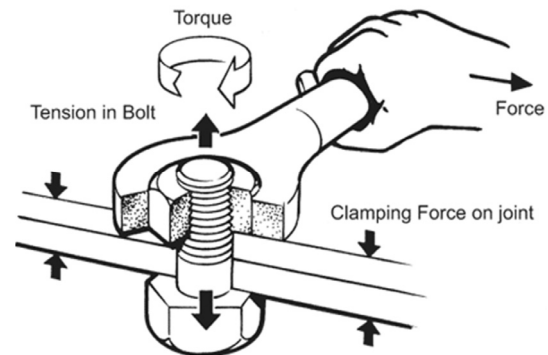


## Moment of a Force



Definition  
Sign convention  
Overturning Force  
Varignon's Theorem  
Force Couples  
Eccentric Loads

## Moment of a Force

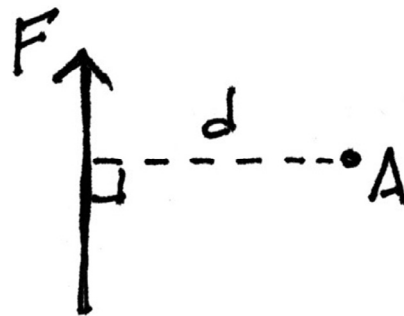
The moment about A due to force F is:

$$M_A = F (d)$$

$M_A$  is the moment about A

F is the force

d is the perpendicular distance between  
the force path and the point A



## Moment of a Force (video)



Mike Guido

<https://www.youtube.com/watch?v=Sl7Usu5jktA>

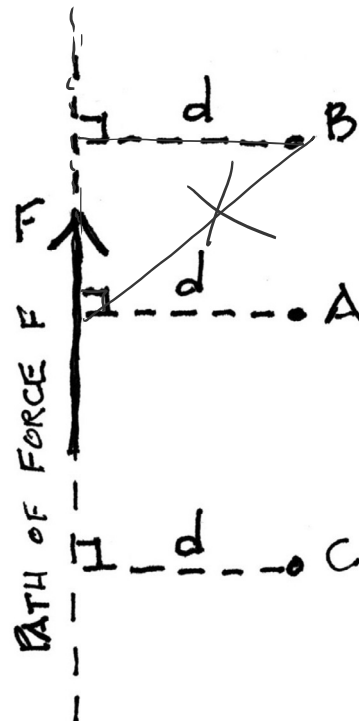
## Moment of a Force

$$M_A = F(d)$$

$$M_B = F(d)$$

$$M_C = F(d)$$

$d$  is always the perpendicular distance between the force path and the point about which the moment is taken



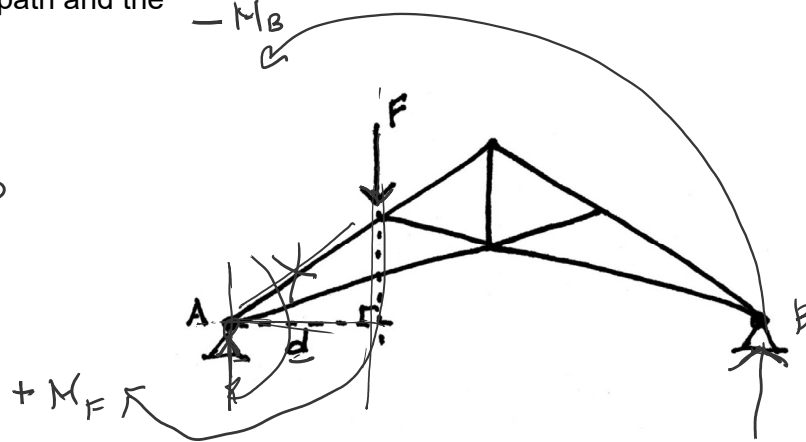
# Moment of a Force

$$M_A = F(d)$$

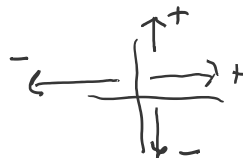
$d$  is the perpendicular distance between the force path and the point A

$$\sum M = 0$$

$$+M_F - M_B = 0$$



# Moment of a Force

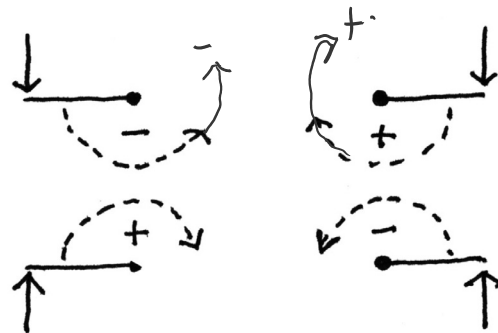


Sign convention (sense)

Clockwise is +

Counter clockwise is -

Moments add using sign.



