Analysis of Four Bar Mechanism

Unit II
Module 2

Velocity Analysis

Analysis of Four Bar Mechanism by Instantaneous Centre Method.

AD- Fixed link.

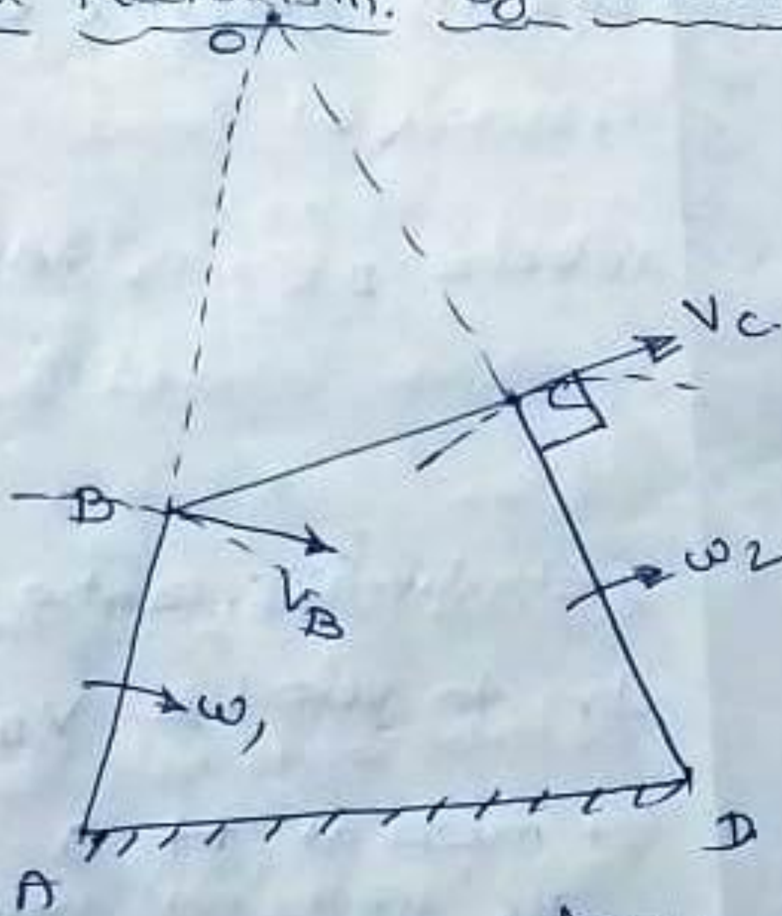
two movable link.

AB and CD

rotating abt pt

A and D respectively.

BC— coupler.



Let AB rotes at uniform angular velocity.

∴ correspondg motion of link BC and CD

need to be found.

Let ω_{AB} = angular velocity of link AB rotating about A in c.w direction.

$\omega_{AB} = \omega,$

ω_{CD} = " " " CD rotating abt D.

$\omega_{CD} = \omega_2.$

ω_{BC} = angular velocity of B.C. to be calculated.

TO

V_B = linear velocity of pt B ⊥r to AB.

$V_B = \omega_{AB} \times AB.$ — (1)

similarly.

$V_C = \omega_{CD} \times CD.$ — (2)

Link AB and Link CD are having motion of rotation.

whereas BC is having motion of translation and rotation as well

Instantaneous centre obtained by drawing ⊥r to velocity V_B and V_C.

It meets at pt O. called instantaneous centre.

∴ BC moves at angular velocity ω_{BC} w.r.t O. w.r.t. pt O Instantaneous centre.

$$V_B = \omega_{BC} \times BO \quad -(3)$$

$$V_C = \omega_{BC} \times CO \quad -(4)$$

$$V_B = \omega_{BC} \times BO \quad \text{— (3)}$$

$$V_C = \omega_{BC} \times CO \quad \text{— (4)}$$

From (1) and (3)

$$\omega_{AB} \times AB = \omega_{BC} \times BO$$

$$\boxed{\omega_{BC} = \frac{\omega_{AB} \times AB}{BO}}$$

From (2) and (4)

$$V_C = \omega_{CD} \times CD = \omega_{BC} \times CO$$

$$\boxed{\omega_{CD} = \frac{\omega_{BC} \times CO}{CD}}$$

problem Fig shows a pin jointed four bar ~~mech~~ linkage having the following dimension.

