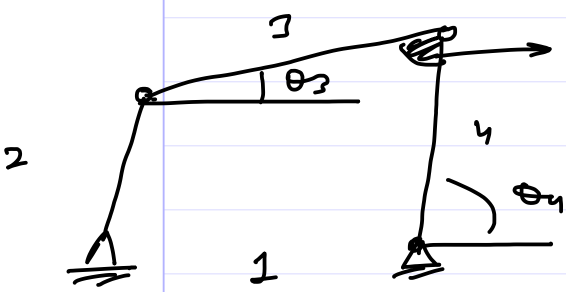
Motion of a Mechanism.

Mechanism'

Influence of length

1. Motion / kinematics
2. Force Transmission



→ Transmission Angle

$\theta_s = |\theta_3 - \theta_4| = \gamma$

understood !!

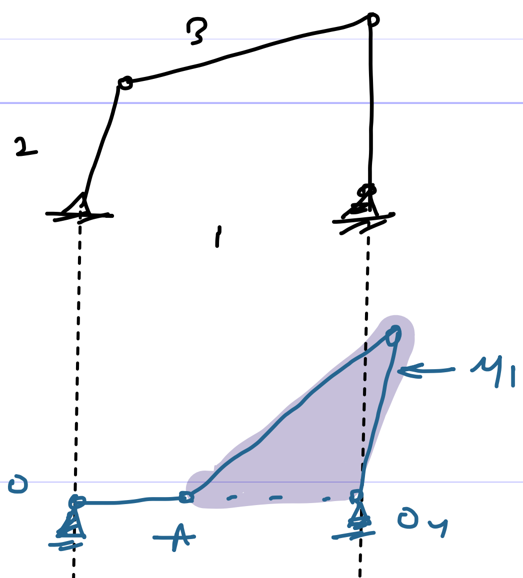
Links → 2 force members.

$0 < \gamma < \frac{\pi}{2}$, if $\begin{cases} \theta_s \\ \frac{\pi}{2} - \theta_s & \theta_s \geq \pi/2 \end{cases}$

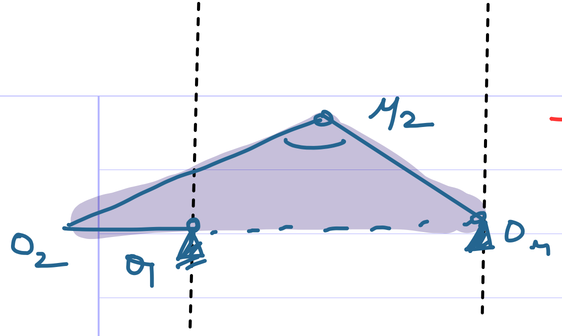
Inversion of 4-bar.

1. CRANK ROCKER → If it satisfies grasoff beforehand.

smallest link; adjacent is fixed.

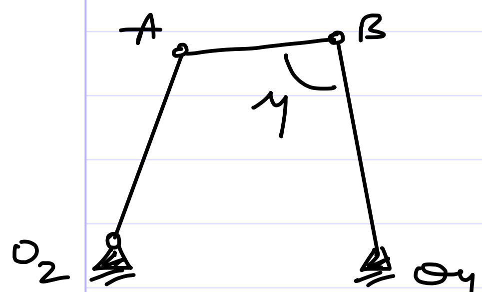


Transmission angle length.



→ becomes obtuse as well ?

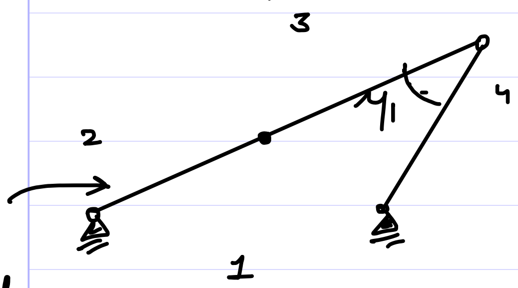
2. Double crank :



AB → shortest.