# Stability Against Overturning

The overturning moment should be less than the resisting Moment (gravity)

$$M_O < M_R$$

OVERTURNING MOMENT,  $M_O$

$$F_{WIND} \times \frac{h_{WALL}}{2}$$

$$240 \text{ LBS} \times 5 \text{ FT} = 1200 \text{ '}\cdot\text{'}$$

RESISTING MOMENT,  $M_R$

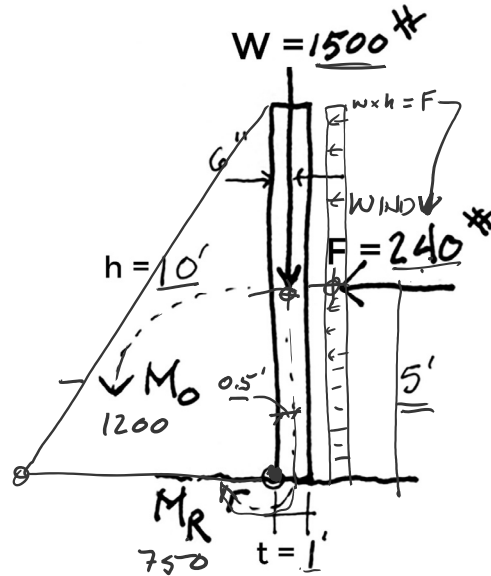
$$W_{CONC} \times \frac{t_{WALL}}{2}$$

$$1500 \text{ LBS} \times 0.5 \text{ FT} = 750 \text{ '}\cdot\text{'}$$

$1200 \text{ '}\cdot\text{'}$  >  $750 \text{ '}\cdot\text{'}$   
 $\therefore$  WALL FAILS!

Example:

concrete wall at 150 PCF  
 wind at 24 PSF

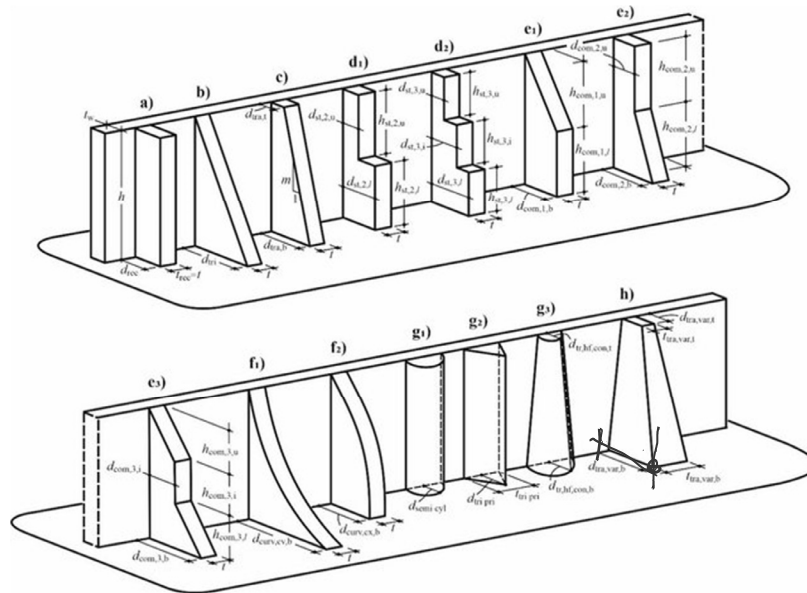


# Stability Against Overturning

$$M_O < M_R$$

Resisting Moment (gravity) must be greater than the overturning moment.

By increasing the length of the buttress, the thrust of the arch is resisted.