Fixed link $AD = 4$ m.

Driven " $CD = 2.5$ m.

Driving " $AB = 1.5$ m.

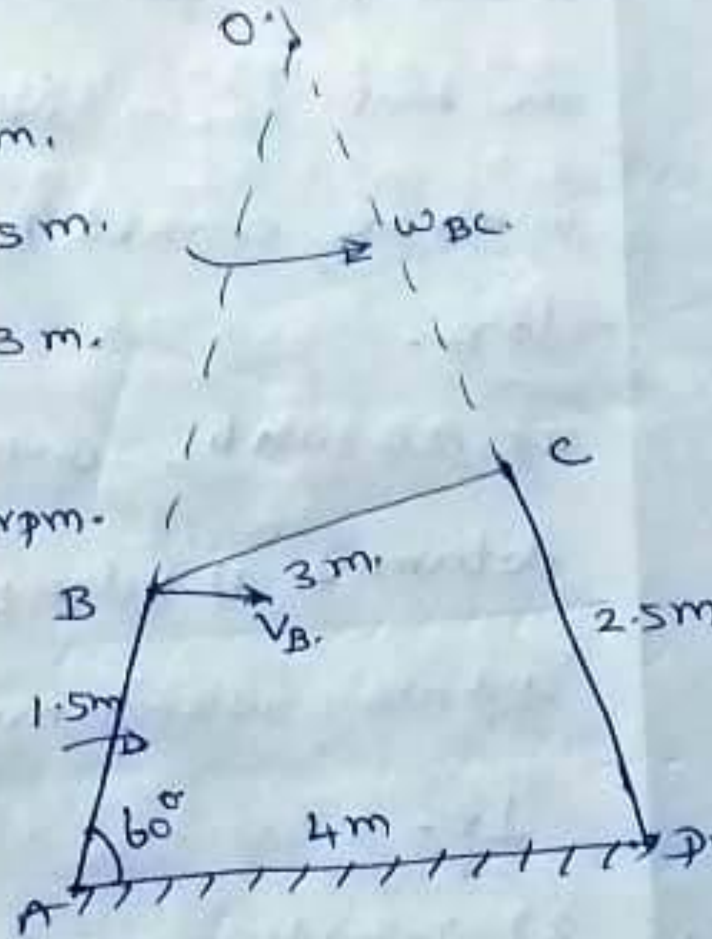
connecting rod $BC = 3$ m.

$\angle BAD = 60^\circ$.

Link AB revolves at 25 rpm.

Determine 1) angular velocity of link CD.

2) angular velocity of link BC.



Soln

soln

Draw Instantaneous centre.

AB rotates at 25 rpm

$\omega_1 = \omega_{AB} = \frac{2\pi N}{60} = \frac{2\times\pi\times 25}{60} = 2.619$ rad/s.

$V_B = \omega_{AB} \times AB$.

$V_B = \omega_{BC} \times BO$

$\omega_{BC} = \omega_{AB} \times \frac{AB}{BO}$

by measurement $BO = 4.65$ m.

$CO = 3$ m.

$\omega_{BC} = 2.619 \times \frac{1.5}{4.65} = 0.845$ rad/sec.

Ans.

similarly.

$\omega_{CD} \times CD = \omega_{BC} \times CO$

$\omega_{CD} = \frac{0.845\times 3}{2.5}$

$= 1.014$ rad/s

2) In a four bar mechanism ABCD. points A and C are fixed points 30cm apart. and AB, CD. are bars 60cm and 70 cm long respectively. which are connected by rod BD which is. 50 cm long.

If AB rotates with uniform speed of 60 rpm. determine. 1) velocity of D. when AB ⊥r to AC. and also. when it makes. 10° on either side. of ⊥r.

