CIV102 - STRUCTURES and MATERIALS

Topic: 1D/2D Equilibrium

1) 1D Equilibrium

$F = ma$ Statics → No Movement
Dynamics → Movement

Big changes from 1D → 2D
Not many from 2D → 3D

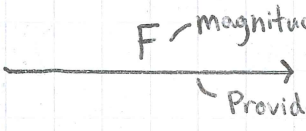
What's the axis?

Forces called actions and reactions
Important to think what is positive and negative

Force: A force is a push or a pull that causes a body to move or change shape
(push or pull: has a directionality; move: acceleration)

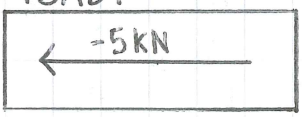
Because a force has a direction and a magnitude, therefore it is a vector.

Force represented by a vector: $\vec{F}$ ← Skip the vector in the notation



Examples:

¡BAD!



Units:
- KN (Kilonewton)
- N (newton)
- lb (pound)
- kip (kilopound)

Body: Something with mass

Examples:

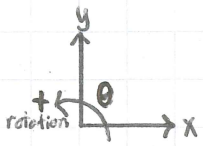
$F = ma$ because statics (No motion)
$\underline{a = 0}$

$\therefore F = \text{Sum of Forces} = (+F_1 - F_2) = 0$

Big Rule:
$\sum F_x = 0$ → Equation of Equilibrium

2) 2D Equilibrium

Axis:

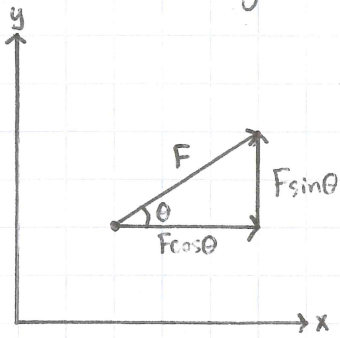


Possible Motions

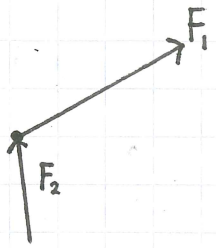
1D → 1
2D → 3
3D → 6

All torques are moments, but not all moments are torques.

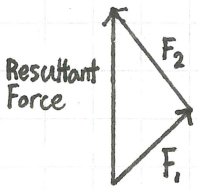
a) Translation Degrees of Freedom (DoF)



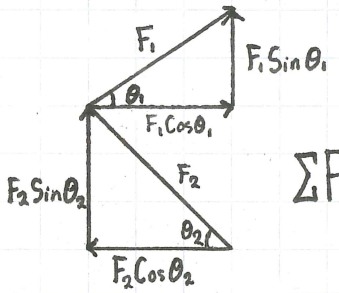
$$\boxed{\begin{aligned}\Sigma F_x &= 0\\ \Sigma F_y &= 0\end{aligned}}$$

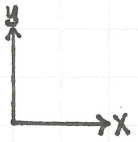


i) Force Polygon



ii) Force Components





$$\Sigma F_x = (F_1 \cos\theta_1 - F_2 \cos\theta_2)$$

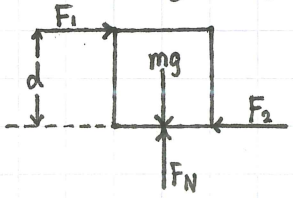
↑ Points to the left

$$\Sigma F_y = (F_1 \sin\theta_1 + F_2 \sin\theta_2)$$

Normal Force: Perpendicular to the Surface
Friction Force = μ Normal Force

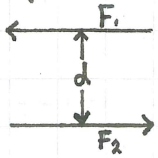
b) Rotations

Free Body Diagram



$$\Sigma F_y = 0$$
$$F_1 = F_2$$
$$\Sigma F_x = 0$$

Couple: Pair of forces acting on the same body that cancel out

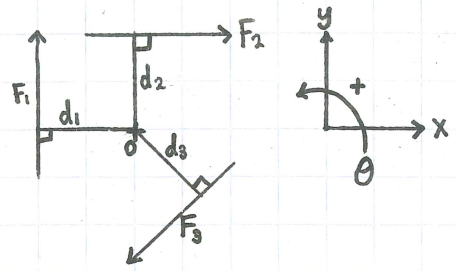


Moment = $F \cdot d$ ← Perpendicular distance between 2 forces

Units: kNm, kilonewton meter

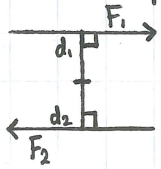
dot product → energy
cross product → moment

More General Case



$$\Sigma M = \underbrace{-F_1 d_1 - F_2 d_2 - F_3 d_3}_{\text{Makes it spin Clockwise}}$$

Check Couples



$$\Sigma M = -F \cdot \frac{d}{2} - F \cdot \frac{d}{2}$$
$$= -F \cdot d$$

Symbol for M