ARCHITECTURAL STRUCTURES I:
STATICS AND STRENGTH OF MATERIALS

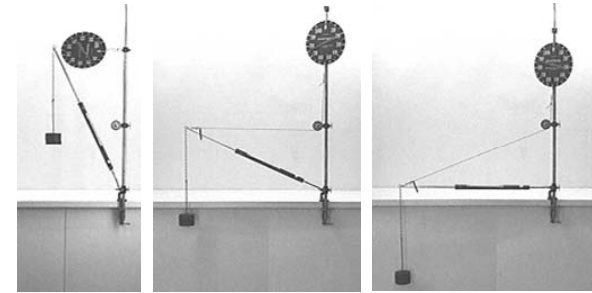*ENDS 231*

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FALL 2007

lecture
three

moments

Moments

- *forces have the tendency to make a body rotate about an axis*

– *same translation but different rotation*

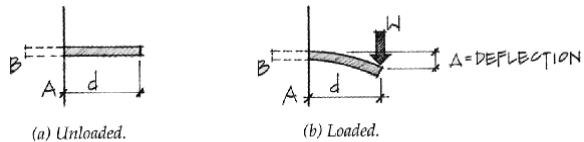## Moments

(a) Unloaded.   (b) Loaded.

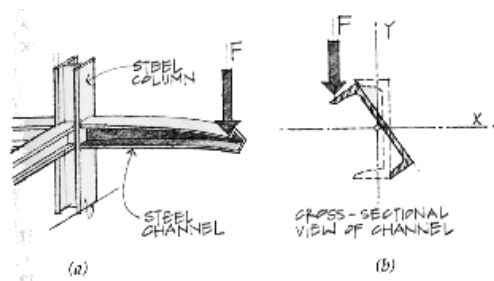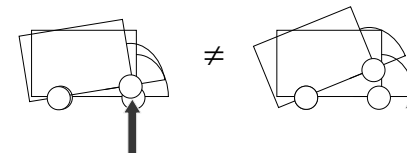Figure 2.33 Moment on a cantilever beam.

Figure 2.34 An example of torsion on a cantilever beam.

Moments
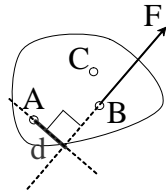
- *a force acting at a different point causes a different moment:*

Moments

- *defined by magnitude and direction*
- *units: N·m, k·ft*
- *direction:*
  - *+ ccw (right hand rule)*
  - *- cw*
- *value found from F and $\perp$ distance*

$$M = F \cdot d$$

- *d also called "lever" or "moment" arm*

Moments

- *with same F:*

$$M_A = F \cdot d_1 < M_A = F \cdot d_2$$
(bigger)

Moments

- *additive with sign convention*
- *can still move the force along the line of action*

$M_A = F\cdot d$
$M_B = F\cdot d'$

$+$

$M_A = F\cdot d$
$M_B = F\cdot d'$

Moments

- *Varignon's Theorem*
  - *resolve a force into components at a point and finding perpendicular distances*
  - *calculate sum of moments*
  - *equivalent to original moment*
- *makes life easier!*
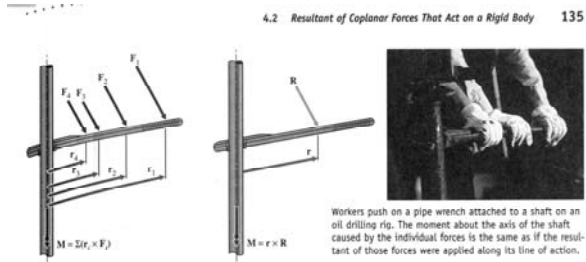 - *geometry*
  - *when component runs through point, d=0*

Physics & Moments of a Force

- *moments of a force*
  - *introduced in Physics as "Torque Acting on a Particle"*
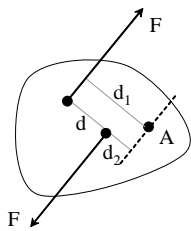 - *and used to satisfy rotational equilibrium*

4.2 *Resultant of Coplanar Forces That Act on a Rigid Body* **135**

Workers push on a pipe wrench attached to a shaft on an oil drilling rig. The moment about the axis of the shaft caused by the individual forces is the same as if the resultant of those forces were applied along its line of action.