2) Instantaneous centre of the bar BD and its angular velocities at in the three position

D

data

$N = 60\ rpm.$

$\omega_1 = \omega_{AB} = \frac{2\pi N}{60} = \frac{2 \times \pi \times 60}{60}$

$= 2\pi\ rad/sec$

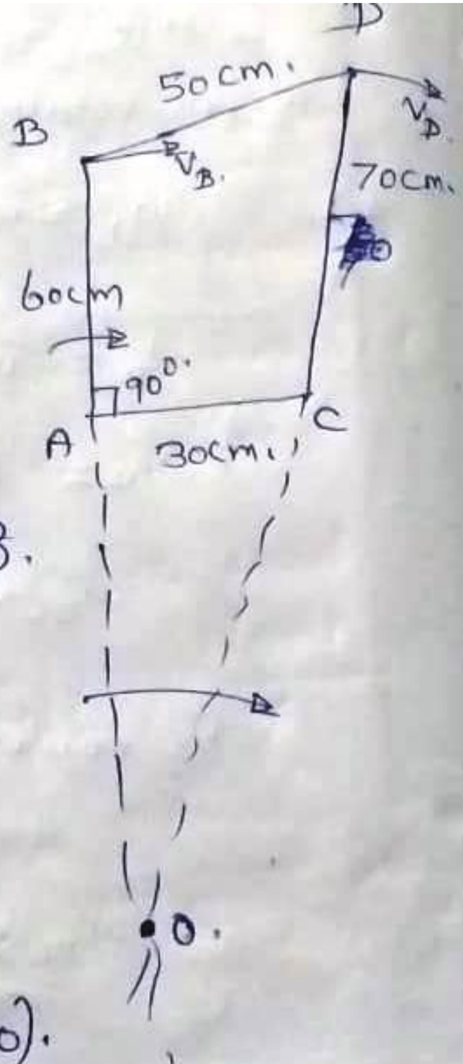
$V_B = \omega_{AB} \times AB = \omega_{BD} \times OB.$

$V_B = 2\pi \times 0.60$

$= 3.768\ m/sec$

By measurement $OA = 103\ cm.$

$\omega_{BD}\ \frac{V_B}{OB} = \frac{3.768}{(1.03+0.60)}.$



$\omega_{BD} = 2.3116\ rad/sec.$

$V_D = \omega_{BD} \times OD = 2.3116 \times 1.63$

$V_D = 4.09\ m/s$ Ans.

case ii . when inclined 10° to le left frome case (i)

movement

$OA = 98 cm.$

$OC = 97 cm.$

$OB = OA + AB = 98 + 60$

$= 158 cm = 1.58 m.$

$OD = OC + CD$

$= 97 + 70 = 167 cm = 1.67 m.$

$V_B = \omega_{BD} \times OB$

$\omega_{BD} = 3.768 / 1.58 = 2.38 \ rad/sec$

$V_D = \omega_{BD} \times OD$

$= 2.38 \times 1.67$

$= 3.98 \ m/sec.$

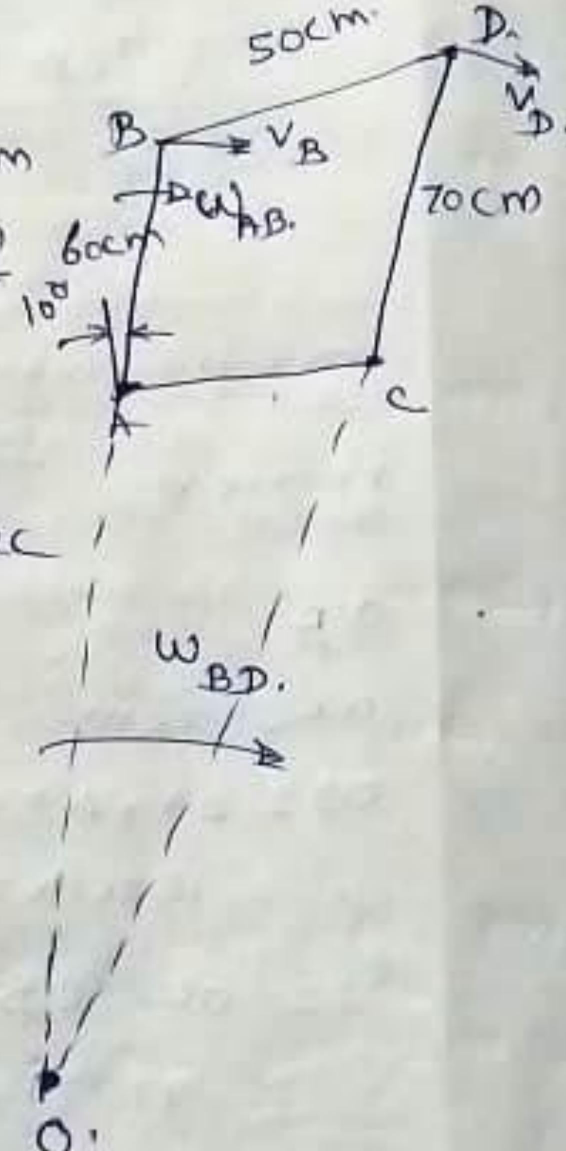
case(iii)

By measurement $OA = 100\,cm$

$OC = 109\,cm.$

$OB = OA + AB = 160\,cm = 1.6\,m$

$OD = OC + CD = 179\,cm = \underline{\underline{1.79\,m}}$



$V_B = \omega_{BD} \times OB$

$\omega_{BD} = \frac{3.768}{1.6} = 2.35\,rad/sec$

$V_D = \omega_{BD} \times OD$

$= 2.35\,rad/sec \times 1.79$

$= \underline{\underline{4.217\,m/sec}}$

No and types of Instantaneous centres in a Mechanism.

In a mechanism, the no of instantaneous centres is the no of possible combinations of two links. It is the no of combinations of n links taken 2 at a time, which is mathematically equal to $^nC_2$.

$$^nC_r = \frac{n!}{r!\,(n-r)!} = \frac{n(n-1)}{\cancel{r}}$$

$$^nC_2 = \frac{n!}{2!\,(n-2)!} = \frac{n(n-1)}{2}.$$

If n = no of links.

No of Instantaneous centre.

$$\boxed{N = \frac{n(n-1)}{2}}$$

Instantaneous centres are of 3-types.

1) Fixed instantaneous centres.

2) permanent instantaneous centres.

3) neither fixed nor permanent instantaneous centres

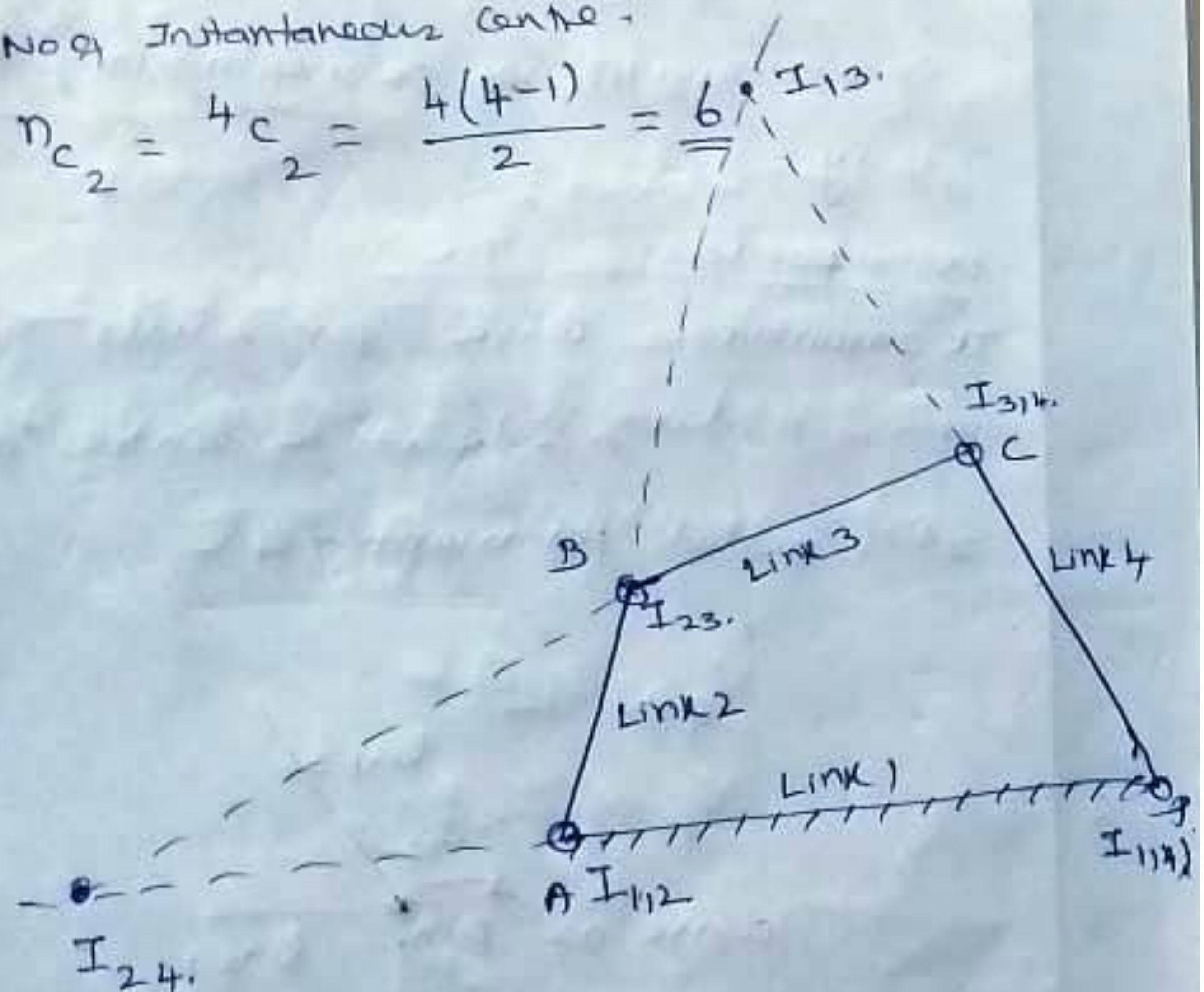
links and.

For four bar mechanism having 4 links and.

in which 1 link is fixed.

No of Instantaneous centre.

$$n_{C_2} = {}^4C_2 = \frac{4(4-1)}{2} = \underline{\underline{6}}$$



* Instantaneous centres I_{12}, I_{14} are fixed instantaneous centres

for all the configurations of the mechanism, they remain at the same place.

<u>I.C</u> I_{23}, I_{34} are permanent Instantaneous centre.

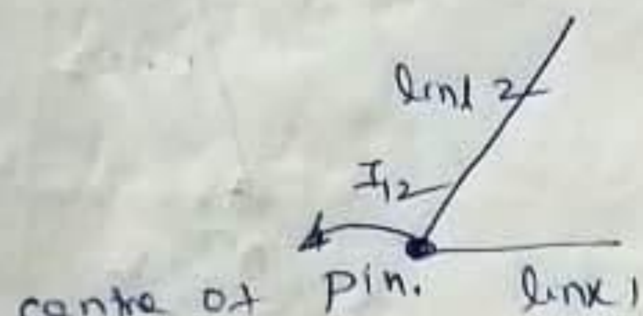
they move when mechanism moves, but joints are permanent in nature

I.C I_{13} and I_{24} are neither fixed nor permanent I.C. as with the change of configuration of the mechanism, they also vary.

Method for locating I.C

The Instantaneous centre for 2 links connected by pin will always be at the centre of the pin.

