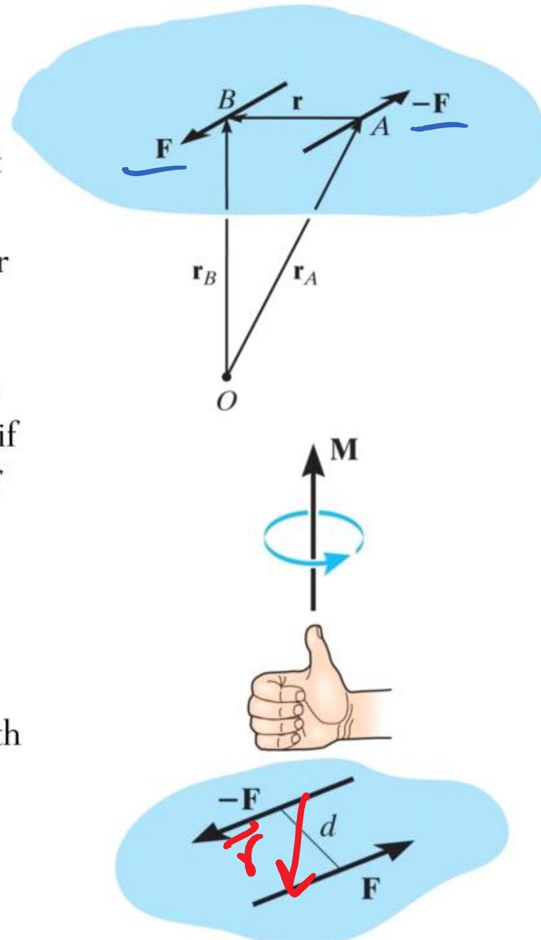
Moment of a couple



A **couple** is defined as two parallel forces that have the same magnitude, but opposite directions, and are separated by a perpendicular distance d.

Since the resultant force is zero, the only effect of a couple is to produce an actual rotation, or if no movement is possible, there is a tendency of rotation in a specified direction.

The moment produced by a couple is called **couple moment**.

Let's determine the sum of the moments of both couple forces about **any** arbitrary point:

net $\vec{F} = \vec{F}_R = 0$

$$\vec{M} = F \cdot d \; \hat{u}_M$$

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

↑ from one ½ of couple F to the other ½

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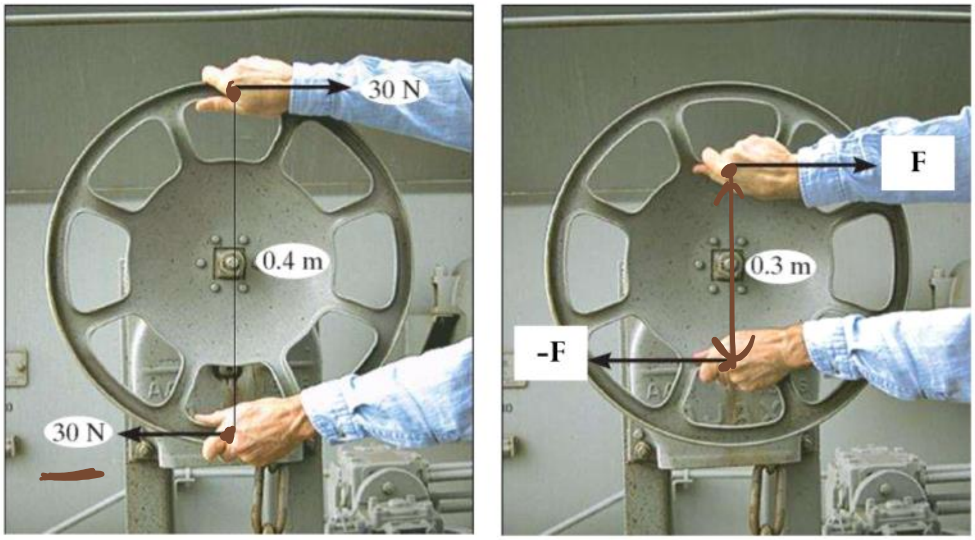
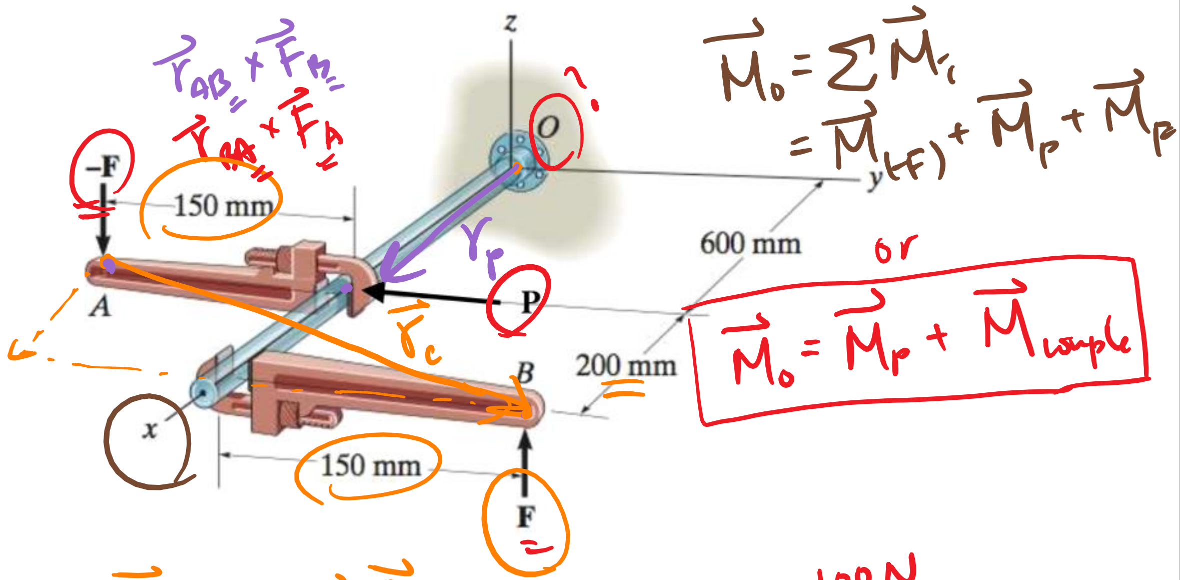


