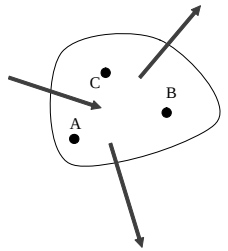
ARCHITECTURAL STRUCTURES I:
STATICS AND STRENGTH OF MATERIALS
ENDS 231
DR. ANNE NICHOLS
SPRING 2008

lecture
five

rigid body equilibrium

Equilibrium

- *rigid body*
  - *doesn't deform*
  - *coplanar force systems*
- *static:*



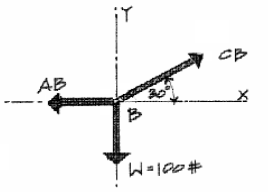
$$R_x = \sum F_x = 0$$

$$R_y = \sum F_y = 0$$

$$M = \sum M = 0$$

Free Body Diagram

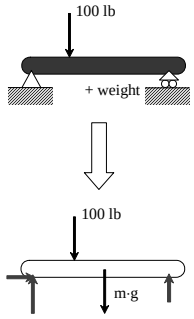
- *FBD (sketch)*
- *tool to see all forces on a body or a point including*
  - *external forces*
  - *weights*
  - *force reactions*
  - *external moments*
  - *moment reactions*
  - *internal forces*



(Example 1)

Free Body Diagram

- *determine body*
- *FREE it from:*
  - *ground*
  - *supports & connections*
- *draw all external forces acting ON the body*
  - *reactions*
  - *applied forces*
  - *gravity*

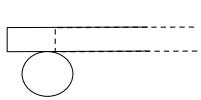


Free Body Diagram

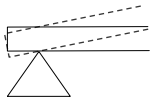
- *include relevant geometry*
  - *guidelines helpful to see moment arms*
- *name and/or color the unknown*
  - *forces*
  - *moments*
  - *angles*
- *solve up to 3 equations*

Reactions

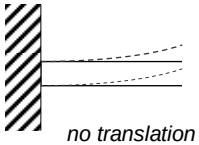
- *result of applying force*
- *unknown size*
- *connection or support type*
  - *known direction*
  - *related to motion prevented*



no vertical motion

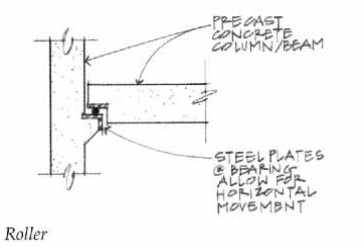


no translation

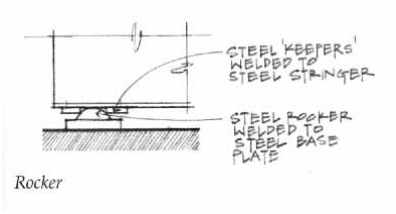


no translation
no rotation

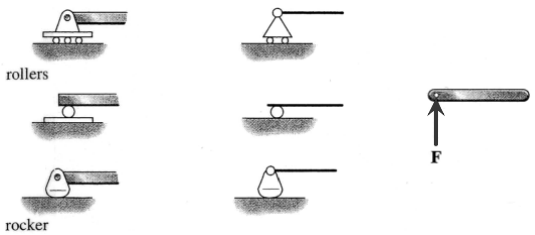
Supports and Connections



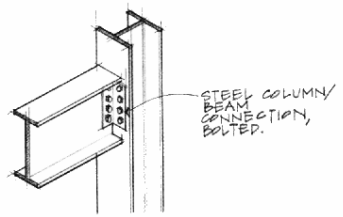
Roller



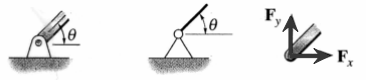
Rocker



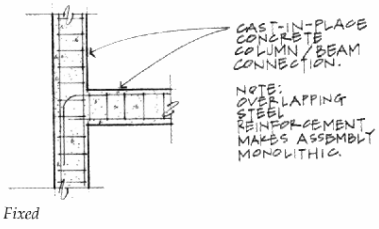
Supports and Connections



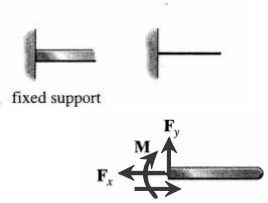
Pin



smooth pin or hinge

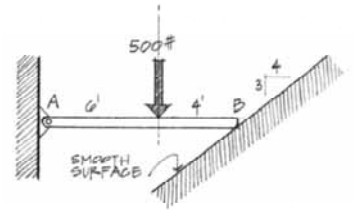


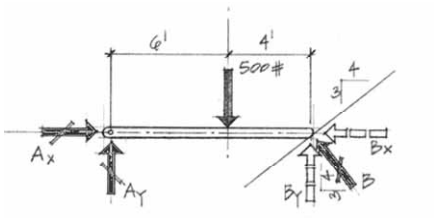
Fixed



FBD Example

- *500 lb known*
- *pin – A_x, A_y*
- *smooth surface – B at 4:3*
- *3 equations*
- *sum moments at*
  - *– A?*
  - *– B? (B_x)*