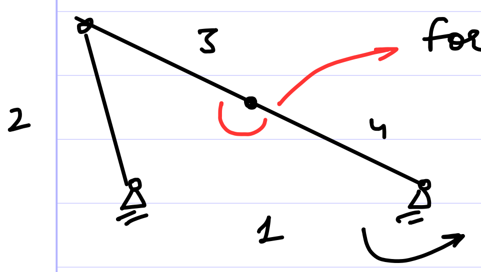
$\mu \in (0, \pi/2)$

3. Non - Grashoff → None of the links complete full revolution.



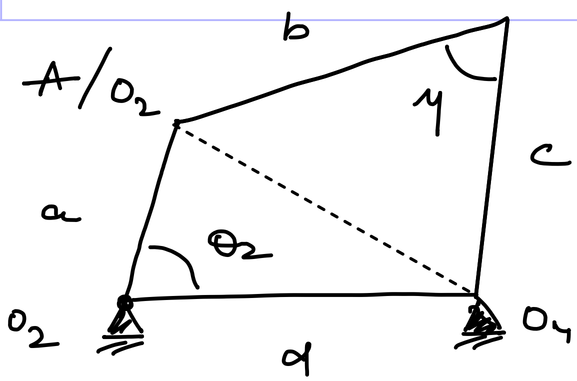
Collinear links.

Torque applied on this



force cannot be transmitted
↓
$T = F \times R \to 0$

Toggle position



Throughout the analysis cosine rule lagana hai

$\triangle O_2 A O_4$

$$\cos\theta_2 = \frac{a^2+d^2-(O_2O_4)^2}{2ad}$$

$$\cos\gamma = \frac{b^2+c^2-(O_2O_4)^2}{2bc}$$

$\longrightarrow$ $$b^2+c^2-2bc\cos\gamma = a^2+d^2-2ad\cos\theta_2$$

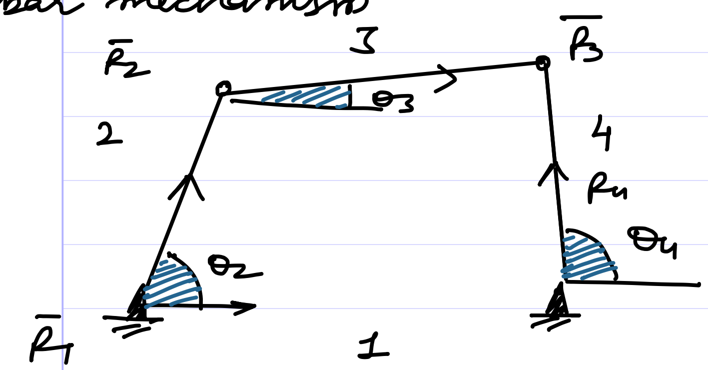
$$\cos\gamma = \frac{b^2+c^2-a^2-d^2+2ad\cos\theta_2}{2bc}$$

$\downarrow$

$\cos\gamma = \pm 1$, then check the criteria.

Position - Velocity:

4-bar mechanism:



Freud Einestein Equation:

$$\bar{R}_2 + \bar{R}_3 - \bar{R}_4 - \bar{R}_1 = \bar{0}$$

Vectorial Approach:

Along 1 - direction

$$R_2\cos\theta_2 + R_3\cos\theta_3 - R_4\cos\theta_4 - R_1 = 0$$

Along z-dir:

$$R_1 \cdot 0 + R_2 \sin\theta_2 + R_3 \sin\theta_3 - R_4 \sin\theta_4 = 0$$

Eliminate θ_3.

$$\to \quad K_1 \cos(\theta_4) - K_2 \cos(\theta_2) + K_3 = \cos(\theta - \theta_4)$$

↓

Freudenstein

$$K_1 = \frac{R_1}{R_2} \; ; \quad K_2 = \frac{R_1}{R_4} \; ;$$

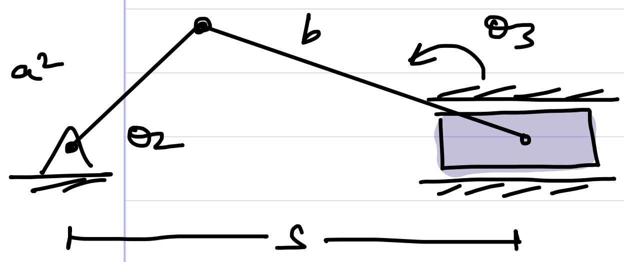
$$K_3 = \frac{R_2^2 + R_4^2 + R_1^2 - R_3^2}{2 R_2 R_4}$$

$$\cos\theta_4 = \cos^2\frac{\theta_4}{2} - \sin^2\frac{\theta_4}{2}$$

$$\sin\theta_4 = 2\sin\left(\frac{\theta_4}{2}\right) \cdot \cos\left(\frac{\theta_4}{2}\right)$$

