Statics - TAM 210 & TAM 211

Lecture 10

February 7, 2018

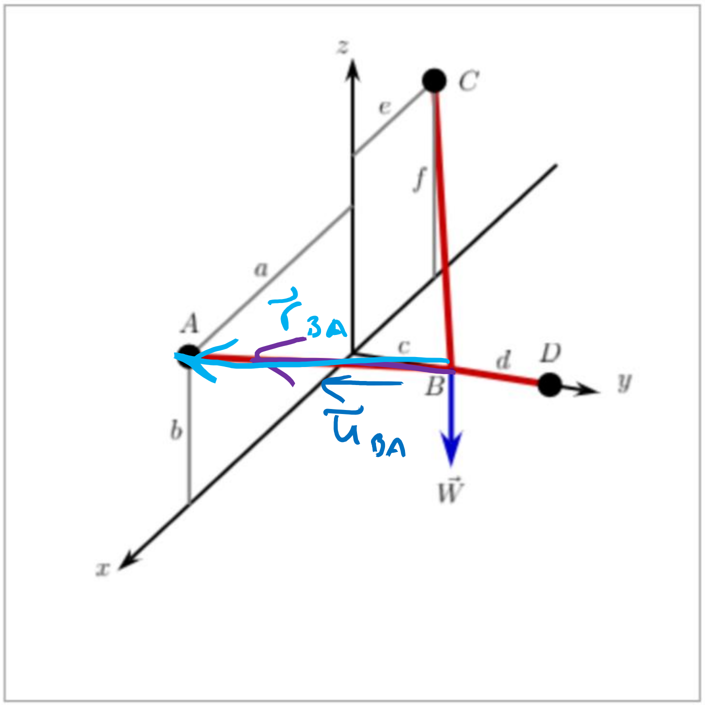
Announcements

- Register your i>clicker on Compass2g if you joined class late
- Upcoming deadlines:
- Quiz 2 (2/7-9)
  - Reserve testing time at CBTF
  - Lectures 5-9
- Friday (2/9)
  - Mastering Engineering Tutorial 5
- Tuesday (2/13)
  - PL Homework 4

HW 2 – let's think about how to solve this problem

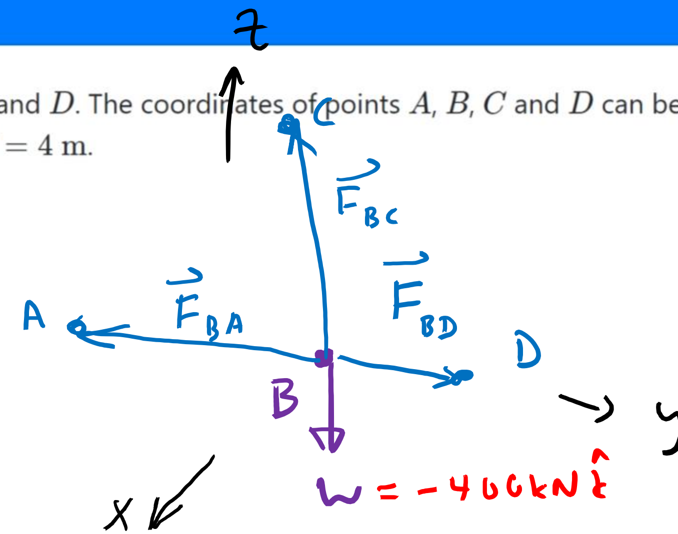
Determine force in the rod

Three rods support a vertical weight $\vec{W} = -400\,\hat{k}$ N at B. The rods are fixed at A, C and D. The coordinates of points A, B, C and D can be obtained using the dimensions $a = 8$ m, $b = 3$ m, $c = 2$ m, $d = 2$ m, $e = 4$ m and $f = 4$ m.



Find $\vec{F}_{BA}$

FBD @ B :



$$\vec{r} \rightarrow \vec{u} \rightarrow \vec{F}$$

$$\vec{F}_{BA} = |F_{BA}|\,\vec{u}_{BA}$$

$$\vec{u}_{BA} = \frac{\vec{r}_{BA}}{|\vec{r}_{BA}|} = \frac{\overset{8}{a}\,\hat{i} - \overset{2}{c}\,\hat{j} + \overset{3}{b}\,\hat{k}}{\sqrt{a^2 + (-c)^2 + b^2}} = u_{BAx}\hat{i} + u_{BAy}\hat{j} + u_{BAz}\hat{k}$$

$$\vec{F}_{BA} = \underset{?}{|F_{BA}|}\,(\underset{\checkmark}{u_{BAx}}\hat{i} + \underset{\checkmark}{u_{BAy}}\hat{j} + \underset{\checkmark}{u_{BAz}}\hat{k})$$

? = unknown, √ = known by plugging in geometry

$$\vec{F}_{BC} = |F_{BC}|\,(u_{BCx}\hat{i} + u_{BCy}\hat{j} + u_{BCz}\hat{k})$$

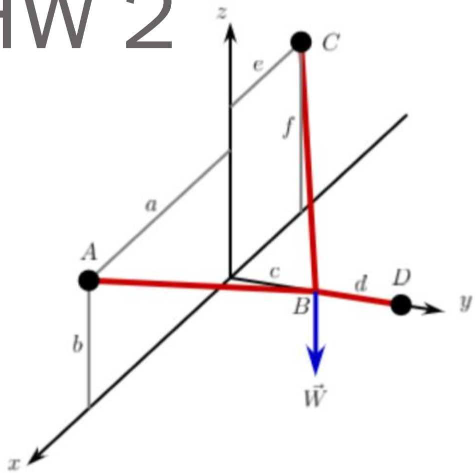
$$\vec{F}_{BD} = |F_{BD}|\,(\cancel{u_{BDx}}\hat{i} + u_{BDy}\hat{j} + \cancel{u_{BDz}}\hat{k})$$

F_{BD} does not have x & z components since only along y-axis

Matlab/Mathematica input:

```
a = 8;
b = 3;
c = 2;
d = 2;
```

HW 2



Write out system of equations based on the FBD @ point B

$$\Sigma F_x: |F_{BA}| u_{BAx} + |F_{BC}| u_{BCx} = 0$$

$$\Sigma F_y: |F_{BA}| u_{BAy} + |F_{BC}| u_{BCy} + |F_{BD}| u_{BDy} = 0$$

$$\Sigma F_z: |F_{BA}| u_{BAz} + |F_{BC}| u_{BCz} - W = 0$$

3 eqns, 3 unknowns $|F_{BA}|, |F_{BC}|, |F_{BD}|$

A cautionary tale: Since # equations ≥ # unknowns, this is a determinate system, so you can solve the problem by simultaneously solving the series of equations. One could solve this problem by hand (i.e., plugging in terms from one equation into another equation). Some of you might try to use a programmable calculator or MATLAB. The following explains what information to insert into the MATLAB command *linsolve*. Should you want to use this command (or the linear solver on your calculator), <u>it is important that you know what information that you are inserting, and why. Otherwise you could be setting yourself up for errors or incorrect answers.</u> If you have not taken a course that discusses matrix algebra (or linear algebra, e.g., MATH 415), then be cautious about using a computational approach to solving a series of equations. "Garbage in = Garbage out"

$$\underbrace{\begin{bmatrix} u_{BAx} & u_{BCx} & u_{BDx} \\ u_{BAy} & u_{BCy} & u_{BDy} \\ u_{BAz} & u_{BCz} & u_{BDz} \end{bmatrix}}_{A} \underbrace{\begin{Bmatrix} |F_{BA}| \\ |F_{BC}| \\ |F_{BD}| \end{Bmatrix}}_{X} = \underbrace{\begin{Bmatrix} 0 \\ 0 \\ W \end{Bmatrix}}_{B}$$

A: 3x3 (r c)

X: 3x1 ?

MATLAB. linsolve

x = linsolve[A, B]

Chapter 4: Force System Resultants

Goals and Objectives

- Discuss the concept of the moment of a force and show how to calculate it in two and three dimensions
- How to find the moment about a specified axis
- Define the moment of a couple
- Finding equivalence force and moment systems
- Reduction of distributed loading

Recap from lecture 9:

- **Moment of a force couple** ($\vec{F}$ and $-\vec{F}$)
  - $\overrightarrow{M_O} = \vec{r} \times \vec{F}$, $|\overrightarrow{M_O}| = Fd$ (where d ≈ ⊥ dist btw $\vec{F}$ and $-\vec{F}$)
  - Couple moment is a **free vector**, i.e. it is **independent** of the choice of location of O!
  - Rotate your i>clicker: apply equal & opposite (not co-linear) forces by each index finger, with **<u>same</u>** small force magnitude & gap between fingers, change locations along i>clicker. Does it have the same rotation?

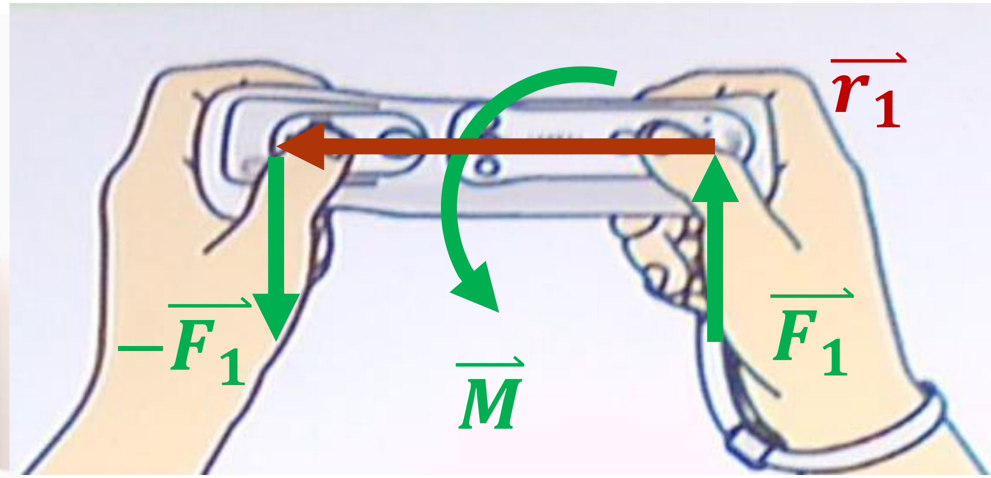
- **Equivalent couples**
  - Rotate your i>clicker: ↑ (or ↓) force magnitude and ↓ (or ↑) gap to get the same rotation. $M_O = F\,d$

- **Resultant couple moment**
  - $\overrightarrow{M_R} = \Sigma \overrightarrow{M_i}$

Moment of a force

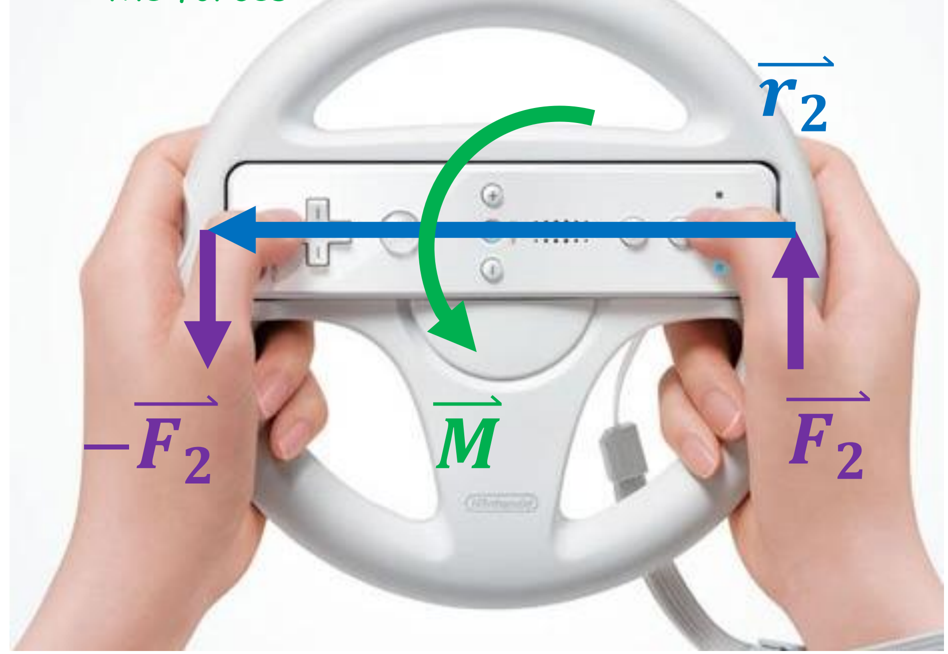
$\overrightarrow{M}$ is a free vector. It can be placed anywhere on the body, and still create a tendency for a rotation

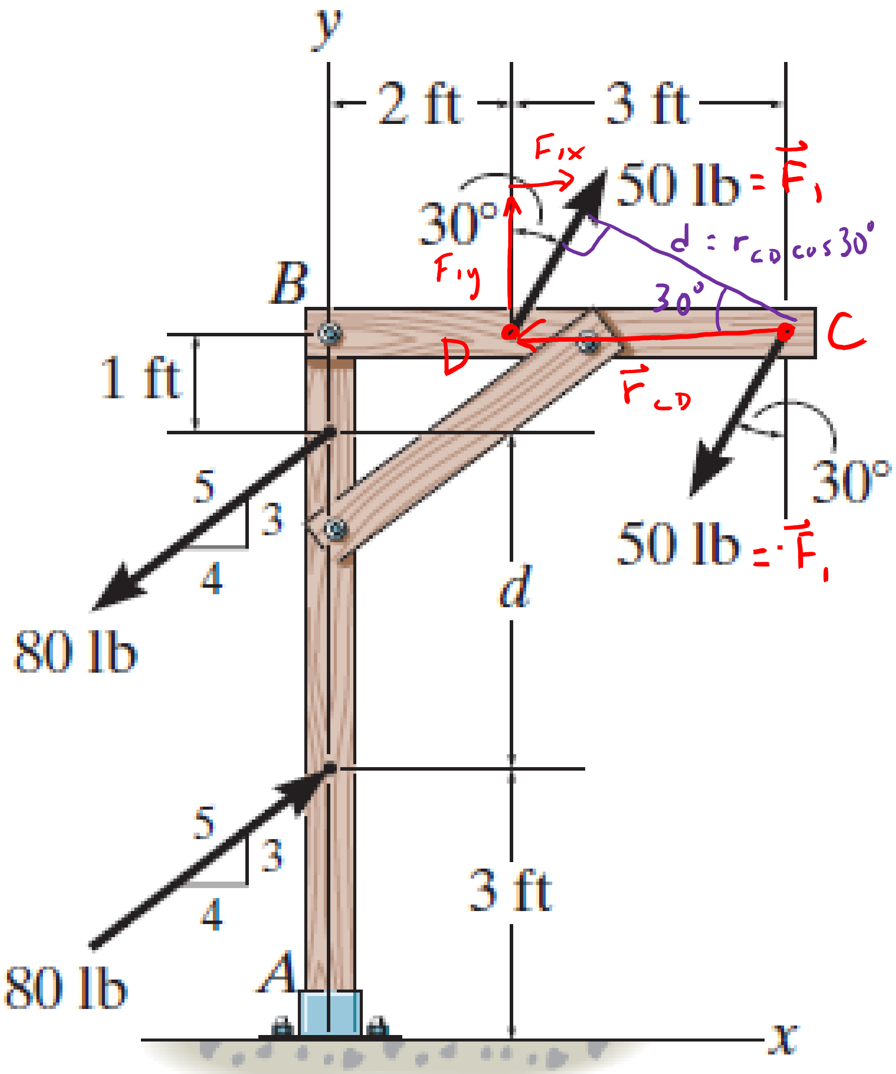
Moment of a force couple and equivalent couples



$\vec{M}$ can be created with just one force or a force couple

The same $\vec{M}$ can be created with different pairings of force magnitude and distance between the forces





Two couples act on the beam with the geometry shown and d = 4 ft. Find the resultant couple

In response to student question about couple moment when $\vec{r}$ is not $\perp$ to $\vec{F}$:

For upper beam, what is the Moment due to the 50lb force couple? Find: $\vec{M}_{upper}$

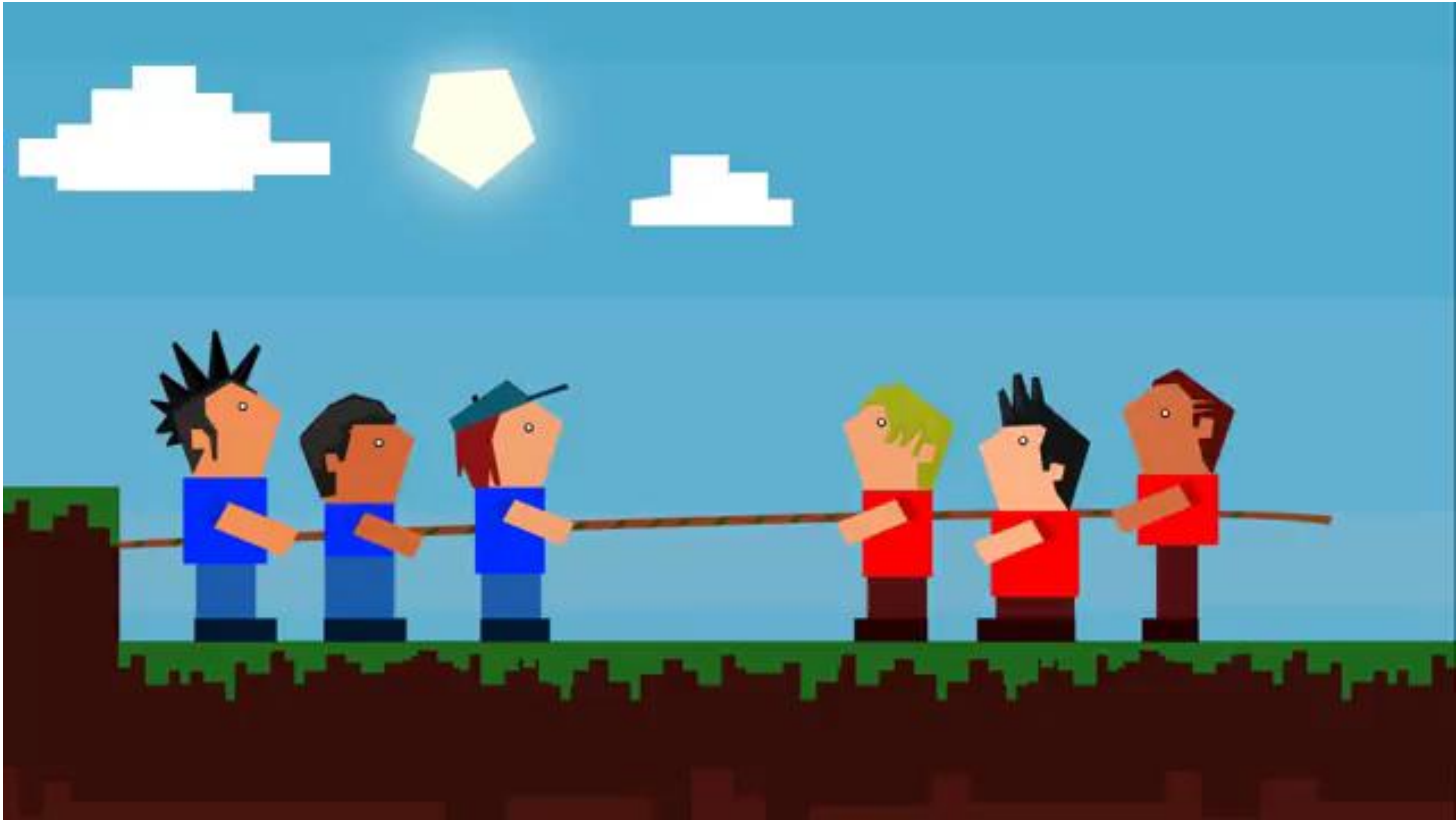
$$\vec{M}_{upper} = \vec{r} \times \vec{F}$$
$$= \vec{r}_{CD} \times \vec{F}_1$$
$$= (-3\text{ft}\,\hat{i}) \times 50(\sin 30\,\hat{i} + \cos 30\,\hat{j})\text{lb}$$
$$= -130\text{ ft}\cdot\text{lb}\,\hat{k}$$

Alternatively, where d is $\perp$ distance

$$|M_{upper}| = dF$$
$$= (|r_{CD}|\cos 30°\text{ ft})(50\text{ lb})$$
$$= (3\cos 30°)\,50\text{ ft}\cdot\text{lb}$$
$$= 130\text{ ft}\cdot\text{lb ccw } (-\hat{k})$$
$$\vec{M}_{upper} = -130\text{ ft}\cdot\text{lb}\,\hat{k} \quad \checkmark \text{ same}$$

Due to running out to time, we'll address the typed problem statement in our next lecture. Hint to find M_R, need to also determine M_{lower}, such that
$M_R = M_{upper} + M_{lower}$

Moving a force on its line of action



https://www.wikihow.com/Win-at-Tug-of-War