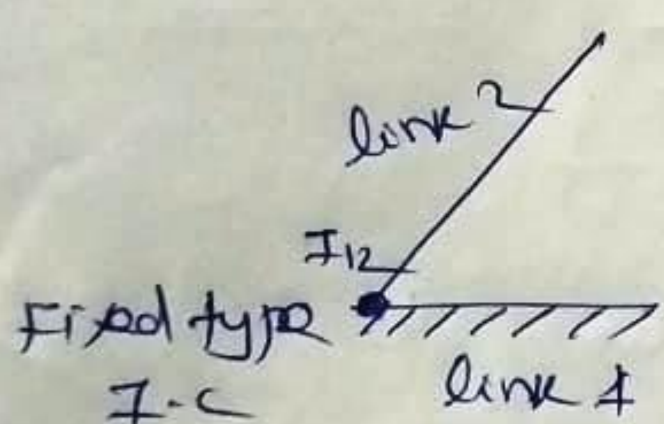
It is called permanent I.C



permanent I.C

If one link is fixed.

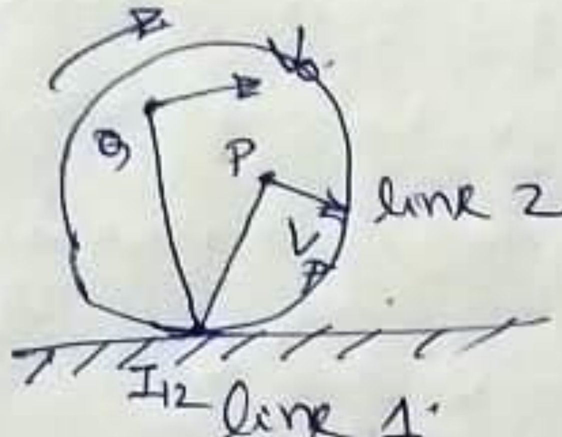
I-C is of fixed type



Instantaneous centre for two links, which are having pure rolling contact.

link 2 rolls on link 1 without sliping.

I.C will be always on point of contact.



velocity of any point on link 2 relative to fixed link 1 will be ⊥r to $I_{12}P$ and proportional to $I_{12}P$.

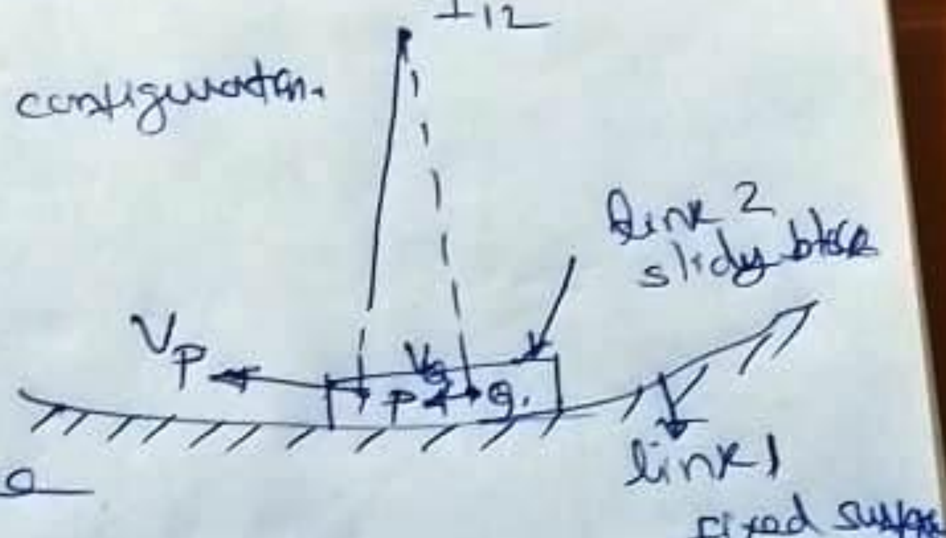
$$V_Q \propto I_{12Q}$$

$$V_P \propto I_{12P}.$$

$$\boxed{\frac{V_P}{V_Q} = \frac{I_{12P}}{I_{12Q}}}$$

Instantaneous centre of two links having sliding contact

I-C will be on the centre of curvature of the curvilinear path of the configuration at that instant.



centre of curvature for curvilinear path is at I_{12}.

Instantaneous centre lies at I_{12}.

$$\frac{V_P}{I_{12P}} = \frac{V_Q}{I_{12Q}}.$$

$$\frac{V_P}{V_Q} = \frac{I_{12P}}{I_{12Q}}.$$