A torque or moment of 12 N·m is required to rotate the wheel. Would F be greater or less than 30 N?

$$M = F \cdot d \longrightarrow F = \frac{M}{d} = \frac{12\ N \cdot m}{0.3\ m}$$

$$\boxed{F = 40\ N} > 30\ N.$$

Find the moment about the support at O? F = 100 N, P = 50 N.



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$\vec{M}_{couple} = \vec{r}_c \times \vec{F}$

$= (200\,mm\,\hat{i} + 300\,mm\,\hat{j}) \times (F)\hat{k}$, F = 100 N

$= (-20000\,\hat{j} + 30000\,\hat{i})\,N.mm$

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

$= (600\,mm\,\hat{i}) \times (-(P)\hat{j})\,N$, P = 50N

$= 3000\,(-\hat{k})\,N.mm$

moment about point O → $\vec{M}_o = \vec{M}_{coup} + \vec{M}_p = (30000\,\hat{i} - 20000\,\hat{j} - 3000\,\hat{k})\,N.mm$

moment along x-axis $\vec{M}_{ox}$ = moment to loosen / tighten the pipe.

$= (\vec{M}_o \cdot \hat{u}_x)\hat{u}_x = (\vec{M}_o \cdot \hat{i})\,\hat{u}_x = 30000\,\hat{i}\;N \cdot mm$

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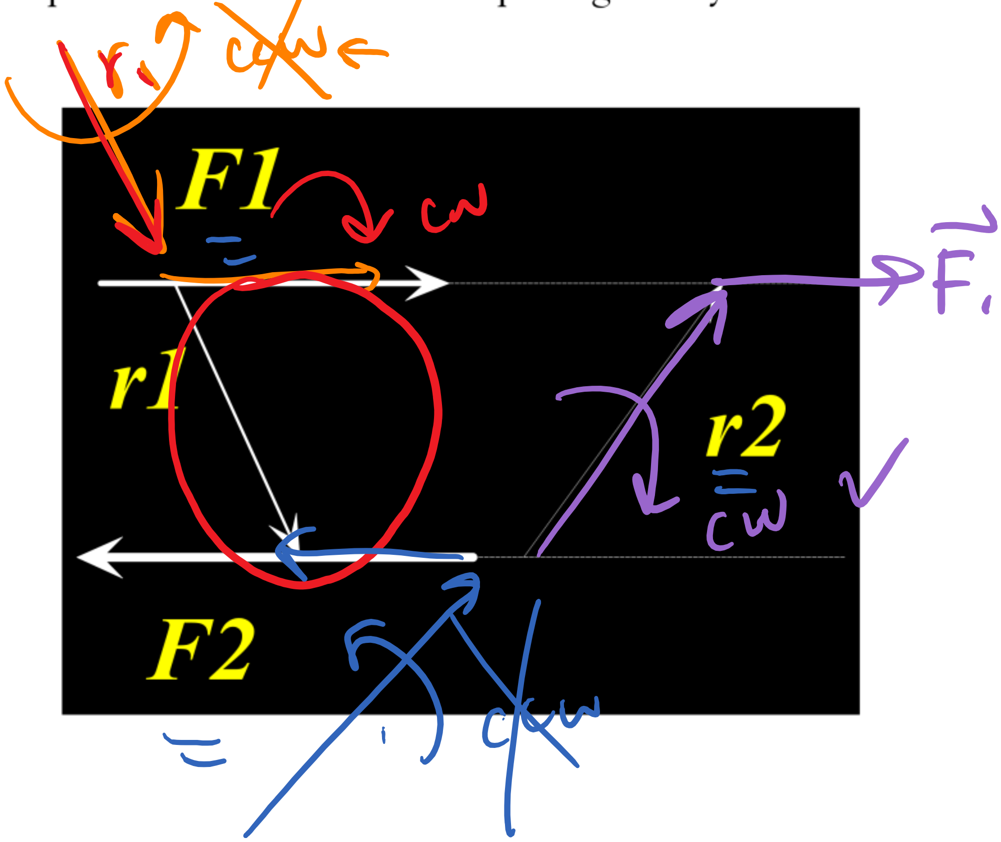
$\boldsymbol{F_1}$ and $\boldsymbol{F_2}$ form a couple. The moment of the couple is given by:

A) $\boldsymbol{r_1} \times \boldsymbol{F_1}$

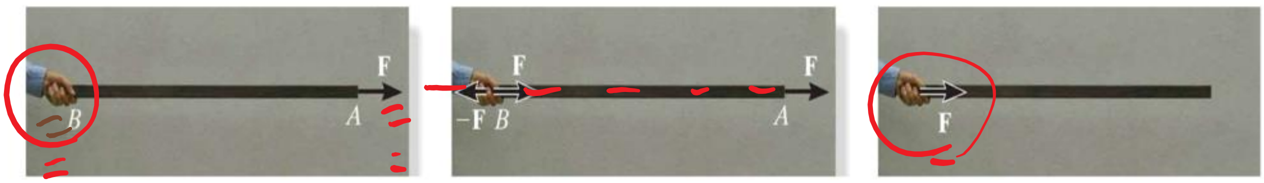
B) $\boldsymbol{r_2} \times \boldsymbol{F_1}$

C) $\boldsymbol{F_2} \times \boldsymbol{r_1}$

D) $\boldsymbol{r_2} \times \boldsymbol{F_2}$



Moving a force on its line of action

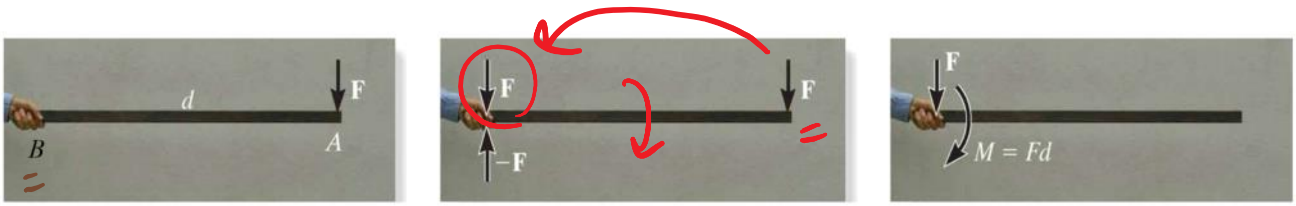


Moving a force from *A* to *B*, when both points are on the vector's line of action, does not change the **external effect**.

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.

Moving a force off of its line of action



What if point *B* is not on the line of action of vector **F**?

When moving a force not along its line of action, the moment it creates about the point of interest must be considered.

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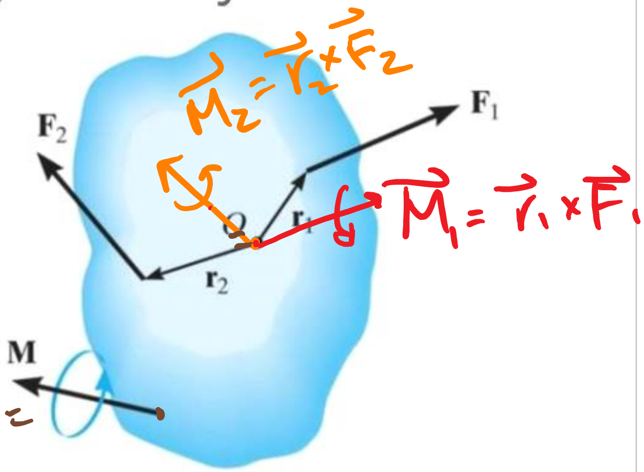
Equipollent (or equivalent) force systems

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*. (R: resultant)



