Lecture 10

Wednesday, September 20, 2017 11:39

To do …

- Quiz 2 this week (**ends Fri**)
- HW 7 due **Thurs**
- WA 1 due **Fri**
- HW 8 due **Tues**

Wednesday, September 20, 2017 11:39

Chapter 4: Force System Results

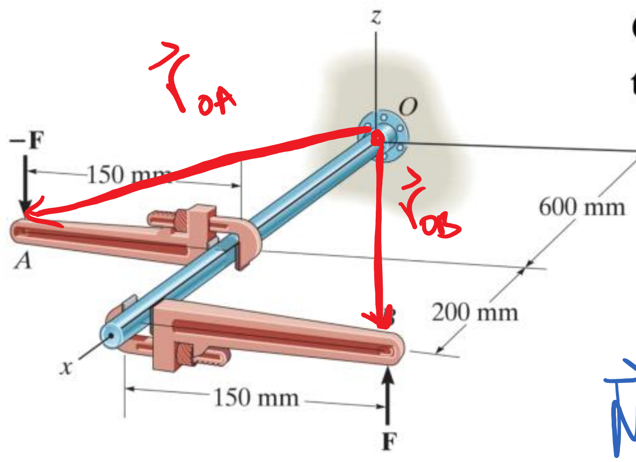
Main goals and learning objectives

- Discuss the concept of the moment of a force and show how to calculate it in two and three dimensions
- Provide a method for finding the moment of a force about a specified axis
- Define the moment of a couple
- Method to simplify a force and couple system to an equivalent system
- Indicate how to reduce a simple distributed loading to a resultant force having a specified location

Wednesday, September 20, 2017 11:39

Couples ...

Wednesday, September 20, 2017 11:39



Express the moment in Cartesian vector form. What is the magnitude?

find moment About O

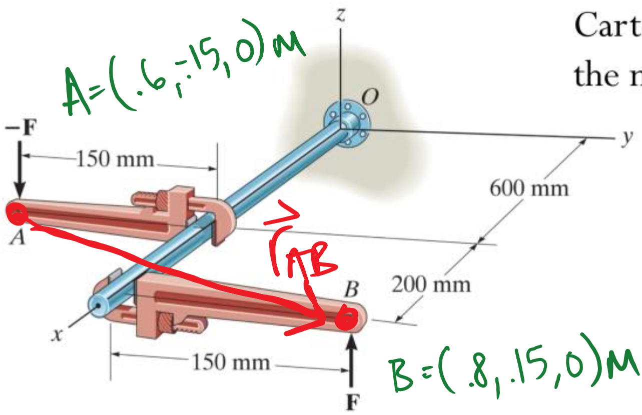
$$\vec{M}_0 = \vec{r}_{OA} \times \vec{F}_A + \vec{r}_{OB} \times \vec{F}_B$$

$$\vec{M}_0 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ .6 & -.15 & 0 \\ 0 & 0 & -F \end{vmatrix} + \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ .8 & .15 & 0 \\ 0 & 0 & F \end{vmatrix}$$

$$\vec{M}_0 = (.15F)\hat{i} - (-.6F)\hat{j} + (.15F)\hat{i} - (.8F)\hat{j}$$

$$\boxed{\vec{M}_0 = (.3\,\hat{i} - .2\,\hat{j})\,\text{m}\cdot F}$$

Express the moment in Cartesian vector form. What is the magnitude?



find moment using couple, distance b/n A & B.

$$\vec{r}_{AB} = \vec{r}_{OB} - \vec{r}_{OA} = [.2, .3, 0]\,m$$

$$\vec{M} = \vec{r}_{AB} \times \vec{F}_B = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ .2 & .3 & 0 \\ 0 & 0 & F \end{vmatrix} =$$

$$\vec{M} = (.3F)\hat{i} - (.2F)\hat{j} = \boxed{[.3\hat{i} - .2\hat{j}]\,m\,F}$$

*SAME AS previous SLIDE!

* try using $\vec{r}_{BA}$?

$$\vec{r}_{BA} = \vec{r}_{0A} - \vec{r}_{0B} = [-.2, -.3, 0]$$

$$\vec{M} = \vec{r}_{BA} \times \vec{F}_A = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -.2 & -.3 & 0 \\ 0 & 0 & -f \end{vmatrix}$$

$$\vec{M} = (-.3)(-f)\hat{i} - (-.2)(-f)\hat{j}$$

$$\boxed{\vec{M} = [.3\hat{i} - .2\hat{j}] \, \text{N} \cdot F}$$

* Same Answer yet Again!

Page 6

Monday, September 12, 2016 11:17

Moving a force on its line of action (L.O.A)

L.O.A.

equivalent to

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

→ translation/rotation of body.

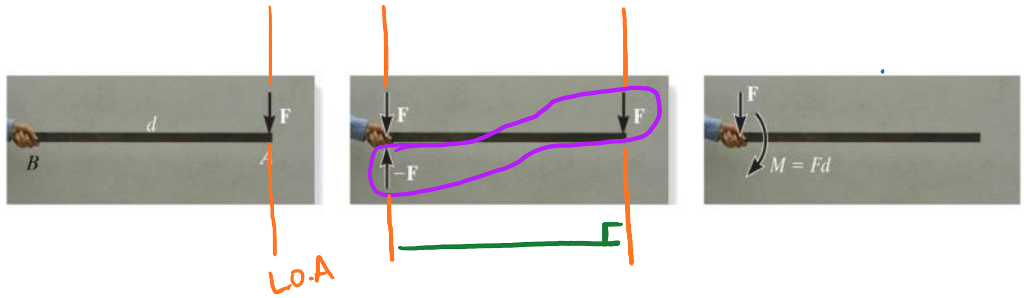
→ depends on where and how force is applied to body

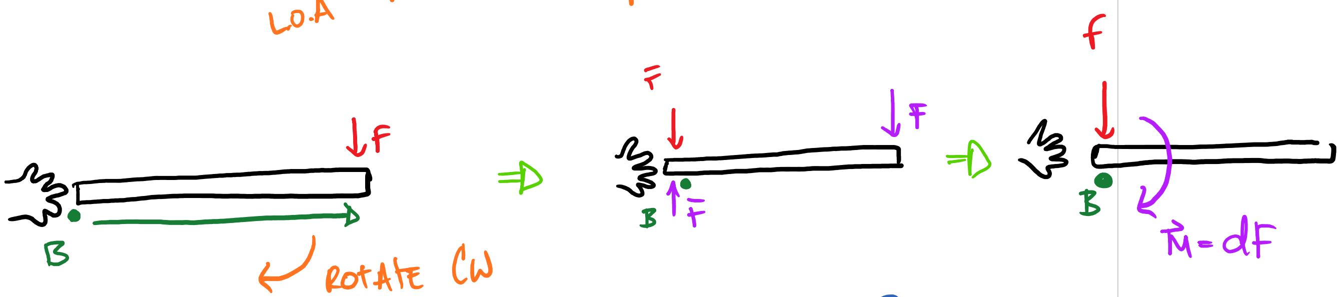
* F is a Sliding Vector

→ line of action is defined, produces the same external effect on a body.

Wednesday, September 14, 2016 10:50

Moving a force off of its line of action





$\Sigma F = F$

$\Sigma M_B = \vec{r}_{BA} \times \vec{F}$

$\Sigma F = F - F - F = -F$

$\Sigma M = dF$

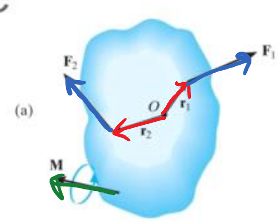
Adding couple moment does not affect sum of forces

* produces same external effects

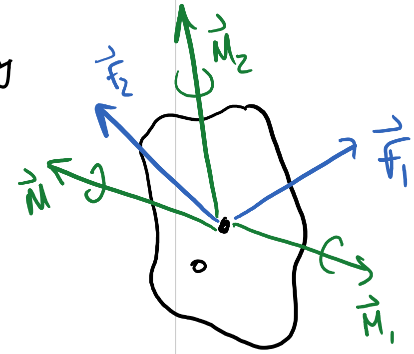
Equipollent (or equivalent) force systems

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

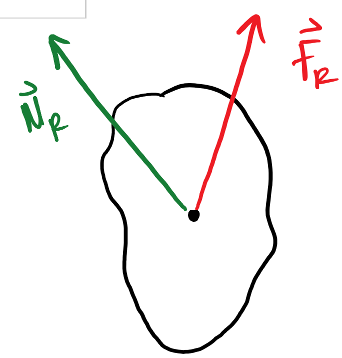
Two force systems are said to be **equipollent** (or equivalent) if they have the **same resultant force** AND the **same resultant moment** with respect to any point *P*.



← Consider the rigid Body with forces And couple



Simplify this system to A Single Resultant force $\vec{F}_R$ And Single Resultant couple Moment $\vec{M}_R$



$$\vec{F}_R = \left[\Sigma F_x, \Sigma F_y, \Sigma F_z\right]$$

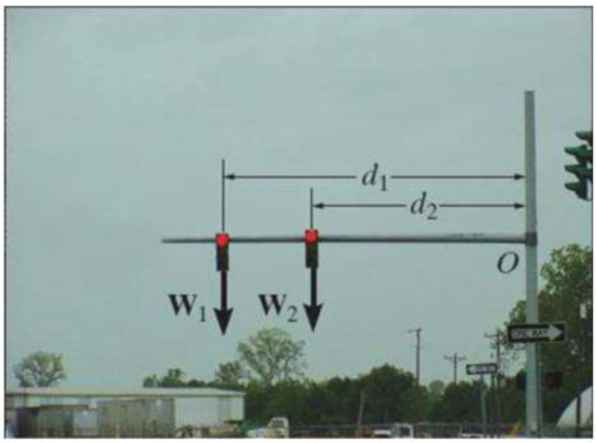
$$\vec{M}_R = \Sigma \vec{M}_C + \Sigma \vec{M}_O$$

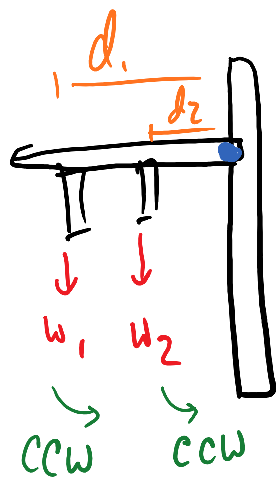
$\Sigma \vec{M}_C$: (Couples)

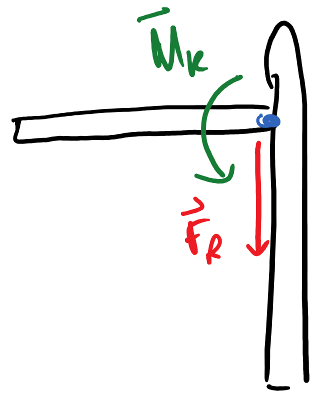
$\Sigma \vec{M}_O \rightarrow \Sigma(\vec{r} \times \vec{F})$ (moment about O)

What is the equivalent system?

@ O







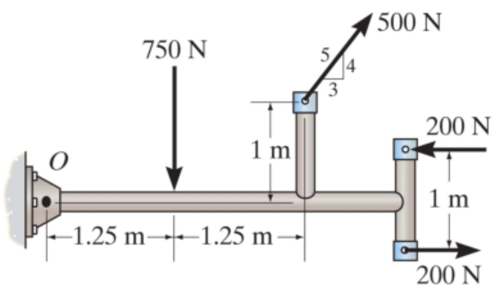
sum forces.

$$\vec{F}_R = [0, -(W_1 + W_2)]$$

note that $\vec{F}_R$ is $\perp$ to $\vec{M}_R$

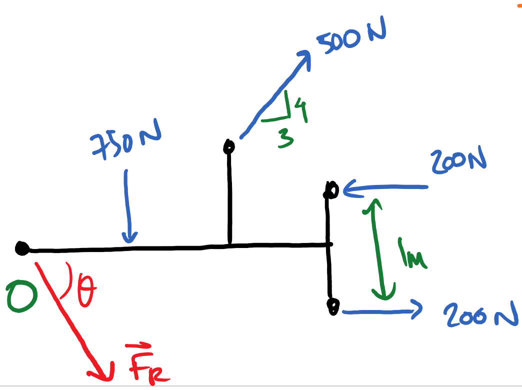
sum moments

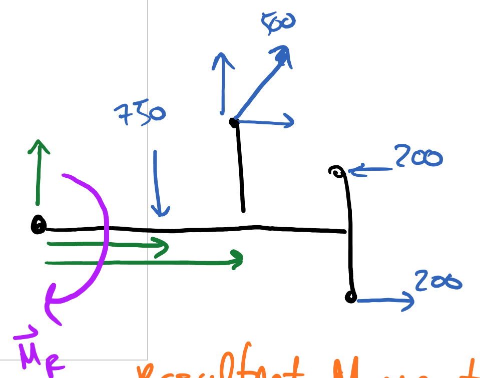
$$\vec{M}_R = d_1 W_1 + d_2 W_2$$



Replace the force and couple system acting on the member by an equivalent force and couple moment acting at point O.

- Draw FBD
- Sum forces
- Find and sum moments.





Resultant force

ΣF_x: $\frac{3}{5}500 - 200 + 200 = 300\,N$

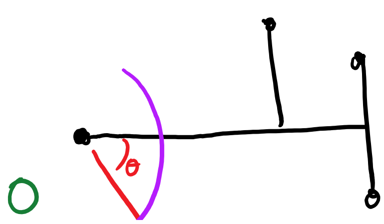
ΣF_y: $\frac{4}{5}500 - 750 = -350\,N$

$|\vec{F}_R| = \sqrt{300^2 + 350^2} = 461\,N$

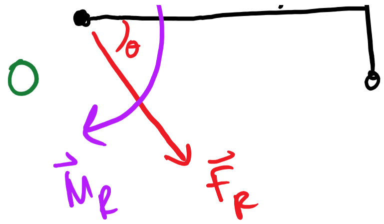
$\theta = \tan^{-1}\left(\frac{F_{Ry}}{F_{Rx}}\right) = 49.4°$

Resultant Moment

$\vec{M}_R = (2.5)\left(\frac{4}{5}500\right) - (1.25)(750) - 1\left(\frac{3}{5}500\right) + (1)(200) = -37.5\,N\cdot m$



← Equiv. system


O
θ
$\vec{M}_R$
$\vec{F}_R$