Moment of a Force
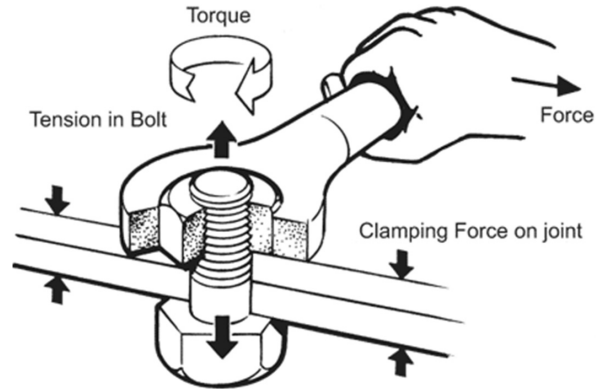

Definition
Sign convention
Overturning Force
Varignon's Theorem
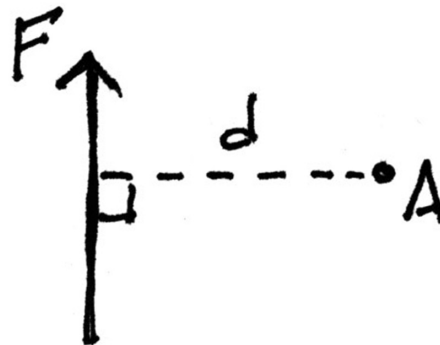Force Couples
Eccentric Loads

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)

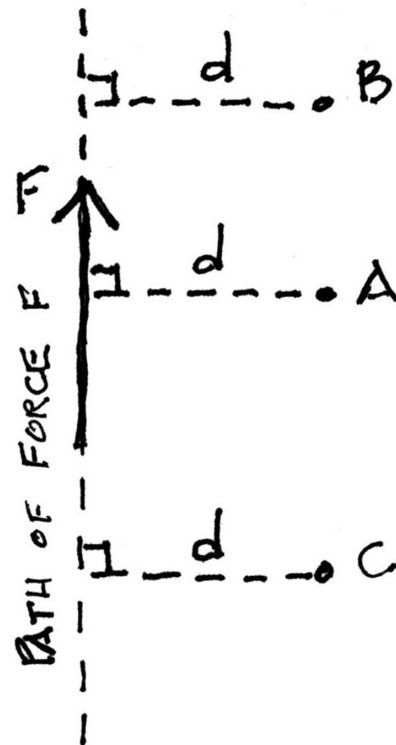Mike Guido   https://www.youtube.com/watch?v=Sl7Usu5jktA

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
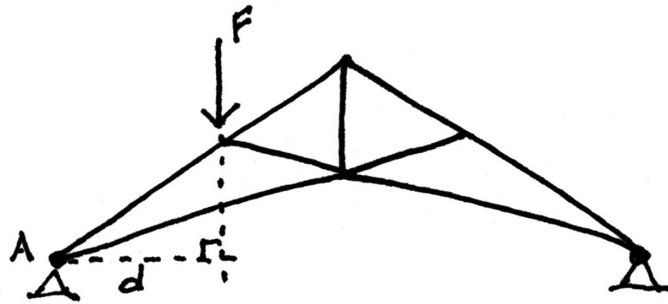
Moment of a Force

$M_A = F (d)$

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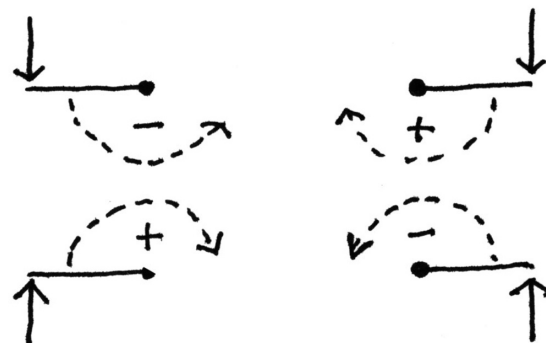between the force path and the
point A

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)

$$M_O < M_R$$

Example:

concrete wall at 150 PCF

wind at 24 PSF

OVERTURNING MOMENT, M_O

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

240 LBS $\times$ 5 FT = 1200 $'^{-\#}$

RESISTING MOMENT, M_R

$\overline{W}_{CONC} \times \dfrac{t_{WALL}}{2}$

1500 LBS $\times$ 0.5 FT = 750 $'^{-\#}$

1200 $'^{-\#}$ > 750 $'^{-\#}$

∴ WALL FAILS !

