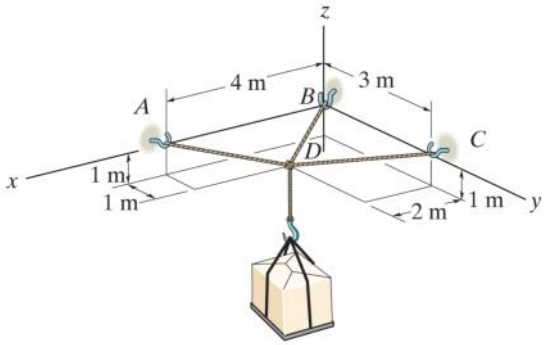
Lecture 07

Wednesday, September 13, 2017 12:34

To do ...

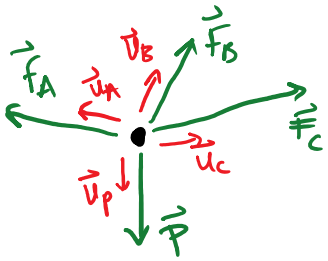
- Quiz 1 this week
- Quiz 2 next week – sign up now!
- Morning office hours:
  - Mon, Wed from 9-10 am in MEB 220H
- HW 5 due **Thurs**
- HW 6 due **Tues**
- Written Assignment

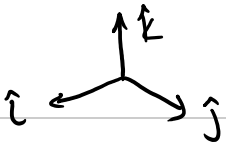


The crate has a mass of 130 kg. Determine the tension developed in each cable for equilibrium.

Plan - DRAW FBD
- write coordinates
- find position vectors
- find unit vectors
- use equations of equilibrium

DRAW FBD





NEED extra FBD to solve for $\vec{P}$

the coordinates ARE:

A = (4, 0, 0)

B = (0, 0, 0)

C = (0, 3, 0)

D = (2, 1, -1)

4 unknowns - $\vec{F}_A, \vec{F}_B, \vec{F}_C, \vec{P}$

3 equations - $\Sigma F_x = 0$
$\Sigma F_y = 0$
$\Sigma F_z = 0$

find position and unit vectors:

$$\vec{r}_{DA} = \vec{r}_A - \vec{r}_D = [2, -1, 1]$$

$$\vec{u}_A = \frac{\vec{r}_{DA}}{|\vec{r}_{DA}|} = \frac{[2, -1, 1]}{\sqrt{6}}$$

$\rightarrow \rightarrow \rightarrow$ $[-2, -1, 1]$ $\vec{r}_{C} - \vec{r}_{D} = [-2, 2, 1]$

$\vec{r}_{DB} = \vec{r}_B - \vec{r}_D = [-2, -1, 1]$

$\vec{u}_B = \dfrac{[-2, -1, 1]}{\sqrt{6}}$

$\vec{r}_{DC} = \vec{r}_C - \vec{r}_D = [-2, 2, 1]$

$\vec{u}_C = \dfrac{[-2, 2, 1]}{3}$

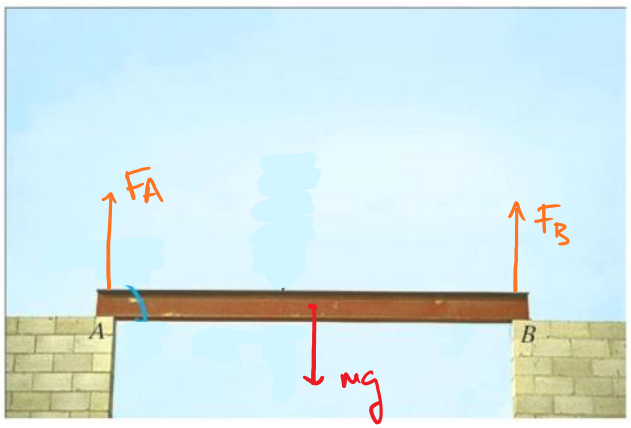
$\vec{F}$	$\hat{i}$	$\hat{j}$	$\hat{k}$
$\vec{F}_A$	$\frac{2}{\sqrt{6}} F_A$	$\frac{-1}{\sqrt{6}} F_A$	$\frac{1}{\sqrt{6}} F_A$
$\vec{F}_B$	$\frac{-2}{\sqrt{6}} F_B$	$\frac{-1}{\sqrt{6}} F_B$	$\frac{1}{\sqrt{6}} F_B$
$\vec{F}_C$	$\frac{-2}{3} F_C$	$\frac{2}{3} F_C$	$\frac{1}{3} F_C$
$\vec{P}$	0	0	$-P$
$\sum \vec{F}$	$(\Sigma f_x)\hat{i}$ $= 0$	$(\Sigma f_y)\hat{j}$ $= 0$	$(\Sigma f_z)\hat{k}$ $= 0$

Chapter 4: Force System Resultants

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

Applications



Beams are often used to bridge gaps in walls. We have to know what the effect of the force on the beam will have on the supports of the beam.

