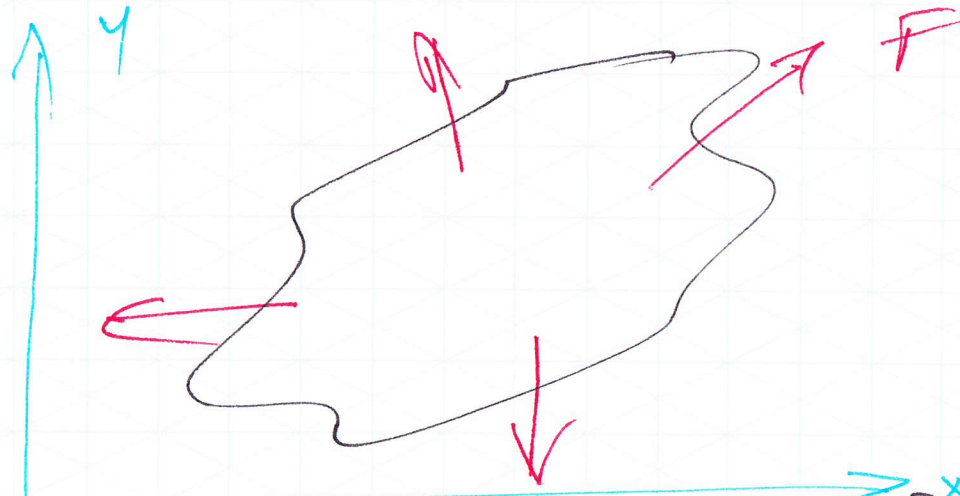


Equilibrium of a Rigid Body



Vector Equations of Equilibrium

$$\sum \vec{F} = 0 \quad \sum M = \sum (\vec{r} \times \vec{F}) = 0$$

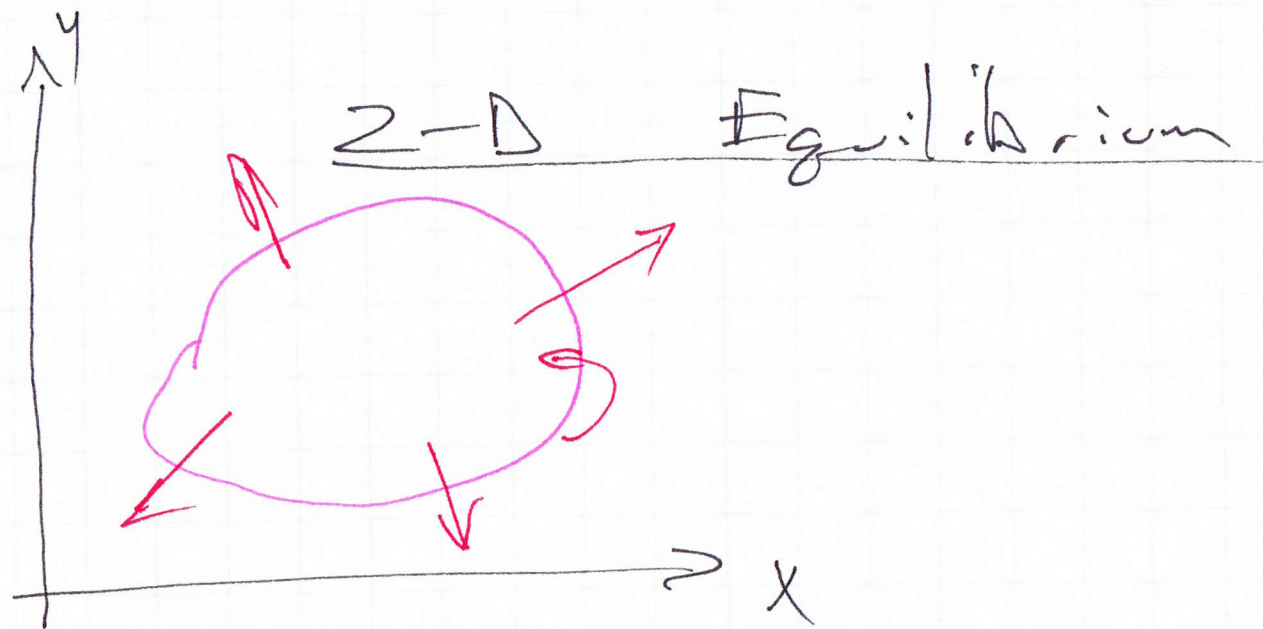
Any Point

Scalar Equations of Equilibrium

$$\sum F_x = 0 \quad , \quad \sum F_y = 0 \quad , \quad \sum F_z = 0$$

$$\sum M_x = 0 \quad , \quad \sum M_y = 0 \quad , \quad \sum M_z = 0$$

6 independent
Scalar Equations
of Equilibrium



Scalar Equations of Equilibrium

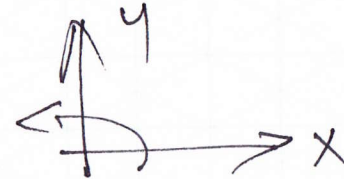