$M = \Sigma(r_i \times F_i)$

$M = r \times R$

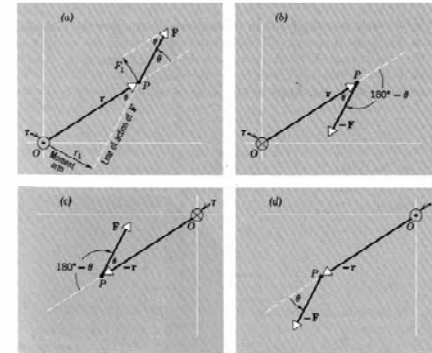## Physics and Moments of a Force

- *my Physics book:*

FIGURE 11–2 The plane shown is that defined by **r** and **F** in Fig. 11–1. (a) The magnitude of τ is given by $Fr_\perp$ (Eq. 11–2b) or by $rF_\perp$ (Eq. 11–2c). (b) Reversing **F** reverses the direction of τ. (c) Reversing **r** reverses the direction of τ. (d) Reversing **F** and **r** leaves the direction of τ unchanged. The directions of τ are represented by ⊙ (perpendicularly out of the figure, the symbol representing the tip of an arrow) and by ⊗ (perpendicularly into the figure, the symbol representing the tail of an arrow).

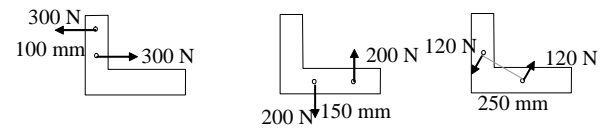## Moment Couples

- *2 forces*
  - *same size*
  - *opposite direction*
  - *distance d apart*
  - *cw or ccw*

$$M = F \cdot d$$

- *not dependant on point of application*

$$M = -F \cdot d = -F \cdot d_1 + F \cdot d_2$$

Moment Couples

- *equivalent couples*
  - *same magnitude and direction*
  - *F & d may be different*

Moment Couples

- *added just like moments caused by one force*
- *can <u>replace</u> two couples with a single couple*

300 N
100 mm → 300 N + 200 N ↑ 200 N ↓ 150 mm = 240 N 240 N 250 mm

Moment Couples

- *moment couples in structures*
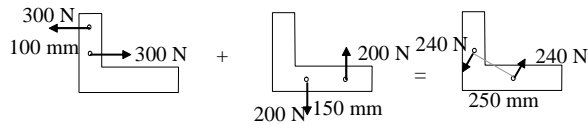
Equivalent Force Systems

- *two forces at a point is equivalent to the resultant at a point*
- *resultant is equivalent to two components at a point*
- *resultant of equal & opposite forces at a point is zero*
- *put equal & opposite forces at a point (sum to 0)*
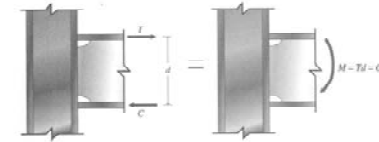- *transmission of a force along action line*
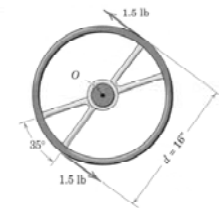
Force-Moment Systems

- *single force causing a moment can be replaced by the same force at a different point by providing the moment that force caused*
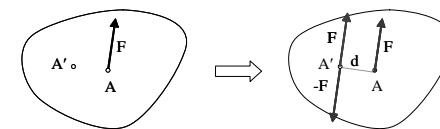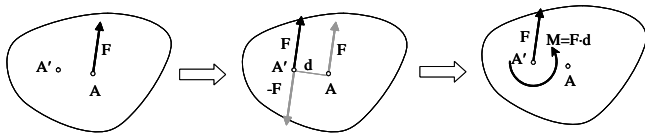
- *moments are shown as arched arrows*

Force-Moment Systems

- *a force-moment pair can be replaced by a force at another point causing the original moment*

Parallel Force Systems
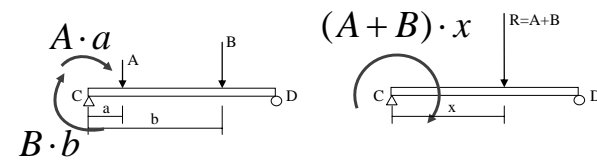
- *forces are in the same direction*
- *can find resultant force*
- *need to find <u>location</u> for equivalent moments*