Shigley

Slider crank



$s \to$ derivative
$a, b \to$ fixed.

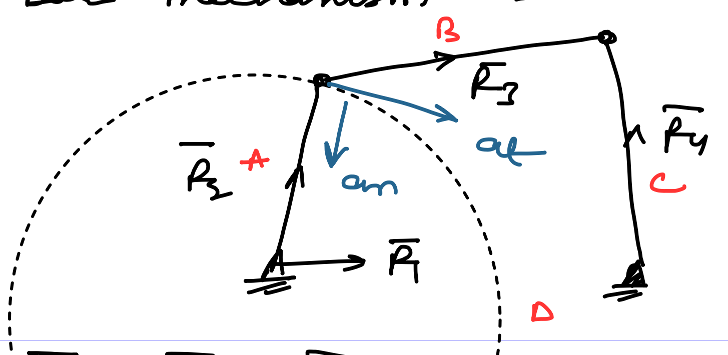
$$\cos(\theta_2) = \frac{a^2 + s^2 - b^2}{2as}$$

Velocity analysis. Important.

4-bar mechanism →

CRANK - ROCKER

Link A is going a circular motion about O.
↓
Normal & Tangential acceleration.



$$\overline{R_2} + \overline{R_3} - \overline{R_4} - \overline{R_1} = 0$$

$$\dot{\underline{R}}_2 + \dot{\underline{R}}_3 - \dot{\underline{R}}_4 - \cancel{\dot{\underline{R}}_1} = 0$$

$$\underset{\sim}{V_A} \qquad \underset{\sim}{V_{B/A}} \qquad \underset{\sim}{V_B}$$

ZUCK

ZUCK

ZUCK

$$\underset{\sim}{V_A} + \underset{\sim}{V_{B/A}} - \underset{\sim}{V_B} = 0$$

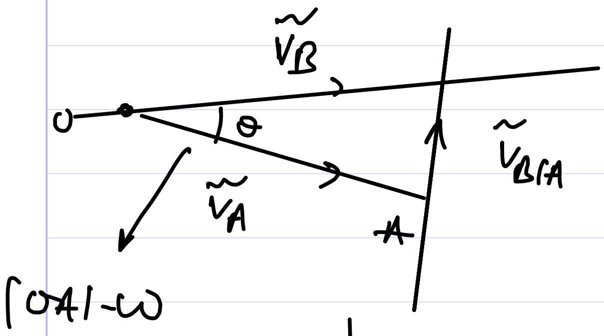
$$\tilde{V}_B = \tilde{V}_A + \tilde{V}_{B/A}$$

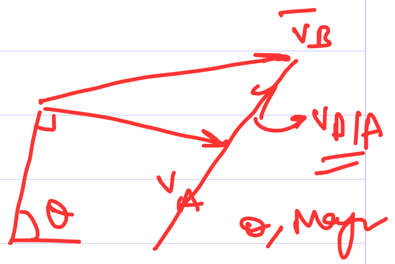
Rotating about a fixed point.

$$\tilde{\omega}_4 \times \tilde{R}_4 = \tilde{\omega}_2 \times \tilde{R}_2 + \tilde{\omega}_3 \times \tilde{R}_3$$

same inst. axis of rotation

GRAPHICALLY →





θ, Mag → sab mil gaya

TIME

Acceleration :

