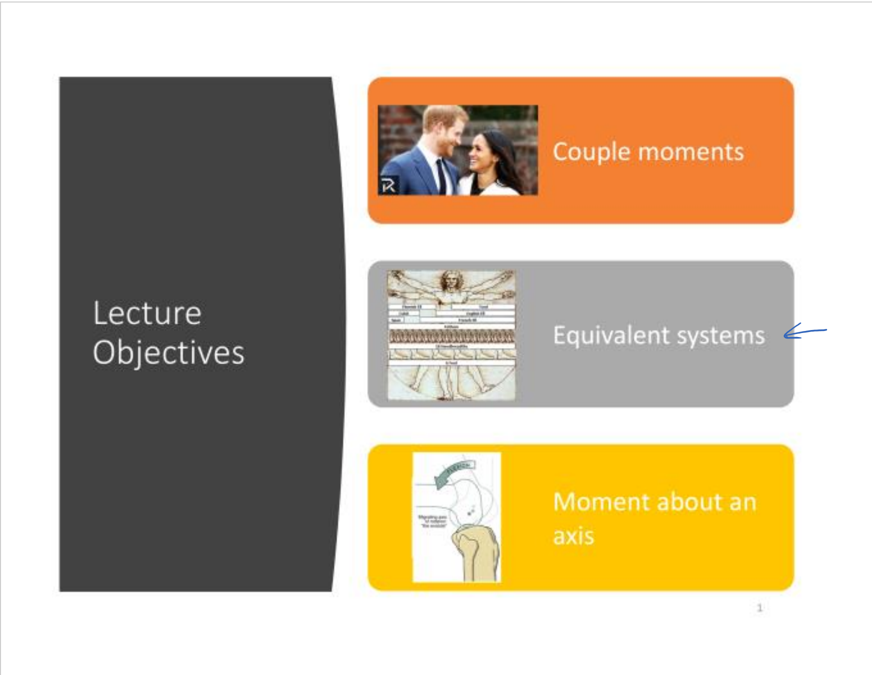
Lec09

Wednesday, September 30, 2020 7:58 AM



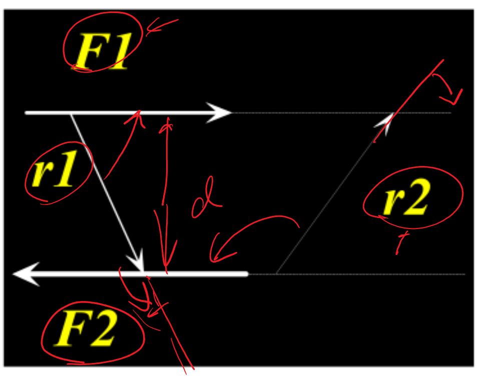
F_1 and F_2 form a couple. The moment of the couple is given by:

A) $r_1 \times F_1$ ✗

✓ B) $\boxed{r_2 \times F_1}$

C) $F_2 \times r_1$

D) ~~$r_2 \times F_2$~~



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

✓ $\vec{r}_1 \times \vec{F}_2$

$|\vec{m}| = |\vec{F}| d$

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

$|\vec{m}|$

$\hat{u}$

Moving a force on its line of action

$\Sigma F_x = 0$

$\Sigma F_y = 0$

O

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

force
moment

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.

$\boxed{\varepsilon, \tau}$

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Moving a force off of its line of action

F

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

External effect:

$\Sigma \vec{F} = 0$

$\Sigma \vec{M} = 0$

$F \cdot d$

$M = 0$

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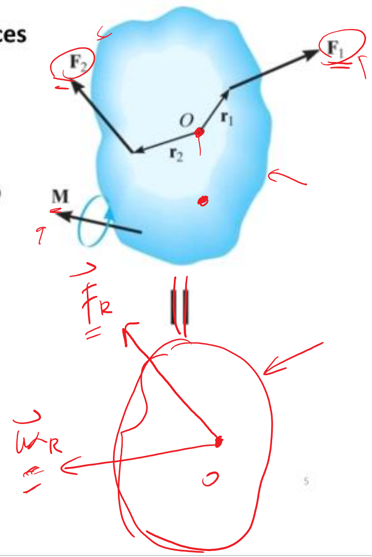
Equipollent (or equivalent) force systems

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*.



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

$$(\vec{M}_R)_O = \vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2 + \vec{M}$$

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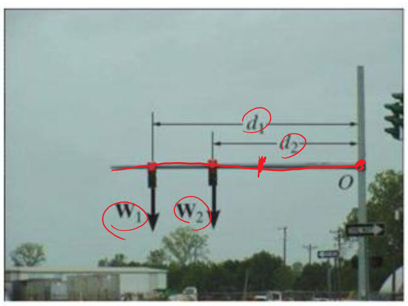
What is the equivalent system?