## Stability Against Overturning

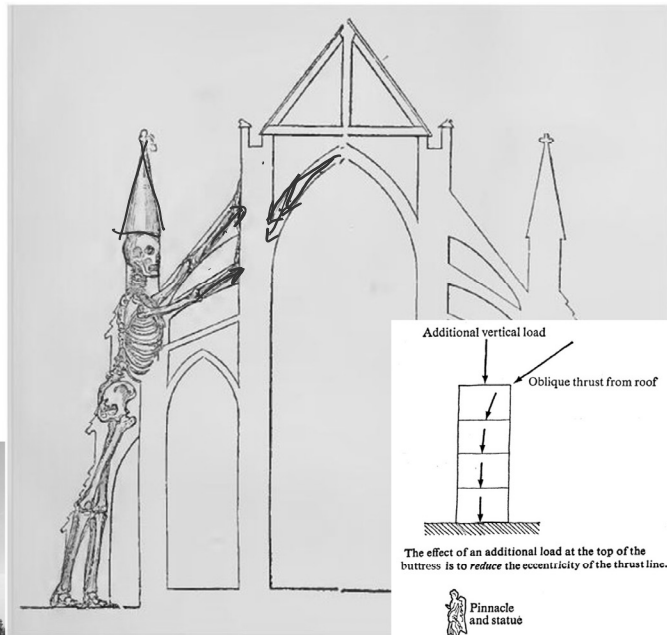
Resisting Moment (gravity) must be greater than the overturning moment.

$$M_O < M_R$$

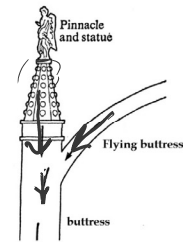
By increasing the weight of the wall with the pinnacle, the thrust of the arch is resisted.



University of Michigan, TCAUP



Bartholomew, (1840)

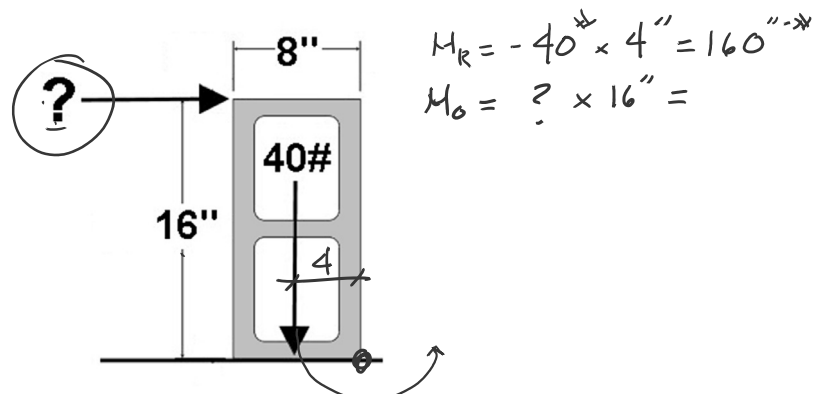


Structures I

Slide 9 of 19

## Overturning Moment

What force in pounds applied 16 inches above the base would be required to overturn the 8" CMU? Show on the sketch the balance of moment forces (overturning vs. resisting moments) and circle the point about which they are taken.