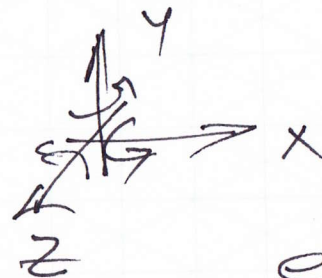
$$\sum F_x = 0, \quad \sum F_y = 0, \quad \sum M_z = 0$$

You can replace either or both $\sum F_x = 0$ and $\sum F_y = 0$ with moment equations about other points

sum of moments about any axis that is parallel to the z-axis.

Free Body Diagram

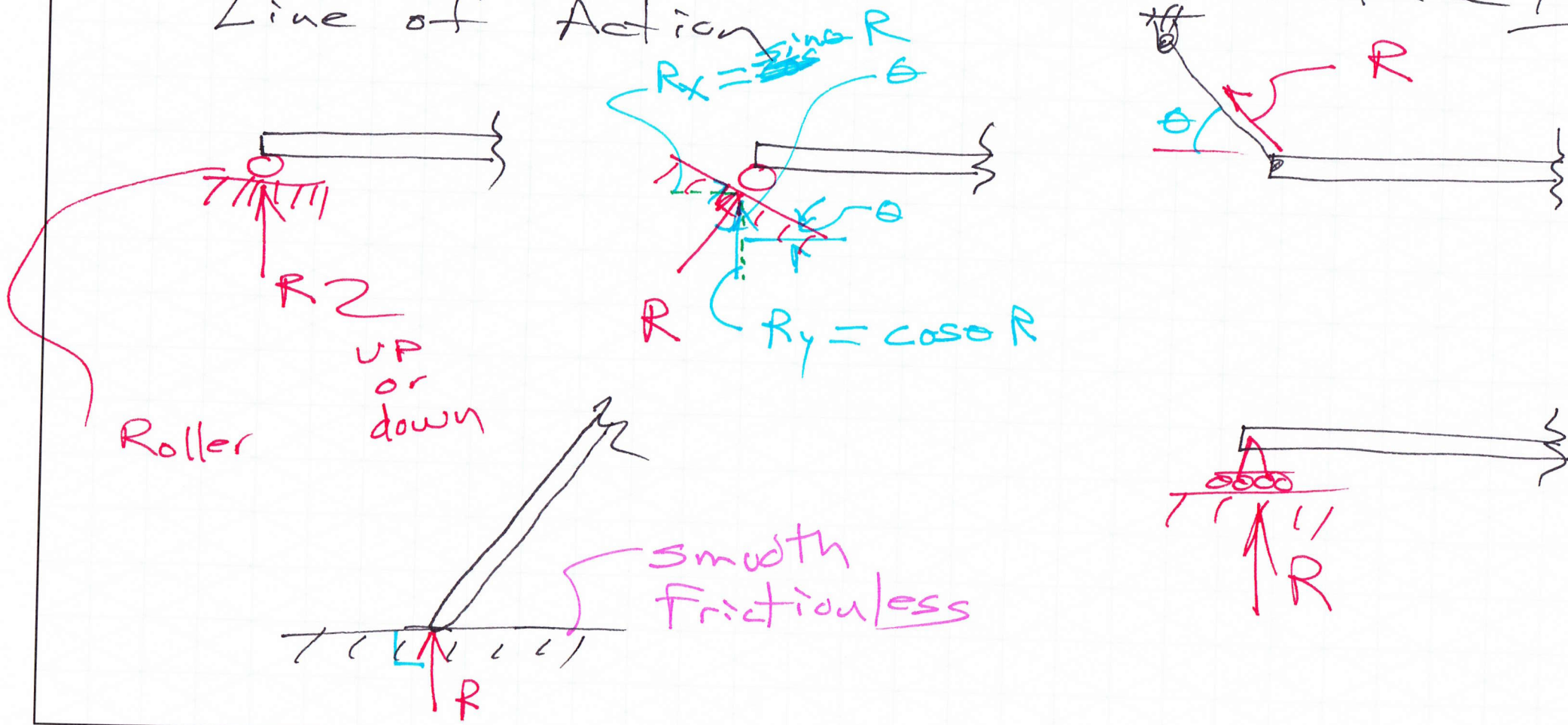
1. Rough sketch of the critical member, part, element -
2. Indicate all forces acting on the body
gravity, applied forces, reactions
3. Geometry - length, angles
4. Equilibrium sign convention