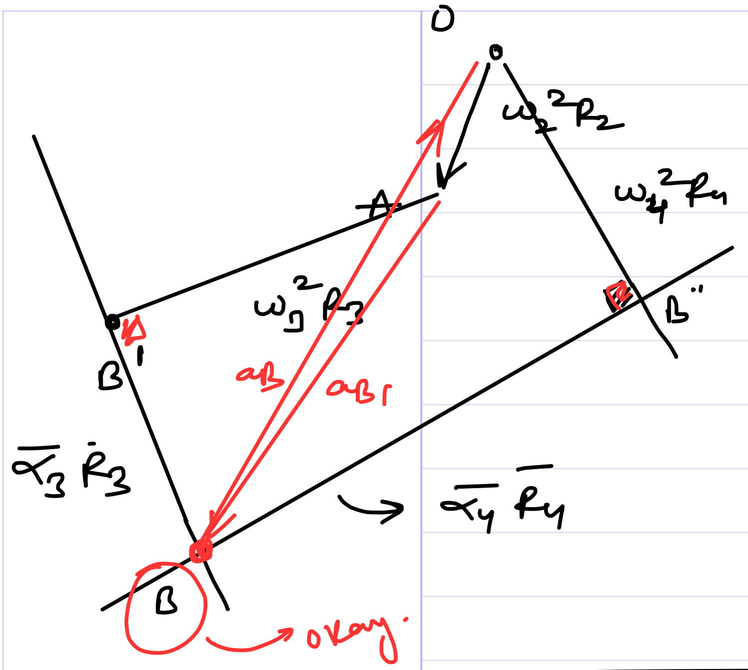
$$\ddot{\underline{R}}_2 + \ddot{\underline{R}}_3 - \ddot{\underline{R}}_4 = 0$$

$$\bar{a}_A + \bar{a}_{B/A} - \bar{a}_B = \bar{0}$$

$$\left(\bar{\omega}_2 \times (\bar{\omega}_2 \times \bar{R}_2) + \bar{\alpha}_2 \times \bar{R}_2\right) + \left(\bar{\omega}_3 \times (\bar{\omega}_3 \times \bar{R}_3) + \bar{\alpha}_3 \times \bar{R}_3\right) = \bar{\alpha}_4 \times \bar{R}_4 + \bar{\omega}_4 \times (\bar{\omega}_4 \times \bar{R}_4)$$

acceleration for Rotating bodies

Const angular velocity.

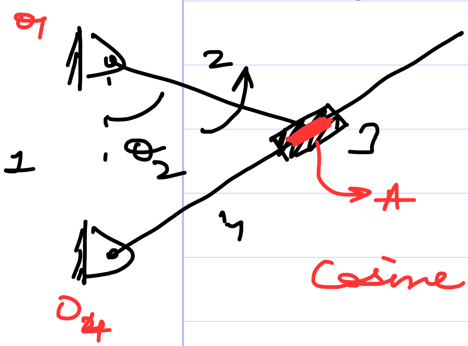


$\omega_2 \rightarrow$ constant
$\downarrow$
$\alpha_2 = 0$

$\omega_3^2 R_3 \rightarrow$ direction known.

6th Feb

Inversion of slider CRANK



To find : Velocity and acceleration of A.

Cosine Law

A_2 and A_3 are always going to be concide.

$A_3 \rightarrow$ point of contact.

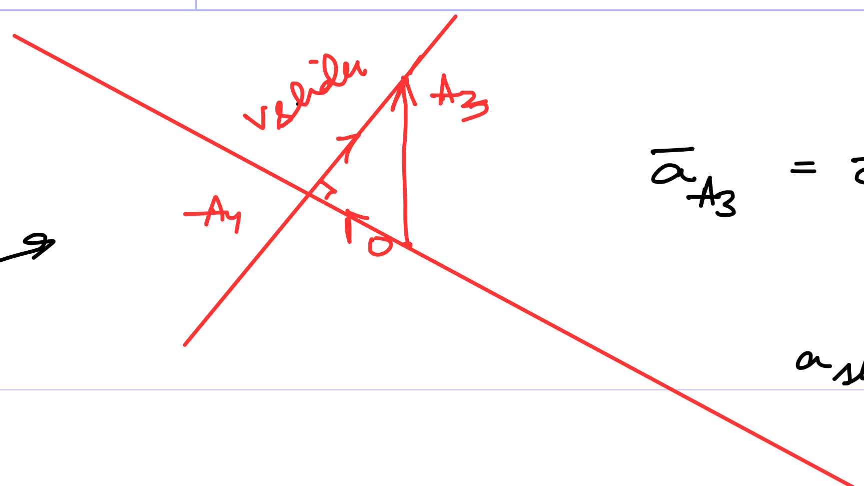
$\underbrace{A_2, A_3}_{\text{Remain same}}, A_4$