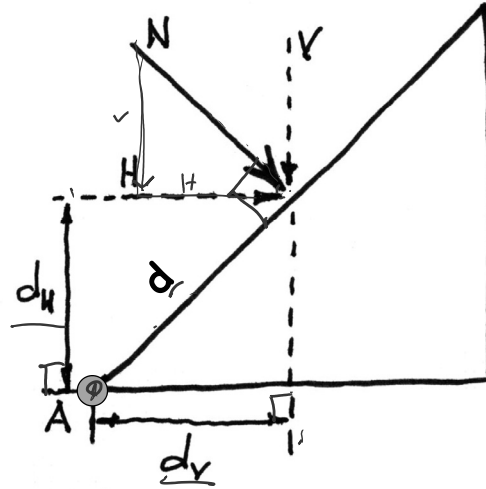


# Moment of a Force

Varignon's Theorem

A moment is equal to the sum of the moments of its components

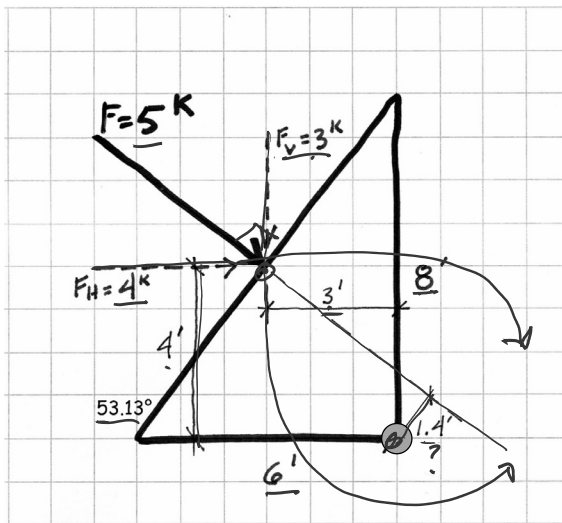
$$N(d) = H(d_H) + V(d_V)$$



# Moment of a Force

Varignon's Theorem

$$K_{ip} = 1000 \text{ *}$$



$$F_V = 5 (\cos 53.13^\circ) = 3^k$$

$$F_H = 5 (\sin 53.13^\circ) = 4^k$$

$$M = -3^k(3') \oplus 4^k(4') = 7^k - 1$$

OR

$$M = 5(1.4') = 7^k - 1$$

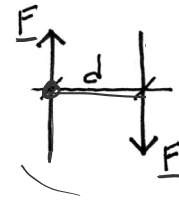
# Force Couple

A force couple is a pair of equal, parallel forces acting in opposite directions.

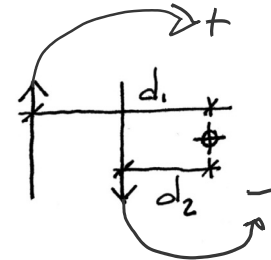
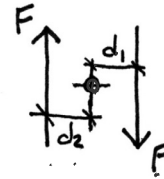
A force couple results in a moment equal to one force times the perpendicular distance between the forces.

The moment is also equal to both forces time the respective distances to some point.

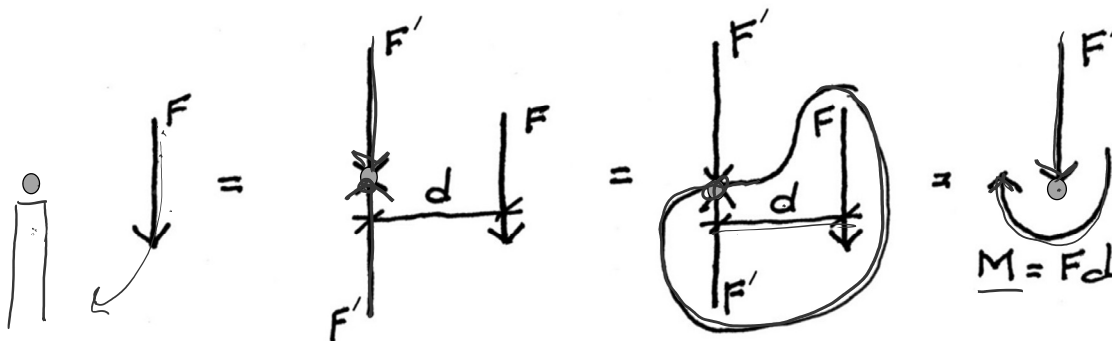
$$F d$$



$$F d_1/2 + F d_2/2$$

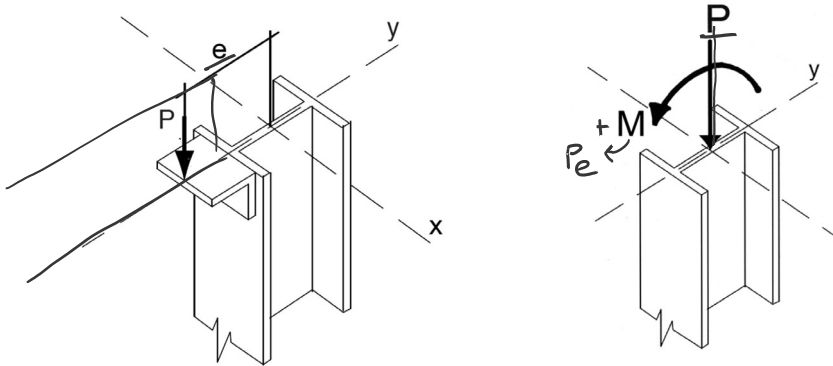


# Replacement of a force by a force + a couple



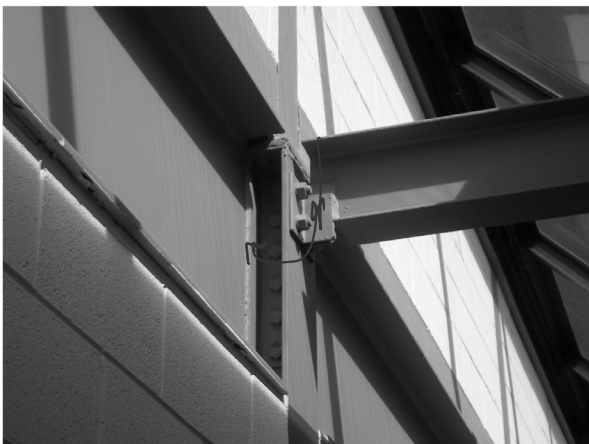
A force can be replaced (represented) by an equal force shifted some distance plus the moment of the original force times the shifted distance.