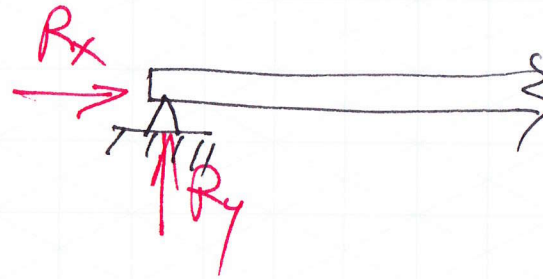
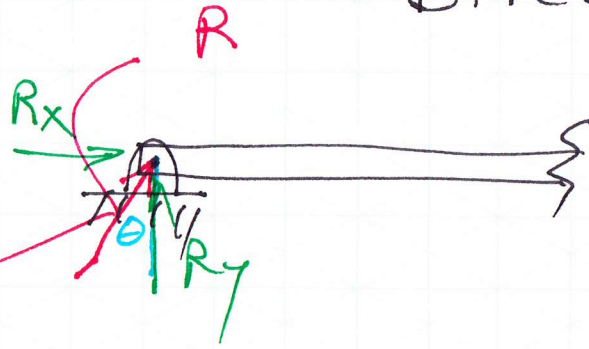
equilibrium sign conventions

2-D Reaction Forces

1. Reactions Equivalent to a force with a known Line of Action



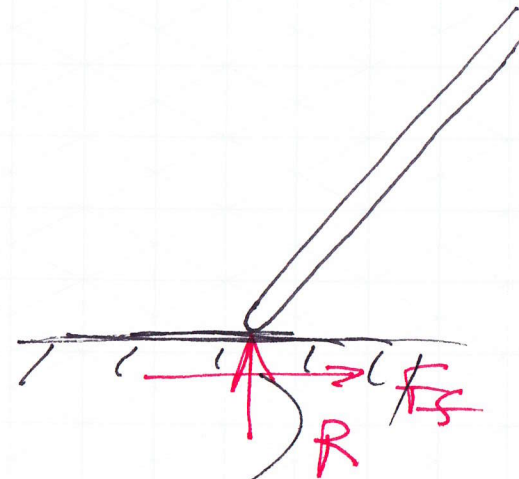
2. Reactions Equivalent to a Force of unknown Direction and Magnitude



Frictionless
Pin

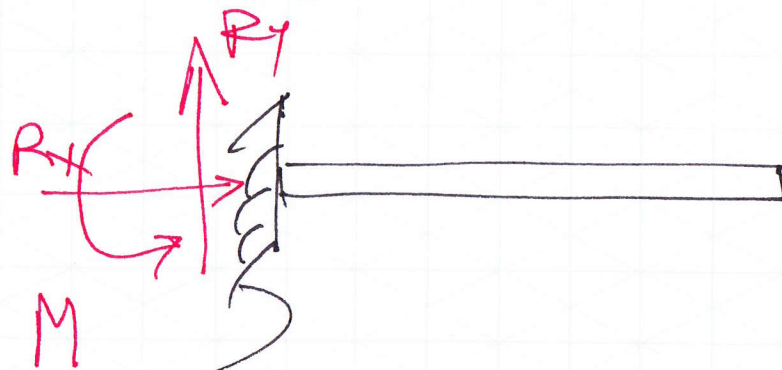
Unknowns are
R and θ

Unknowns could
also be
 R_x and R_y

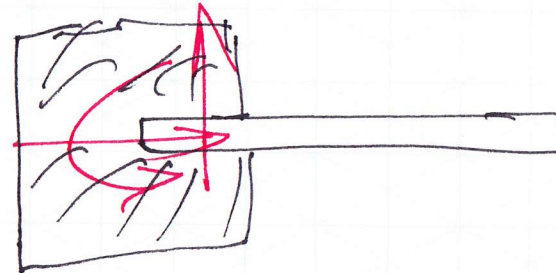


Rough Surface

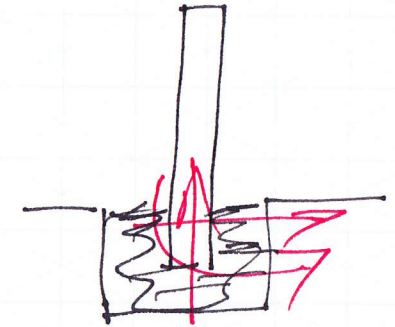
3. Reaction equivalent to a force of unknown direction and a moment.