$$\bar{V}_{A_2} = \bar{V}_{A_3}$$
$$\bar{a}_{A_2} = \bar{a}_{A_3}$$

$$\bar{V}_{A_3} = \bar{V}_{A_4} + \bar{V}_{rel}$$

$\downarrow$
velocity of slider wrt link 4.

graphics

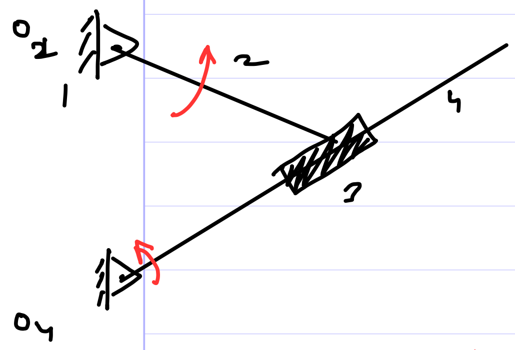


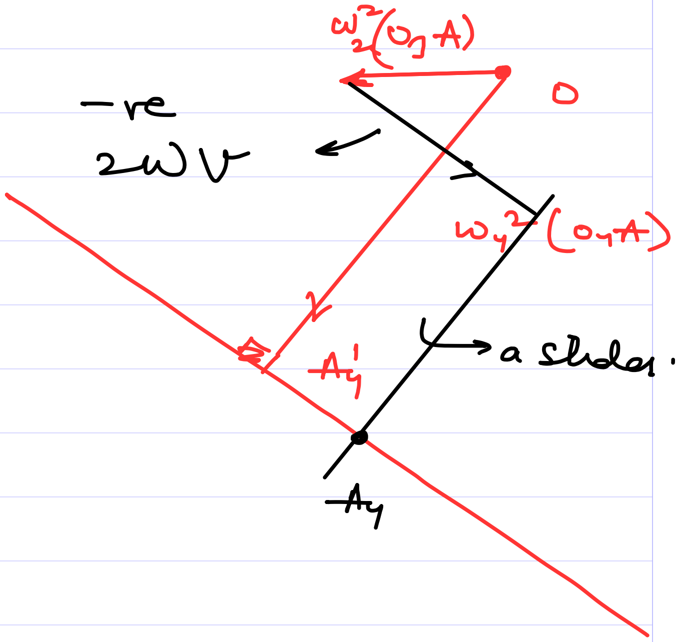
better?

$$\bar{a}_{A_3} = \bar{a}_{A_4} + \bar{a}_{rel}$$

a_{slide} $a_{coriolis}$

Acceleration diagram.





$O_3A = \omega_2^2(O_2A)$

$O_4A' = \omega_4^2(O_4A)$

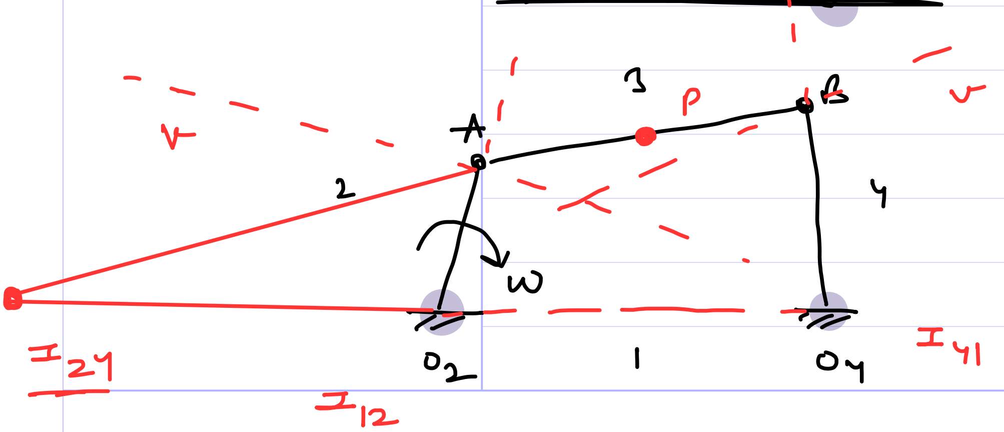
$O_3A = \omega_2^2(O_2A)$

$O_4A' = \omega_4^2(O_4A)$

• ICOR lies here.