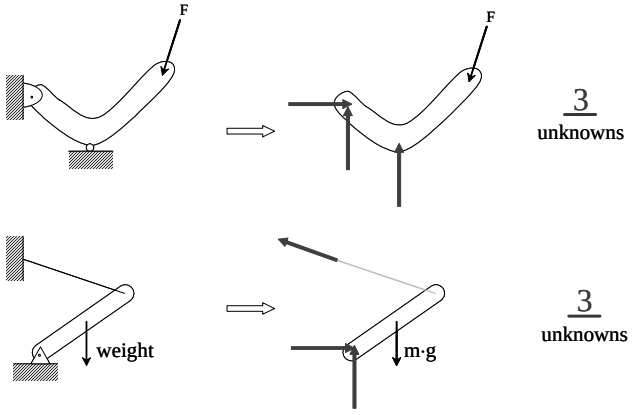


Moment Equations

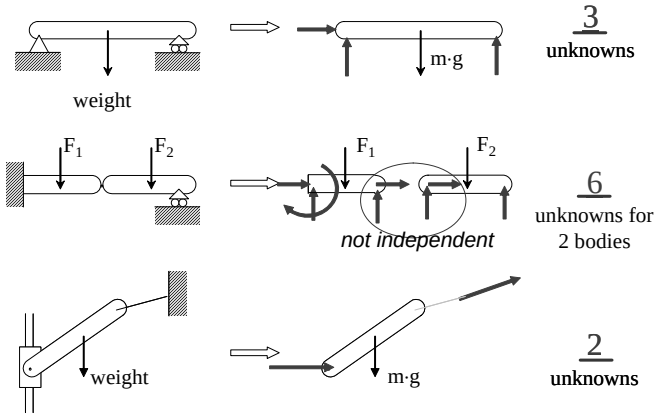
- *sum moments at intersection where the most forces intersect*
- *multiple moment equations may not be useful*
- *combos:*

$$\sum F_x = 0 \qquad \sum F = 0 \qquad \sum M_1 = 0$$
$$\sum F_y = 0 \qquad \sum M_1 = 0 \qquad \sum M_2 = 0$$
$$\sum M_1 = 0 \qquad \sum M_2 = 0 \qquad \sum M_3 = 0$$

Recognizing Reactions

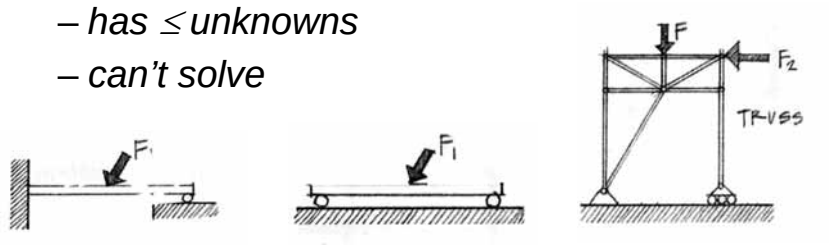


Recognizing Reactions



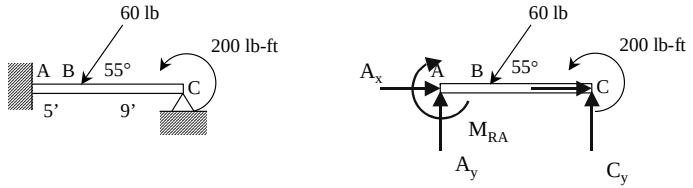
Constraints

- *completely constrained*
  - *doesn't move*
  - *may not be statically determinate*
- *improperly or partially constrained*
  - *has ≤ unknowns*
  - *can't solve*

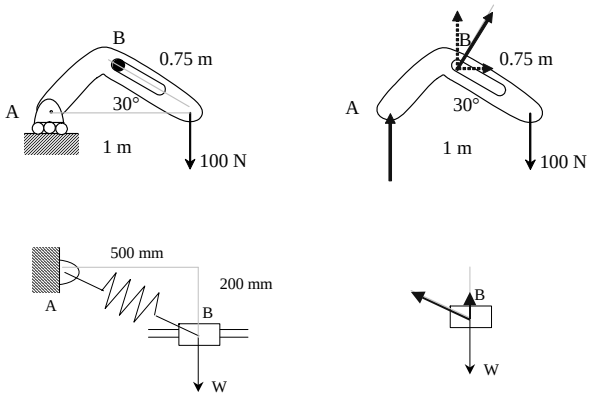


Constraints

- *overconstrained*
  - *won't move*
  - *can't be solved with statics*
  - *statically indeterminate to n^th^ degree*

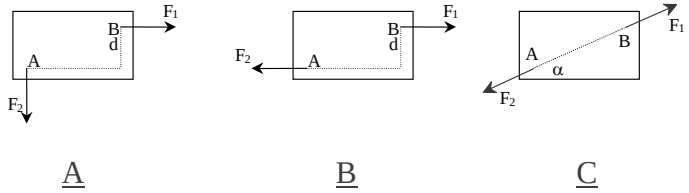


Partial Constraints



Two Force Rigid Bodies

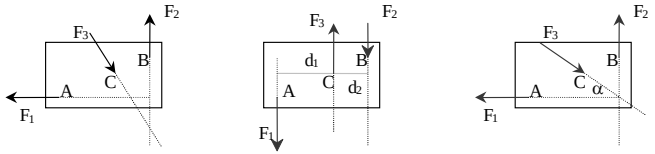
- *equilibrium:*
  - *forces in line, equal and opposite*



A B C

Three Force Rigid Bodies

- *equilibrium:*
  - *concurrent or parallel forces*



A (no) B C

Cable Reactions

- *equilibrium:*
  - *more reactions (4) than equations*
  - *but, we have slope relationships*
  - *x component the same everywhere*