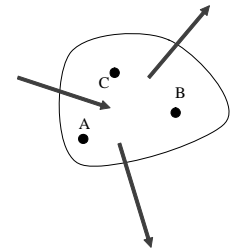


# rigid body equilibrium



# Equilibrium

- rigid body
  - doesn't deform
  - coplanar force systems



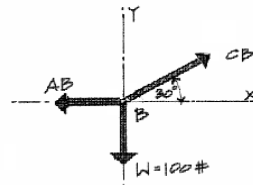
- static:
 
$$R_x = \sum F_x = 0$$

$$R_y = \sum F_y = 0$$

$$M = \sum M = 0$$

# Free Body Diagram

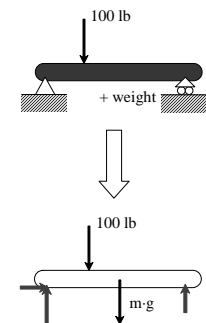
- FBD (sketch)
- tool to see all forces on a body or a point including
  - external forces
  - weights
  - force reactions
  - external moments
  - moment reactions
  - internal forces



(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

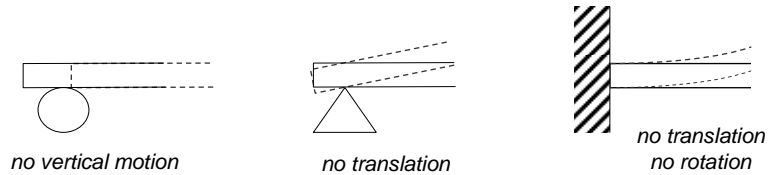


# Free Body Diagram

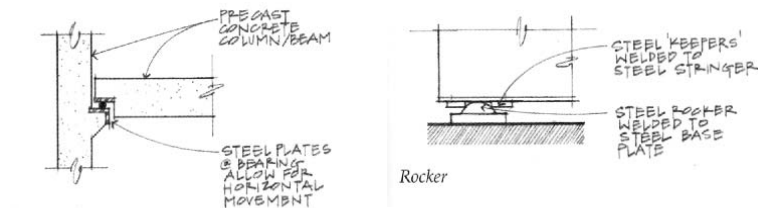
- include relevant geometry
  - guidelines helpful to see moment arms
- name and/or color the unknown
  - forces
  - moments
  - angles
- solve up to 3 equations

# Reactions

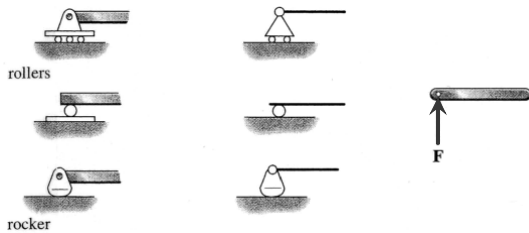
- result of applying force
- unknown size
- connection or support type
  - known direction
  - related to motion prevented