$a_{A_3} - a_{rel} = a_{a_4}$

Inst. Centre Of Velocity - w.r.t any other body - "CENTRODE"



$V_P = I_{13} \times \omega_3$

${}^4C_2$ links.

Finding angular velocities -

$$V_A = \omega_2 \times O_2A = \omega_3 \times (I_{13})$$ → get ω_3 from here.

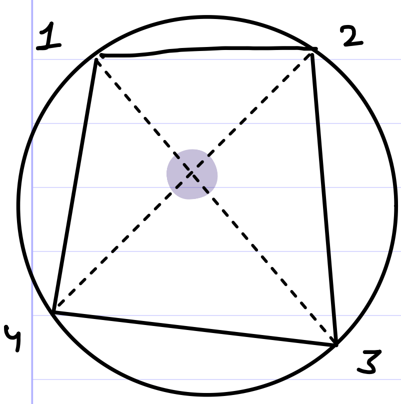
Angular velocity Ratio = $\frac{\text{output speed}}{\text{Input speed}}$.

13 → because of ground.

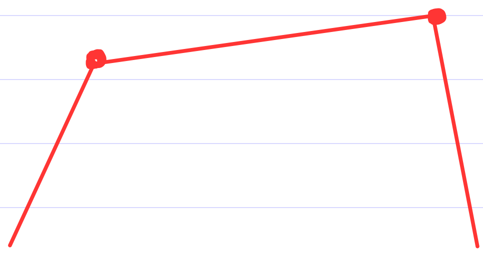
For 2 moving links → point w.r.t which either of the 2 bodies is undergoing pure Rotation.

At this point both bodies have same ABSOLUTE VELOCITY.

KINEMATICS DIAGONAL



At I_{24}
$V_2 = V_4$

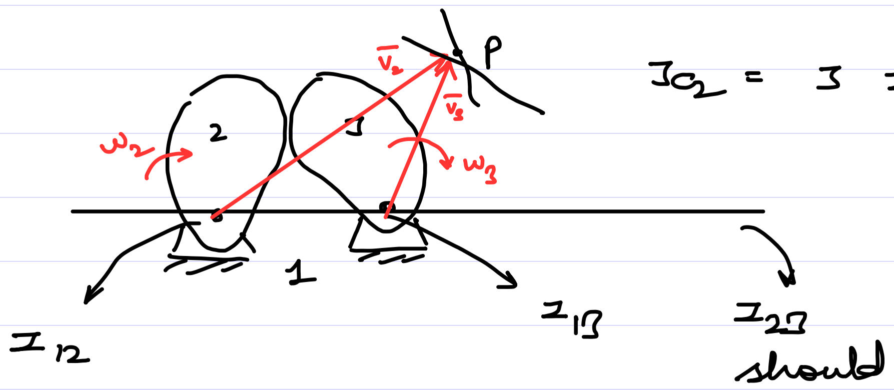


V of link at the IAOR!!

$\omega_2(I_{24}O_2) = \omega_4(I_{24}O_4)$

Arnold Kennedy mechanism.

ICV's of 3 rigid bodies undergoing plane rigid motion w.r.t each other are collinear.



$^3C_2 = 3$ ICV's

Assume P is not lying on line joining I_{12} I_{13}

At P : $\overline{V_2} = \overline{V_3}$ [absolute]

ICV

$$\vec{\omega_2} \times (I_{12}P) = \vec{\omega_3} \times (P I_{13})$$

Only the line I_{13} I_{23} makes sense.
The dir. and mag. not lying on line would not be possible

Ex: