UNIT II KINEMATICS OF LINKAGE MECHANISMS 9

Displacement, velocity and acceleration analysis of simple mechanisms – Graphical method – Velocity and acceleration polygons – Velocity analysis using instantaneous centres – kinematic analysis of simple mechanisms – Coincident points – Coriolis component of Acceleration – Introduction to linkage synthesis problem.

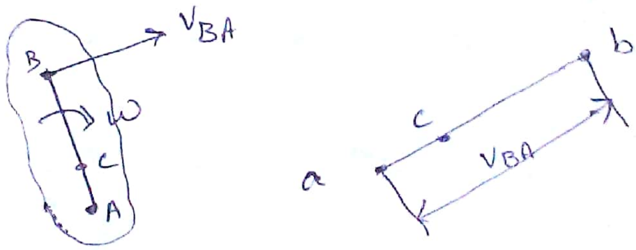
Kinematics of linkage mechanisms :-

* The relative velocity method for determining the velocity of different Points in the mechanism.

Relative velocity of two bodies moving in straight lines :-

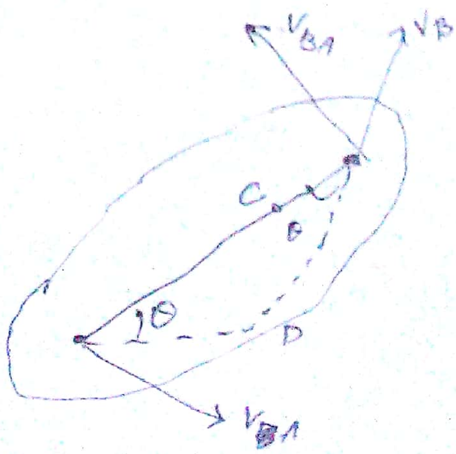
Motion of a link :-

* velocity of any Point on a link w.r.t another Point on the same link is always ⊥ to the line joining these Points on the configuration diagram.



velocity of a Point on a link by relative velocity method :-

* Consider two Points A & B on a link.



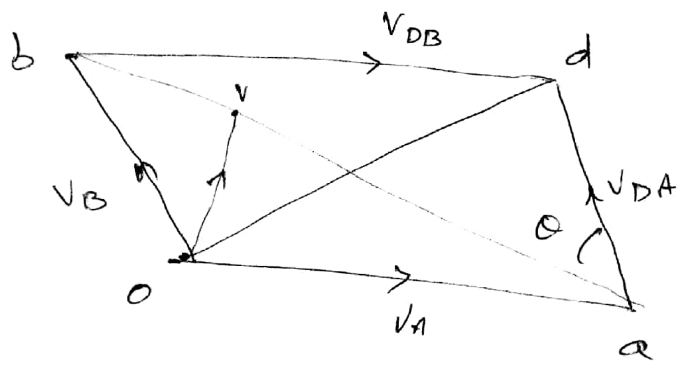
Procedure :-

* Take some Convenient Point o, known as the Pole.

* Through 'o', draw oa Parallel & equal to V_A to some Suitable scale.

* Through a, draw a line ⊥ to AB, this line will represent the velocity of B w.r.t A i.e; V_{BA}.

* Through o draw a line // to V_B intersecting the line V_{BA} at b.



Velocity diagram.

Centrode :-

* The instantaneous Centre of a moving body may be defined as that Centre which goes on Changing from one instant to another.

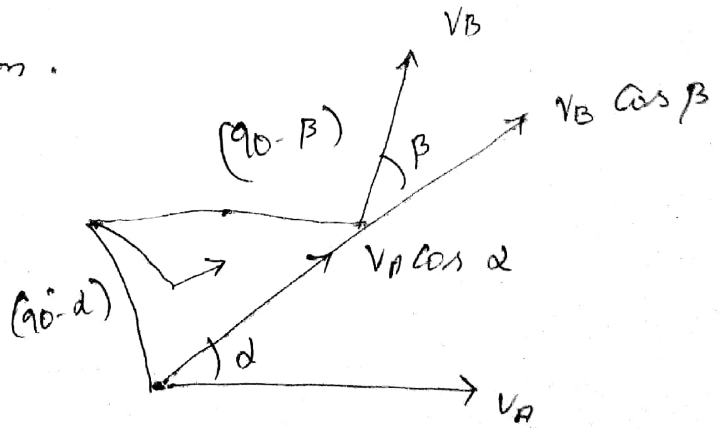
* The locus of all such instantaneous Centre is known as centrode.