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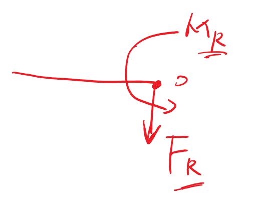
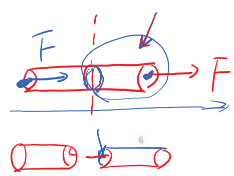


$$F_R = W_1 + W_2$$

$$M_R = W_1 d_1 + W_2 d_2$$



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

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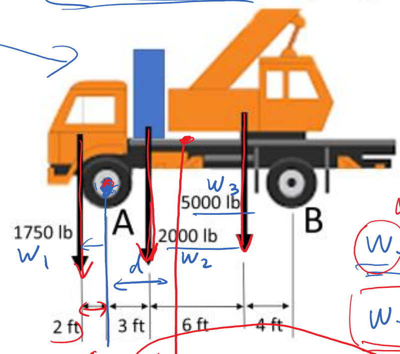
Example – 2D Equivalent System

Replace weights of the components of the truck with a single equivalent weight and specify its location measured from *A*.



$W = \boxed{W_1 + W_2 + W_3}$ F_R

$\boxed{W \cdot d} = \boxed{3 \cdot W_2 + (3+6) W_3 - 2 W_1}$ M_R

$$d = \frac{3W_2 + 9W_3 - 2W_1}{W_1 + W_2 + W_3}$$

d $\boxed{W_1 + W_2 + W_3}$

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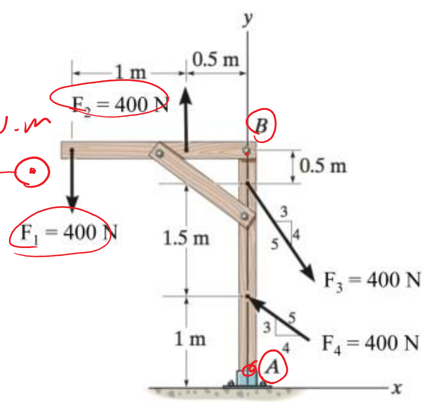
Example – 2D Equivalent System

What is the resultant force and moment on point *A* and *B* from F_1 and F_2?

A or B :

$\vec{F}_R = 0$

$|\vec{M}_R| = |F| \cdot d = 400\ N \cdot m$



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Example – 2D Equivalent System

What is the resultant force and moment on point *A* and *B* from F_3 and F_4?

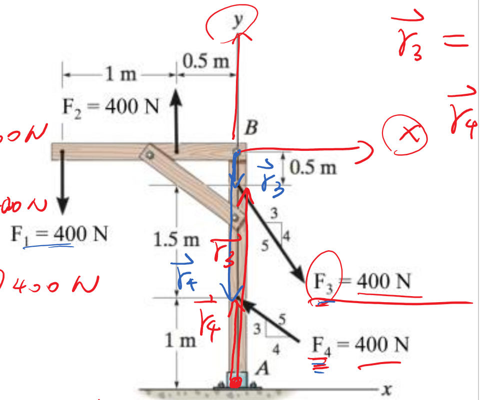
$\vec{F}_R = \vec{F}_3 + \vec{F}_4$

$\vec{F}_3 = \left(\frac{3}{5}\hat{i} - \frac{4}{5}\hat{j}\right) 400N$

$\vec{F}_4 = \left(-\frac{4}{5}\hat{i} + \frac{3}{5}\hat{j}\right) 400N$

$\vec{F}_R = \left(-\frac{1}{5}\hat{i} - \frac{1}{5}\hat{j}\right) 400N$

for both A and B.



$\vec{r}_3 = (0, 2.5, 0)$

$\vec{r}_4 = (0, 1, 0)$

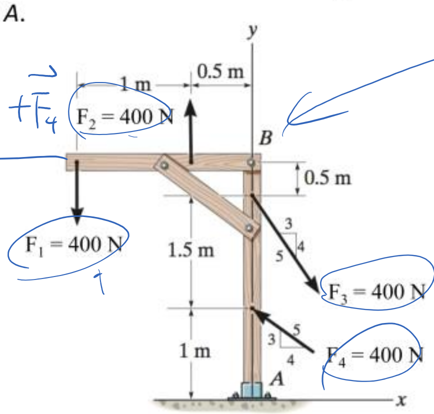
A: $\vec{M}_R = \vec{r}_3 \times \vec{F}_3 + \vec{r}_4 \times \vec{F}_4$

B: $\vec{M}_R = \vec{r}_3 \times \vec{F}_3 + \vec{r}_4 \times \vec{F}_4$

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*.

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



$(\vec{M}_R)_A =$

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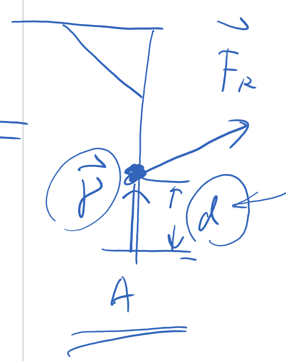

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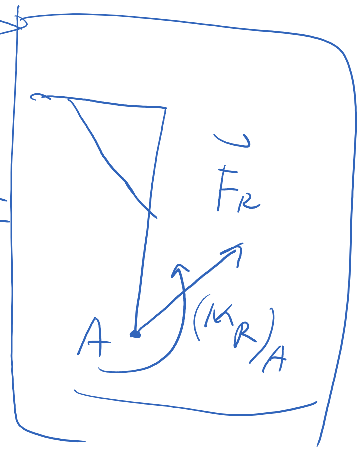

$\vec{r} \times \vec{F}_R = (\vec{M}_R)_A$