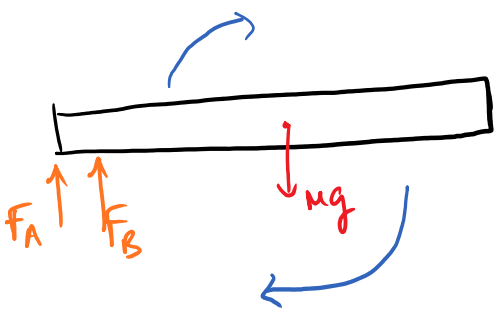
Rigid Bodies have size And shape.

A force MAY not ALWAYS go through CENTER of mass.

CONSIDER THE BEAM:

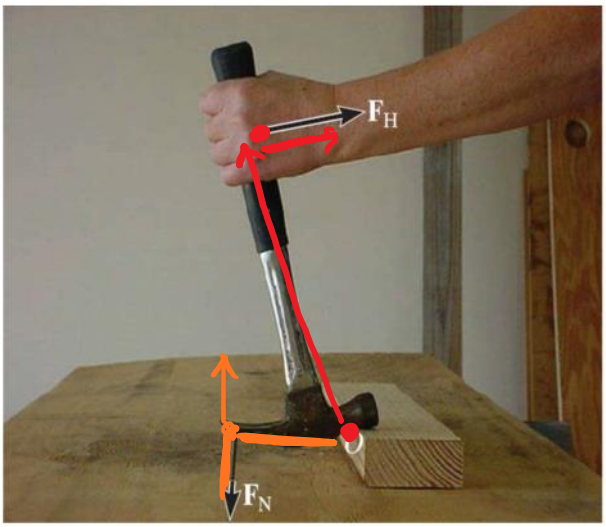
the sum of forces $\Sigma F_y = 0$, translational EM.

but what About:

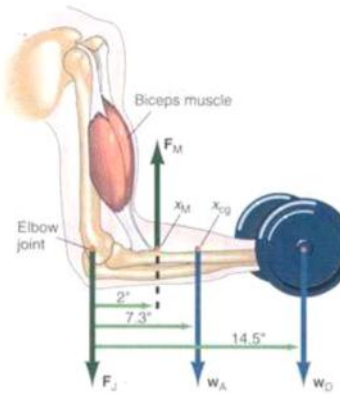


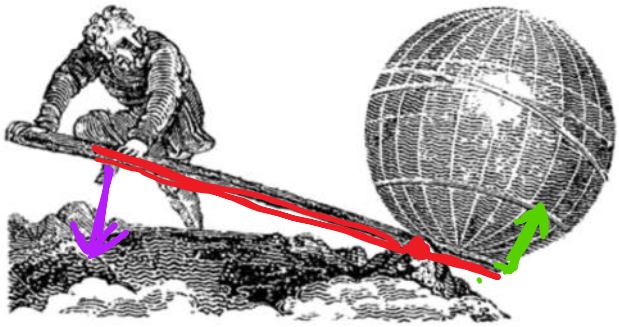
sum of forces $\Sigma F_y = 0$, but you Know this Will ROTATE!

Applications



Carpenters often use a hammer in this way to pull a stubborn nail. Through what sort of action does the force F_H at the handle pull the nail? How can you mathematically model the effect of force F_H at point O?





Moment 1.a very brief period of time. An Exact point in time. 2. importance. 3. A turning Effect produced by a force acting at a distance on An object.

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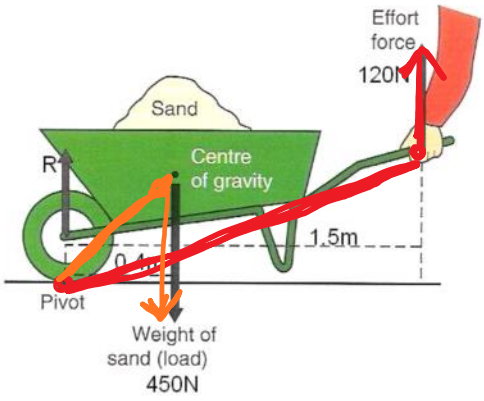
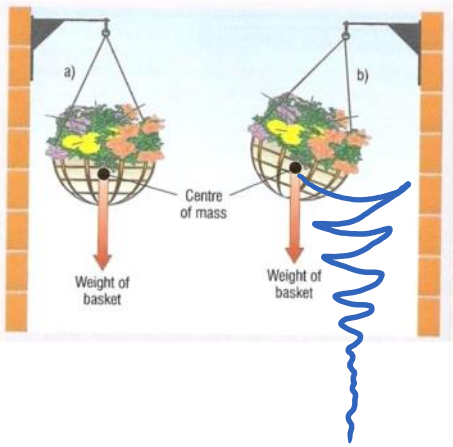
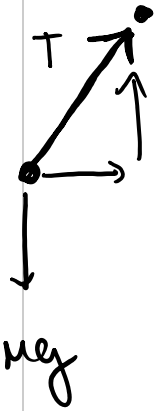
Applications

Using moments



If suspended, a body will come to rest with its centre of mass directly below the point of suspension.

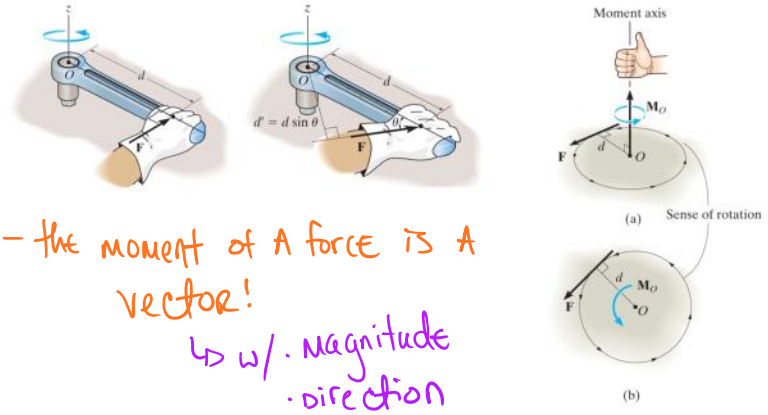




Moment 1.a very brief period of time. An Exact point in time. 2. importance. 3. A turning Effect produced by a force acting at a distance on An object.

Moment of a force – scalar formulation

The **moment of a force about a point** provides a measure of the **tendency for rotation** (sometimes called a torque).



- the moment of a force is a vector!
  - ↳ w/. magnitude
  - direction

- magnitude $M_o = dF$

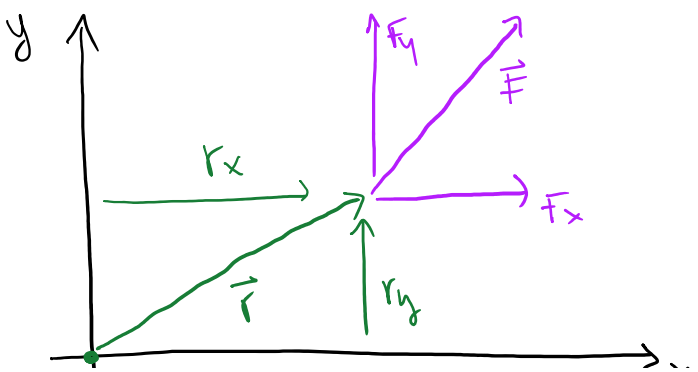
IMPORTANT FOR:

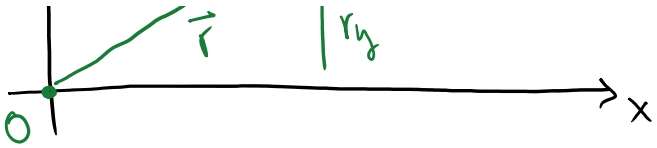
* Rigid bodies.
* Line of Action of a force not acting on point of rotation

- d is perp or shortest dist. from point O to line of action of $\vec{F}$.
  - ↳ geometric rep. of applied force.

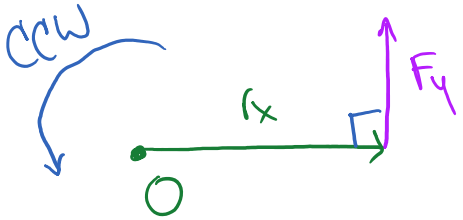
- direction: perpendicular to the plane that contains $\vec{F}$ and moment arm $\vec{d}$
  - * use the right hand rule $\vec{d} \times \vec{F}$

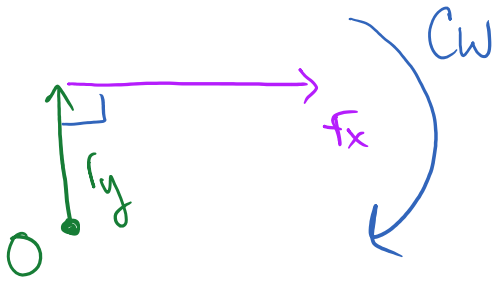
- Scalar formulation:
  - $\vec{F}$ and $\vec{d}$ are 2-dimensional.





look for components that ARE perp.





$$\vec{M} = (r_x F_y - r_y F_x)\,\hat{k} \quad N \cdot m$$

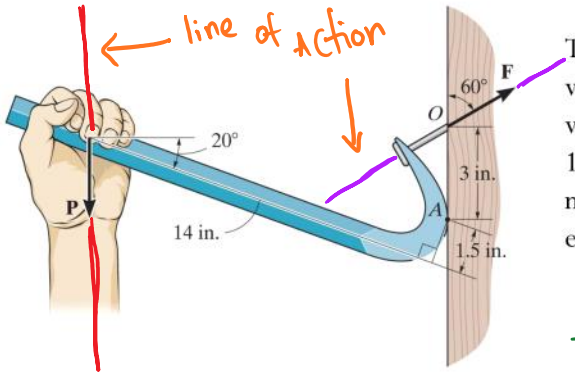
Newton · meter

* moment is A vector with units lb · ft

* CCW - counter clockwise moments - positive

* CW - clockwise moments - negative

Moment of a force – scalar formulation

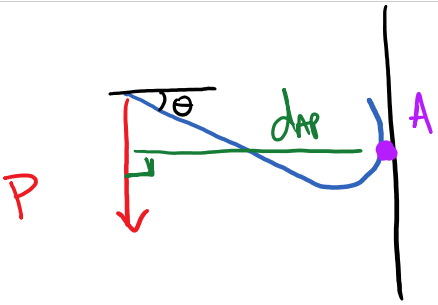


The crowbar is subjected to a vertical force of P = 25 lb, whereas it takes a force of F = 155 lb at the claw to pull the nail out. Find the moment of each force about point A.

given: mag. and dir of $\vec{P}$, $\vec{F}$

find: $\vec{M}_P$ and $\vec{M}_F$ about A

First, find $\vec{M}_P$



$\vec{M}_P = d_{AP} P$

L_D moment arm

using the diagram, find d_{AP}

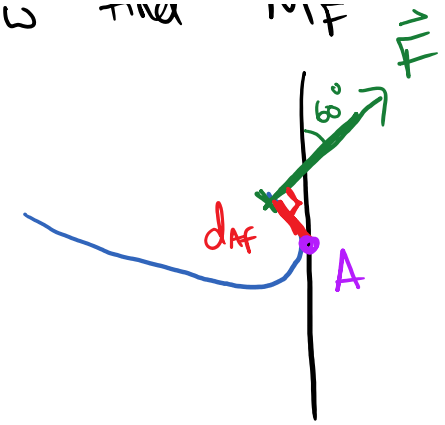
$$d_{AP} = 14\cos(20) + 1.5\sin(20)$$

therefore

$$\vec{M}_P = d_{AP}P = 25\left(14\cos(20) + 1.5\sin(20)\right) = 341 \text{ in·lb CCW}$$

Now find $\vec{M}_F$ ≥

Now find M_F



$$\vec{M}_F = d_{AF} F$$

$$\vec{M}_F = d_{AF} F = 155(3\sin(60)) = \boxed{403 \text{ in lb} \quad CW}$$

Since $M_F > M_P$, $P = 25$ lb is NOT sufficient to pull out the nail