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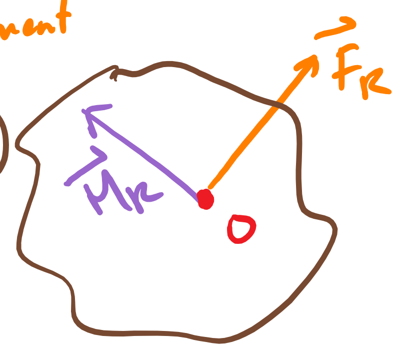

$$\vec{F}_R = \sum \vec{F} = \vec{F}_1 + \vec{F}_2$$

$$\vec{M}_R = \sum M + \sum \vec{r}_i \times \vec{F}_i \quad \text{(about point O)}$$

$$= \vec{M} + \vec{M}_1 + \vec{M}_2$$

$$= \vec{M} + \vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2$$

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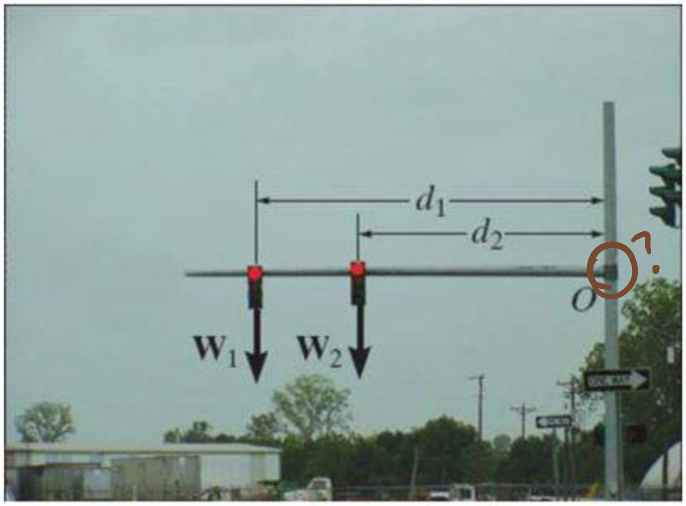
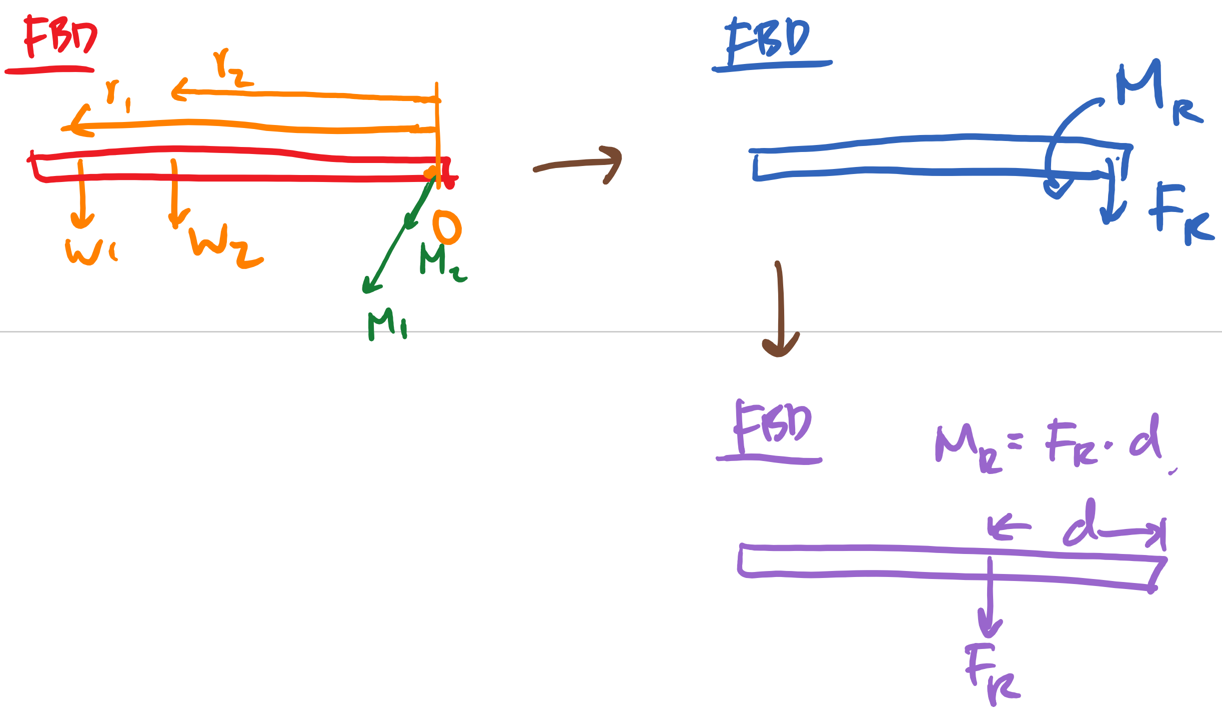
What is the equivalent system?



Next time ...



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