Methods for determining the velocity of a Point on a link:

* Instantaneous Centre method.
* Relative velocity method.

Instantaneous Centre method:-

* The instantaneous Centre method of analysing the motion in a mechanism is based upon the Concept that any displacement of a body having motion in one plane can be considered as a pure rotational motion of a rigid link as a whole about some centre known as Instantaneous Centre (or) Virtual Centre of rotation.



Now resolving the velocities along AB

$$V_A \cos\alpha = V_B \cos\beta$$

$$\frac{V_A}{V_B} = \frac{\cos\beta}{\cos\alpha} = \frac{\sin(90^\circ-\beta)}{\sin(90^\circ-\alpha)}$$

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by lamis theorem,

$$\frac{AI}{\sin(90-\beta)} = \frac{BI}{\sin(90-\alpha)}$$

$$\frac{V_A}{V_B} = \frac{AI}{BI} \quad (or) \quad \frac{V_A}{AI} = \frac{V_B}{BI} = \omega$$

ω - angular velocity of rigid link.

Properties of Instantaneous centre,

* A rigid link rotates instantaneously relative to another link at the Instantaneous centre for the configuration of the mechanism considered.

* The velocity of instantaneous centre relative to any third rigid link will be same whether the instantaneous centre is regarded as a point on the first rigid link or on the second rigid link.

No. of Instantaneous Centre in mechanism :-

* Constrained kinematic chain is equal to the no. of possible combination of two links.

$$N = \frac{n(n-1)}{2}$$, $n \rightarrow$ no. of links.

Types :-

* 1. Fixed instantaneous centres
  2. Permanent instantaneous centre
  3. Neither fixed nor Permanent I C.

Aronhold Kennedy theorem :-

* The states that if three bodies move relatively to eachother the have three instantaneous centre lie on a straight line.

Method for locating I C.

* 1st of all, determine the no. of instantaneous Centres by using relation

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

* Make a list of all the instantaneous Centres in a mechanism. Since for a four bar mechanism there are Instantaneous Centres.

* Locate the fixed & Permanent Instantaneous Centre by inspection.

* locate the remaining neither fixed nor Permanent instantaneous centres by Kennedy's theorem

* Join the Points by Solid line to Show that these Centres are already found.

* In order to find the two Instantaneous Centres join two such Points that the line joining them form two adjacent triangles in the circle diagram.

Ex :-

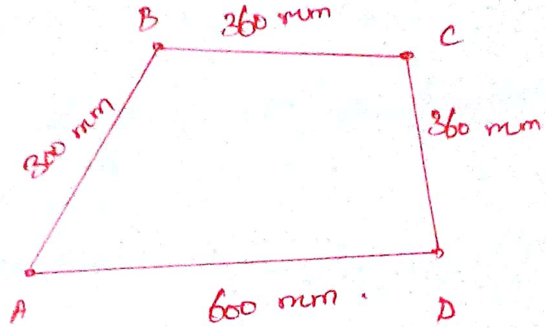
In a Pin jointed four bar mechanism as shown in fig

AB = 300 mm , BC = CD = 360 mm & AD = 600 mm

the angle ∠BAD = 60°. the Crank AB rotates uniformly

at 100 rpm. locate all the Instantaneous Centre &

find the velocity of the link BC.