## Replacement of a force by a force + a couple



A force can be replaced (represented) by an equal force shifted some distance plus the moment of the original force times the shifted distance.

## Replacement of a force by a force + a couple





## Cantilever Moment

The support moment of a cantilever equals the force of the load times the distance to the support.

$$W = 1 \text{ Maß Bier} = 1 \text{ kg} = 2.2 \text{ lbs}$$

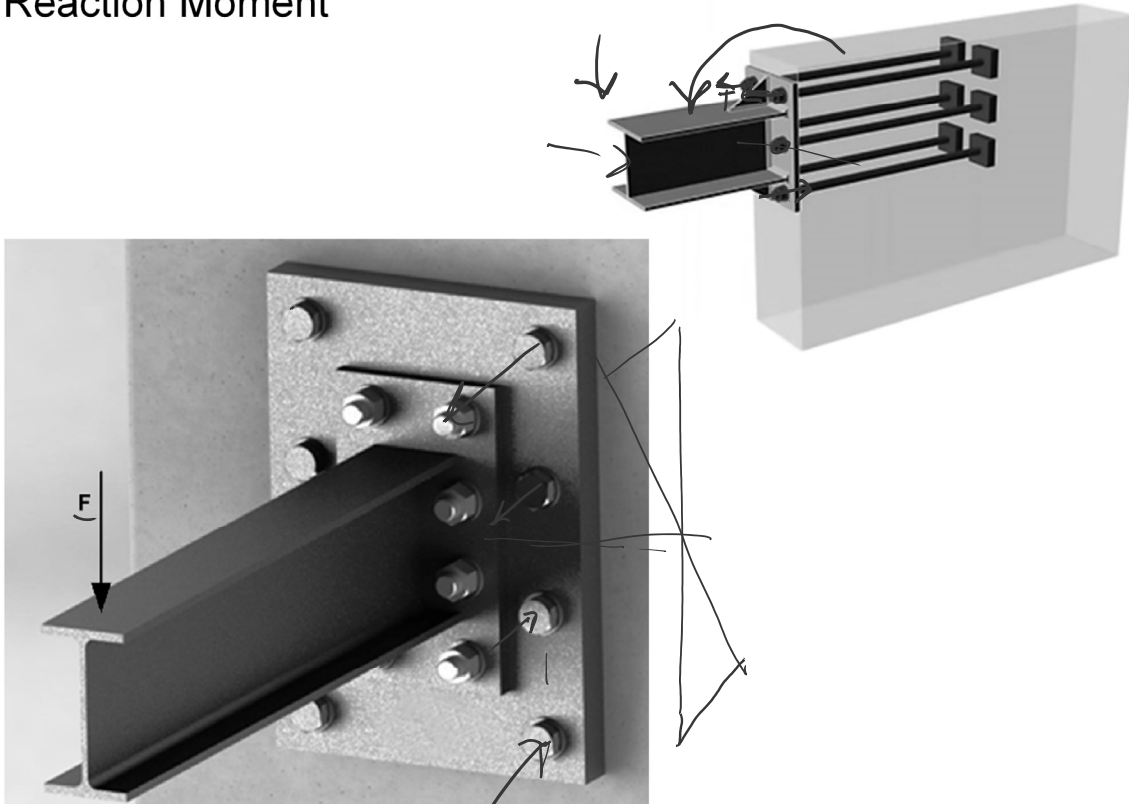
$$d = 2 \text{ ft}$$

$$\text{Moment} = W d = 2.2 \times 2 = 4.4 \text{ ft-lbs}$$



Oktoberfest – St Joseph Oratory, Detroit  
Saturday Sept. 21 & Sunday Sept. 22  
<http://www.institute-christ-king.org/detroit-oktoberfest>

## Reaction Moment



# Reaction Moment

## Example

1. Label components of reactions. Depending on the support condition, include vertical, horizontal and rotational.
2. Write an equation for the summation of horizontal forces. (if there is only one, it will be equal to zero)
3. Write an equation for the summation of vertical forces.
4. Write an equation for the summation of rotational forces (moments).
5. It is good practice to write one additional equation to check the results. In this case summation of rotational forces at B also = 0.

$$\sum V = 0 \quad \sum H = 0 \quad \sum M = 0$$

