Chapter 16

Types of Motion

Rotation

- **Fixed Axis:-**

→ **Angular Position (θ)**

from reference point to position

$\Delta\theta = \theta_2 - \theta_i$

if $\Delta\theta > 0$ Counterclockwise

if $\Delta\theta < 0$ clockwise

→ **Angular Velocity (ω)**

$\omega = \frac{d\theta}{dt}$ same direction as $\Delta\theta$

→ **Angular Acceleration (α)**

$\alpha = \frac{d\omega}{dt}$

if $\alpha > 0$ ω is increasing

if $\alpha < 0$ ω is decreasing

- $\alpha\, d\theta = \omega\, d\omega$

You can use equation of Motion

$\omega_2 = \omega_1 + \alpha t$

$\omega_2^2 = \omega_1^2 + 2\alpha(\Delta\theta)$ in Rad.

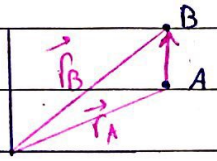
$\theta_2 = \theta + \omega_1 t + \frac{1}{2}\alpha t^2$

Translation (16.2)

$\vec{r}_B = \vec{r}_A + \vec{r}_{B/A}$

$\vec{V}_B = \vec{V}_A$

$\vec{a}_B = \vec{a}_A$



Rot + Tran

- **General planar Motion**

- if you have two points on the same Rigid Body Then: (from A to B)

$\vec{V}_B = \vec{V}_A + \vec{\omega} \times \vec{r}_{B/A}$

→ B.A are on the same body

→ ω is the Angular velocity of that body

And: $\vec{V}_B = \vec{V}_A + \vec{V}$

$\vec{r}_B = \vec{r}_A + r_{B/A}$

from axis to point

$$\vec{V} = \omega r \vec{u}_t$$

$\vec{V}$: linear velocity; ω: Angular velocity

← Relation Between Angular & linear Parameters

$$\vec{a} = \underbrace{\vec{\alpha} \times \vec{r}}_{\vec{a}_t} - \underbrace{\omega^2 \vec{r}}_{\vec{a}_n}$$

$\vec{a}$: linear Acceleration

Instantaneous Center of zero velocity

The location of instant center → it lies in an axis ⊥ to the plane which has zero velocity

① Given $\vec{V}_A$, ω

$$|\vec{r}| = \frac{|\vec{V}_A|}{|\omega|}$$

② Given $\vec{V}_B$, $\vec{V}_A$

parallel

- Same as non parallel in Magnitude
- If $V_B = V_A$, Ic is in the Middle
- If the Movement is only Translation, Ic is at ∞

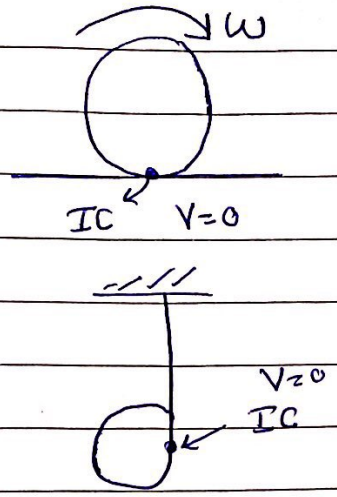
non parallel

$$|r_{A/Ic}| = \frac{|V_A|}{|\omega|}$$

$$|r_{B/Ic}| = \frac{|V_B|}{|\omega|}$$

④ Wheel:

IC:



Relative Motion Analysis - Acceleration

$$\vec{a}_B = \vec{a}_A + \underbrace{\vec{\alpha} \times \vec{r}_{B/A}}_{a_t} - \underbrace{\omega^2_{AB}\, \vec{r}_{B/A}}_{a_n}$$

Translation — Rotation

* if two points are on different Rigid bodies Then you can find V, a using these laws

$$\vec{V}_B = \vec{V}_A + \vec{\Omega} \times \vec{r}_{B/A} + \vec{V}_{B/A}$$

Angular velocity of the coordinate system x,y,z axis ... Rod ...

$$\vec{a}_B = \vec{a}_A + \dot{\vec{\Omega}} \times \vec{r}_{B/A} + \vec{\Omega} \times (\vec{\Omega} \times \vec{r}_{B/A}) + 2\vec{\Omega} \times \vec{V}_{B/A} + \vec{a}_{B/A}$$

Angular acceleration of the coordinate Systems

$a_{B/A}$: Acc of B with respect to A in the direction of sliding.