Fixed
Support



Built-in



R_x	R_y	M
R	θ	M

2-D or 3-D

Sketch a F.B.D. — indicate forces known and unknown

Apply scalar Equations of Equilibrium

$$\sum F_x = 0, \quad \sum F_y = 0, \quad \text{and} \quad \sum M_z = 0$$

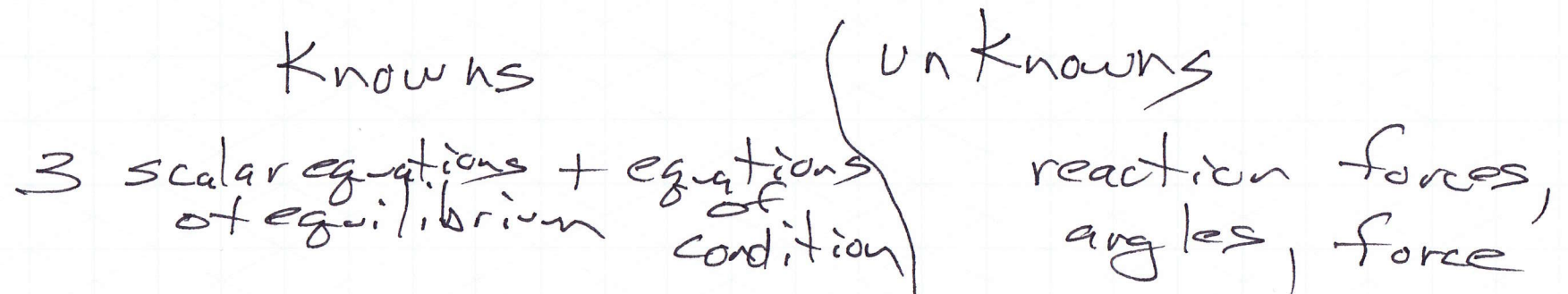
Sometimes you have equations of condition. 2-force member or cable hinge.

$$\sum F_x = 0, \quad \sum M_A = 0, \quad \sum M_B = 0$$

$$\sum M_A = 0, \quad \sum M_B = 0, \quad \sum M_C = 0$$

Statically Indeterminate/Determinate

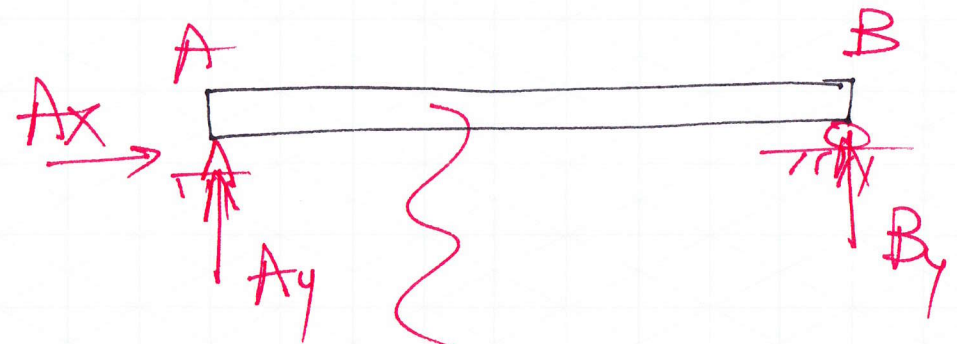
There are not enough equations to solve for the unknowns



Knowns < unknowns - Certain Indeterminacy

Knowns = unknowns - May be determinate

Stable or Unstable



Simply Supported Beam
No equations of Condition

Knowns
Scalar Equations
3 = 3
Unknowns
Ax, Ay, By

Factors That Indicate Instability

- All reactions are parallel
- Fewer than 3 reactions
Unknowns < Knowns
- Reactions are concurrent