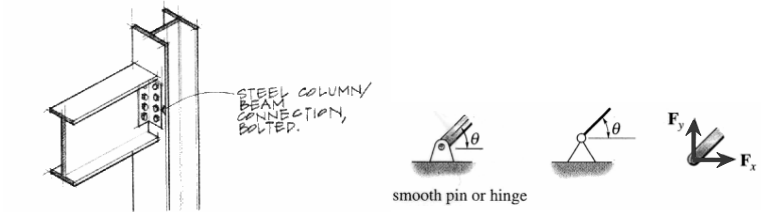
# Supports and Connections



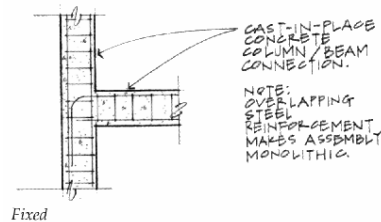
Roller



# Supports and Connections



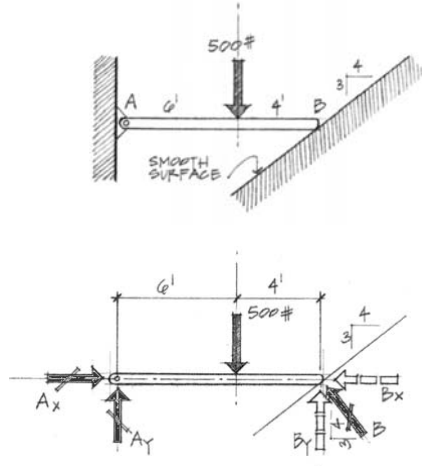
Pin



Fixed

## FBD Example

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

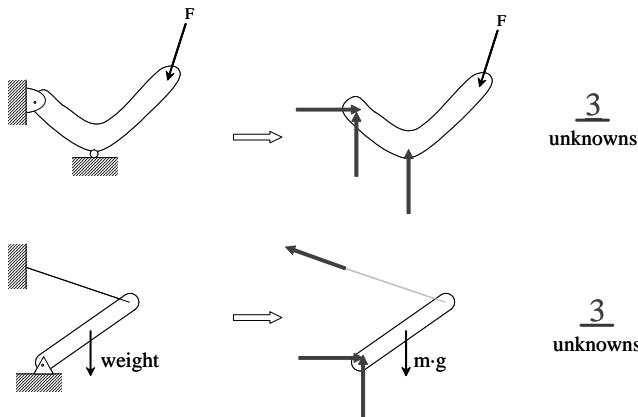


## Moment Equations

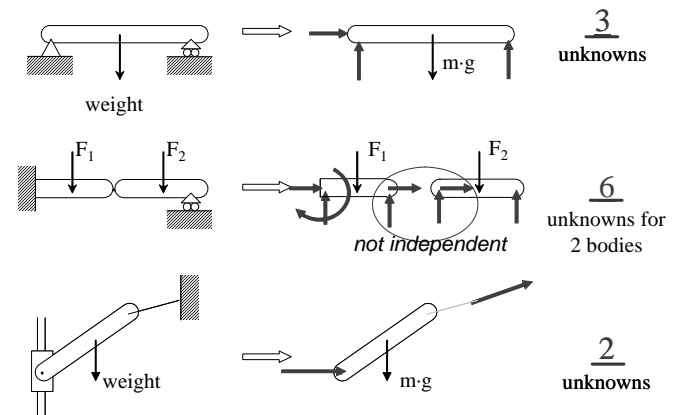
- sum moments at intersection where the most forces intersect
- multiple moment equations may not be useful
- combos:

$$\begin{array}{lll} \sum F_x = 0 & \sum F = 0 & \sum M_1 = 0 \\ \sum F_y = 0 & \sum M_1 = 0 & \sum M_2 = 0 \\ \sum M_1 = 0 & \sum M_2 = 0 & \sum M_3 = 0 \end{array}$$

## Recognizing Reactions

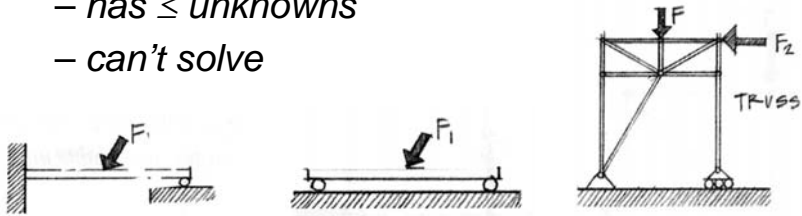


## Recognizing Reactions



## Constraints

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



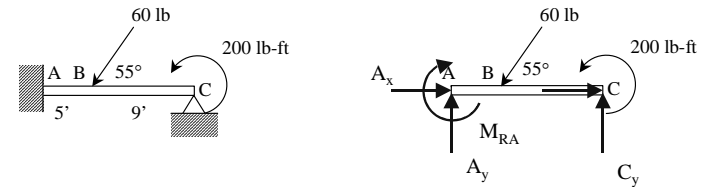
Rigid Bodies and Supports 14

Architectural Structures I  
ENDS 231

S2004abn

## Constraints

- *overconstrained*
  - won't move
  - can't be solved with statics
  - statically indeterminate to  $n^{\text{th}}$  degree

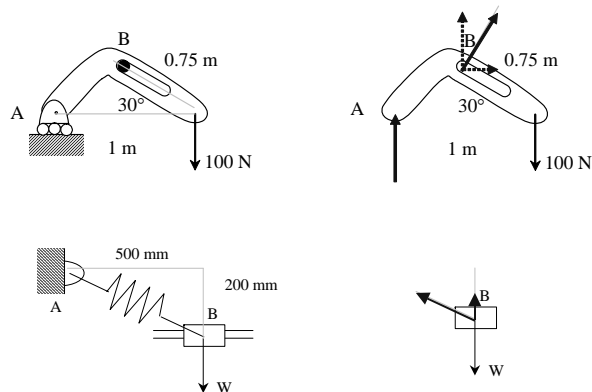


Rigid Bodies and Supports 15

Architectural Structures I  
ENDS 231

S2004abn

## Partial Constraints



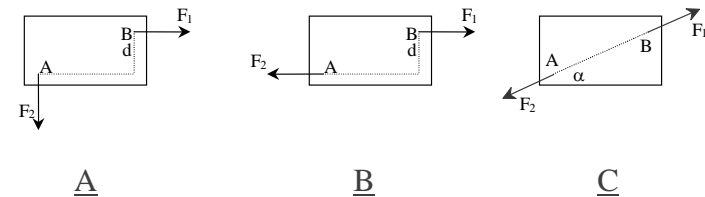
Rigid Bodies and Supports 16

Architectural Structures I  
ENDS 231

S2004abn

## Two Force Rigid Bodies

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



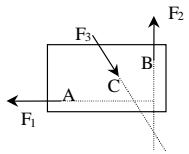
Rigid Bodies and Supports 22

Architectural Structures I  
ENDS 231

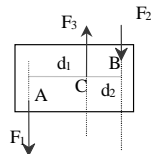
S2004abn

## Three Force Rigid Bodies

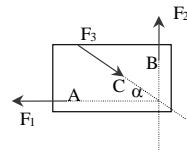
- equilibrium:
  - concurrent or parallel forces



A



B



C

## Cable Reactions

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