W = 1500 #

6"

h = 10'

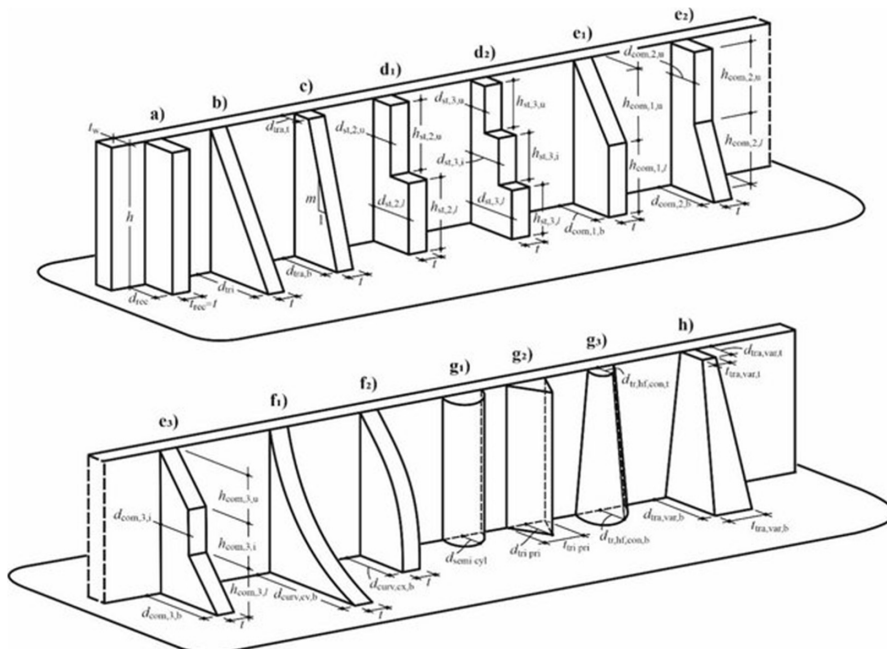M_O

F = 240 #

5'

M_R

t = 1'
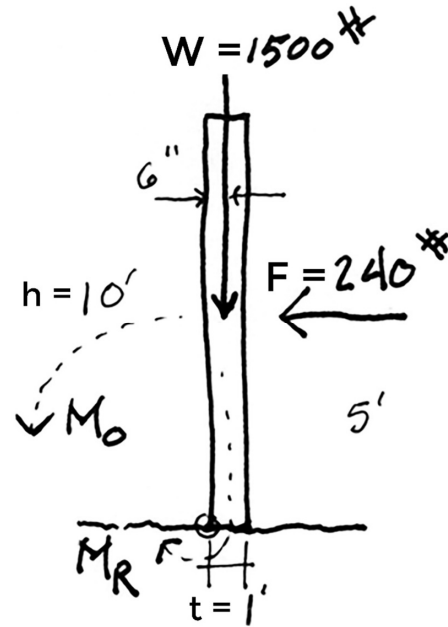
Stability Against Overturning

$$M_O < M_R$$

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

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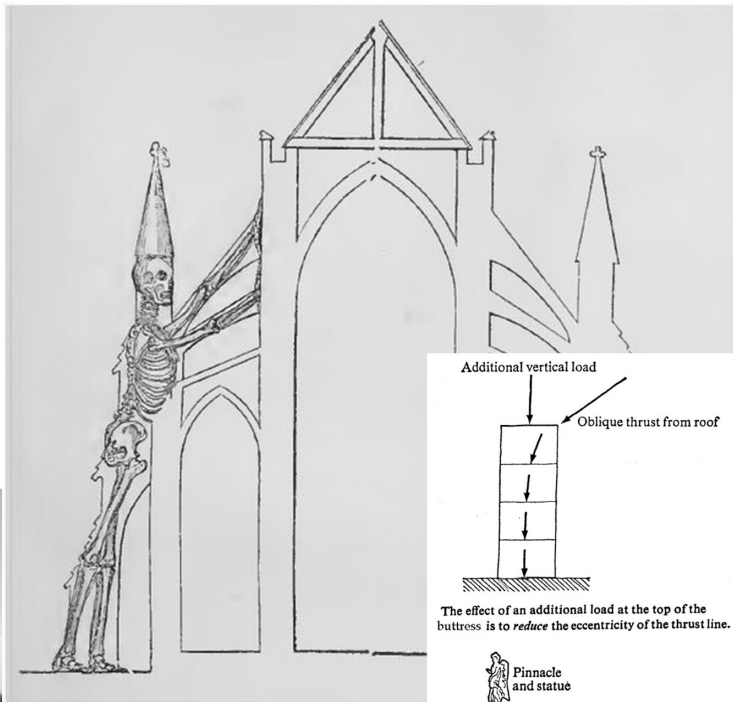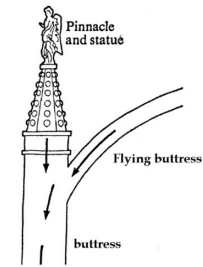
Stability Against Overturning

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.


Bartholomew, (1840)

Additional vertical load

Oblique thrust from roof

The effect of an additional load at the top of the buttress is to *reduce* the eccentricity of the thrust line.

Pinnacle and statue

Flying buttress

buttress

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.
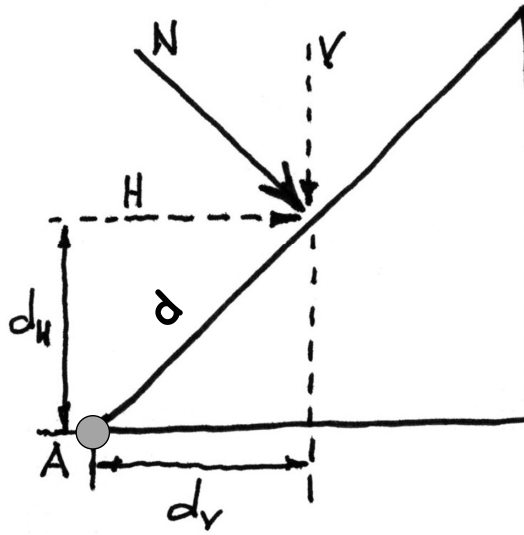

8"

?

40#

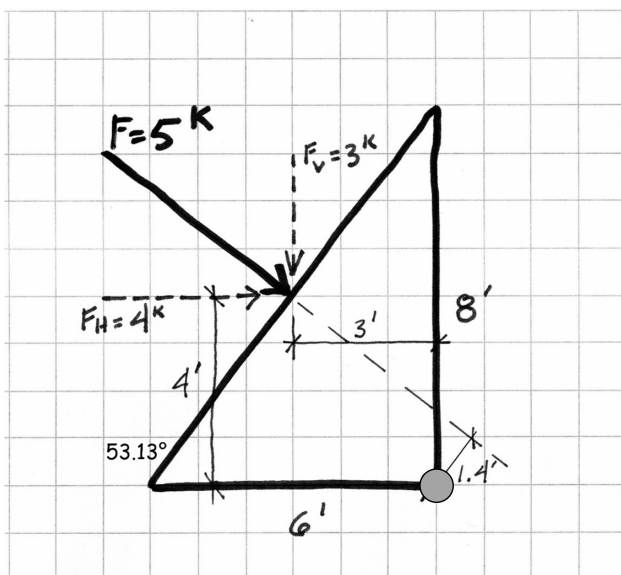**16"**
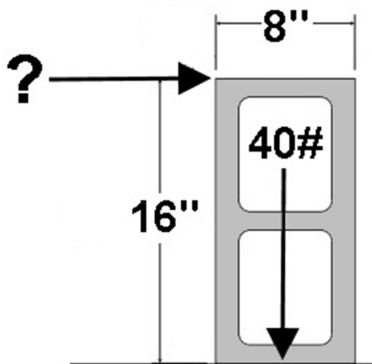
Moment of a Force

Varignon's Theorem

A moment is equal to the sum of the moments of it's components

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

Moment of a Force
Varignon's Theorem

$$F_v = 5 \ (\cos 53.13°) = 3^K$$

$$F_h = 5 \ (\sin 53.13°) = 4^K$$
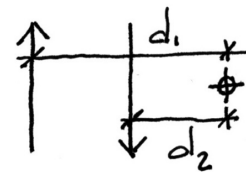
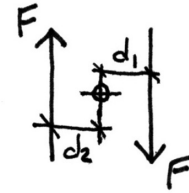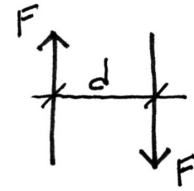$$M = -3^K(3') + 4^K(4') = 7^{K-1}$$
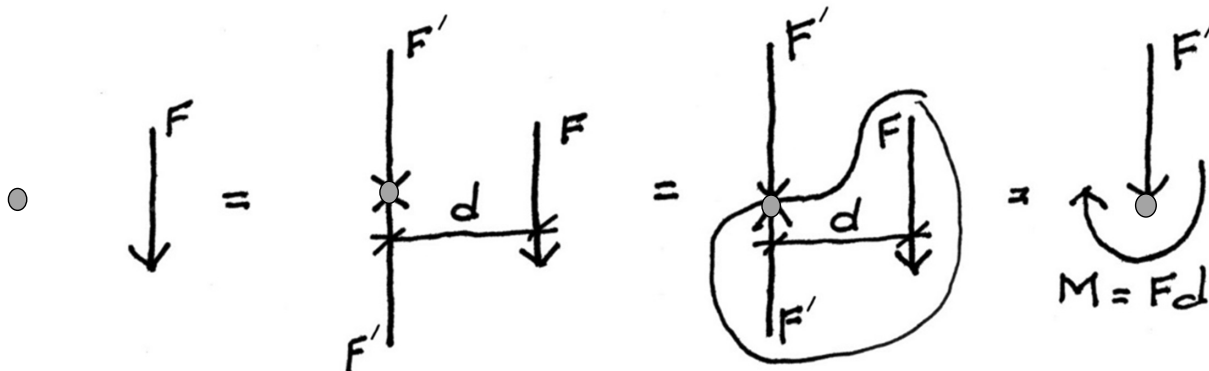
$$OR$$

$$M = 5 \ (1.4') = 7^{K-1}$$

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.

Replacement of a force by a force + a couple

$$M = Fd$$

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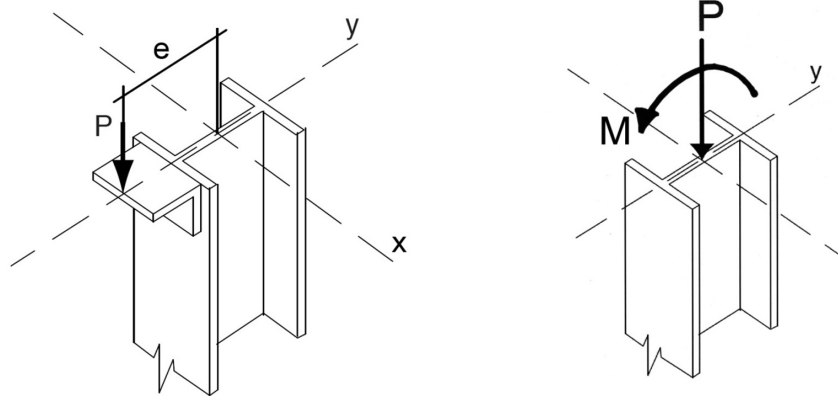
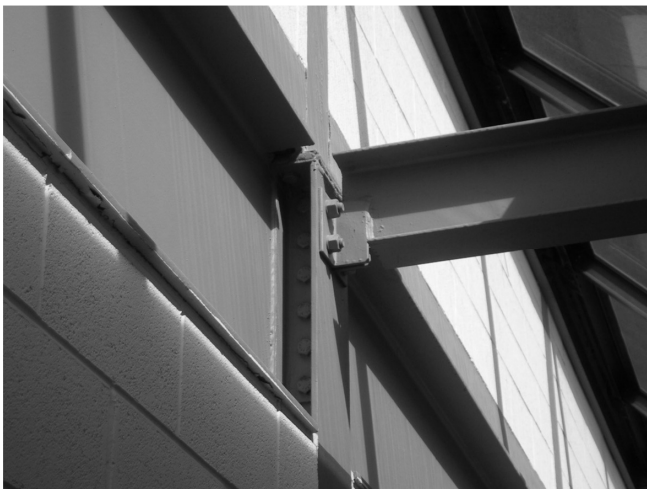# Replacement of a force by a force + a couple

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 Maß Bier = 1 kg =
   = 2.2 lbs

d = 2 ft

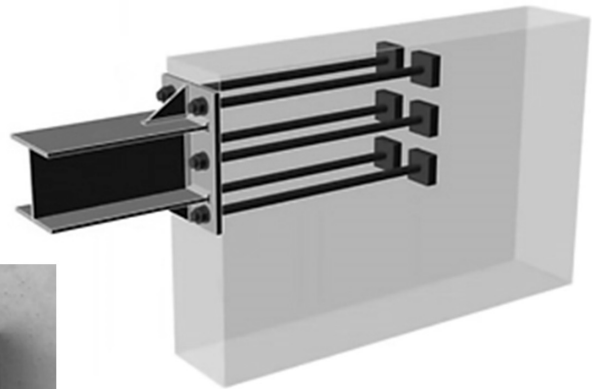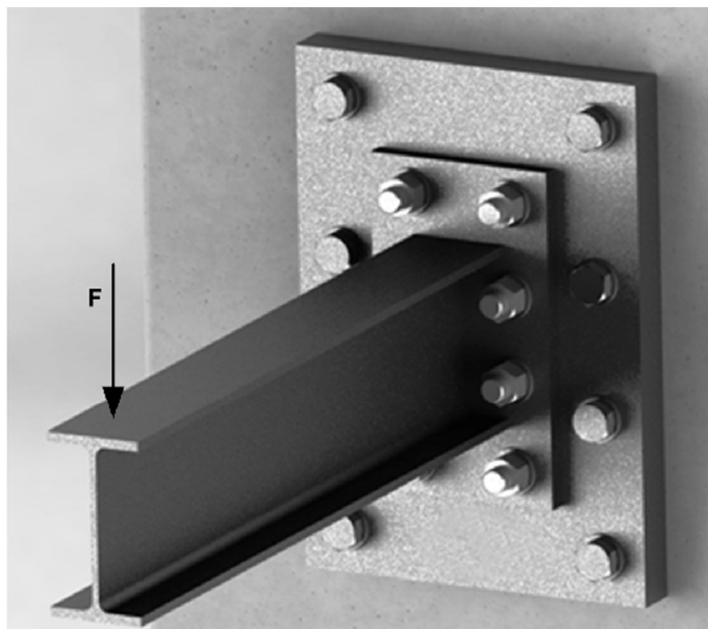Moment = W d = 2.2 x 2 =
   = 4.4 ft-lbs

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.
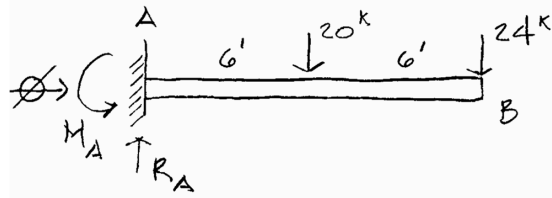
$$\Sigma F_v = 0$$
$$0 = R_A - 20 - 24$$
$$\underline{R_A = 44^k \uparrow}$$

$$\Sigma M = 0$$
$$0 = -M_A + 20(6) + 24(12)$$
$$\underline{M_A = 408^{k-'} \curvearrowright}$$