Given :-

$N_{AB} = 100$ r.p.m

$$\omega = \frac{2\pi N}{60} = \frac{2\pi\, 100}{60}$$

$$= 10.47 \text{ rad/s}$$

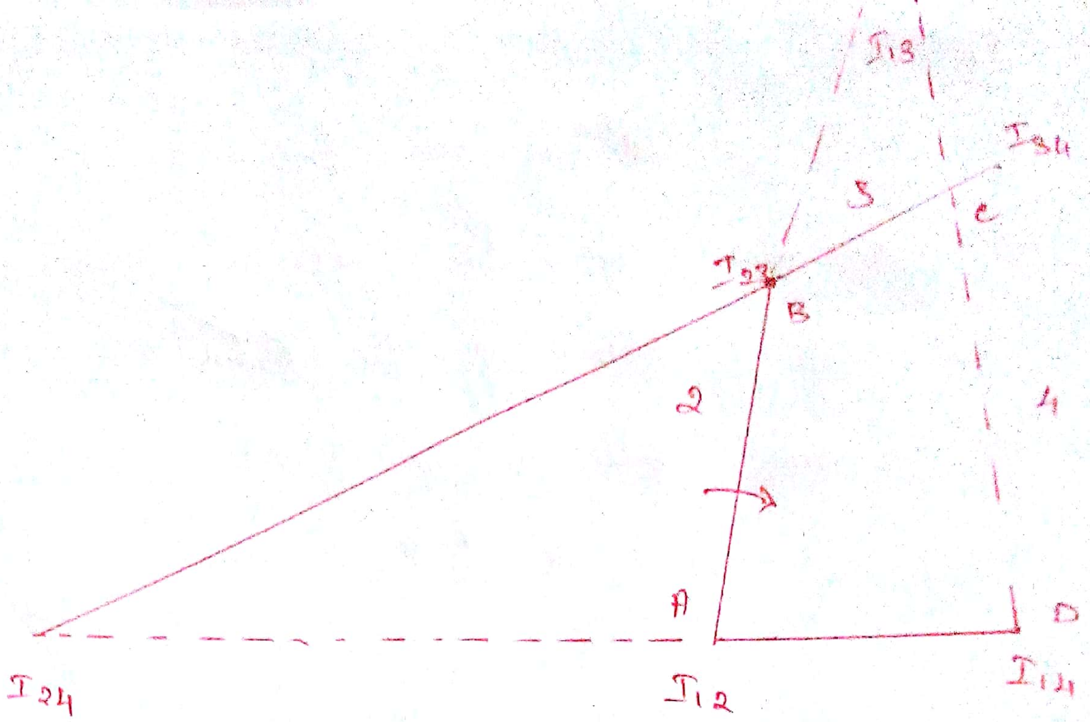
length of Crank AB = 300 mm = 0.3 m

$$V_B = \omega_{AB} \times AB = 10.47 \times 0.3$$

$$= 3.141 \text{ m/s}.$$

Location of I.C

$$N = \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$$



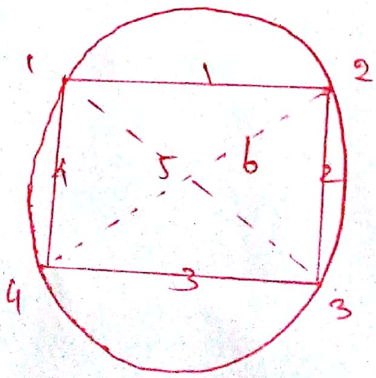
Angular velocity of the link BC

ω_{BC} = Angular velocity of the link BC

$V_B = \omega_{BC} \times I_{13}B$

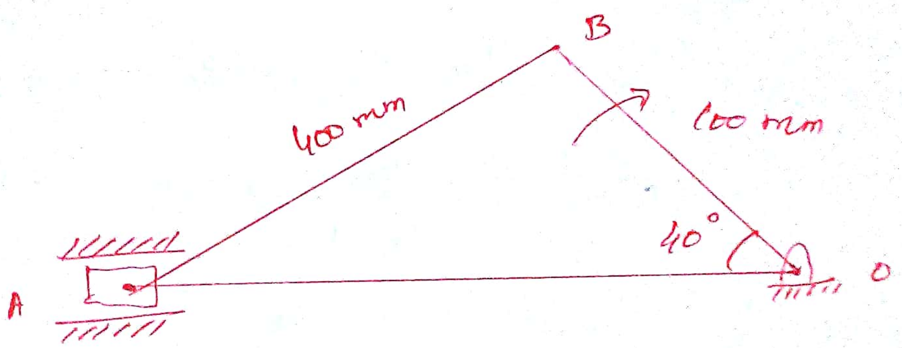
$I_{13}B = 500\ mm = 0.5\ m$

$$\omega_{BC} = \frac{V_B}{I_{13}B} = \frac{3.141}{0.5} = 6.28\ rad/s$$



Ex:-

locate all the IC of the slider crank mechanism as shown in fig. The lengths of crank AB & connecting rod AB are 100 mm & 400 mm respectively. If the crank rotates clockwise with an angular velocity of 10 rad/s. find 1. velocity of the slider. 2. Angular velocity of the connecting rod AB.



Given :-

$\omega_{OB} = 10$ rad/s

$OB = 100$ mm $= 0.1$ m

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

$= 10 \times 0.1 = 1$ m/s

Location of IC.

$$N = \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$$

velocity of slider,

$I_{13}A = 460$ mm $= 0.46$ m

$I_{13}B = 560$ mm $= 0.56$ m

w.r.t

$$\frac{V_A}{I_{13}A} = \frac{V_B}{I_{13}B}$$

$$V_A = V_B \times \frac{I_{13}A}{I_{13}B}$$

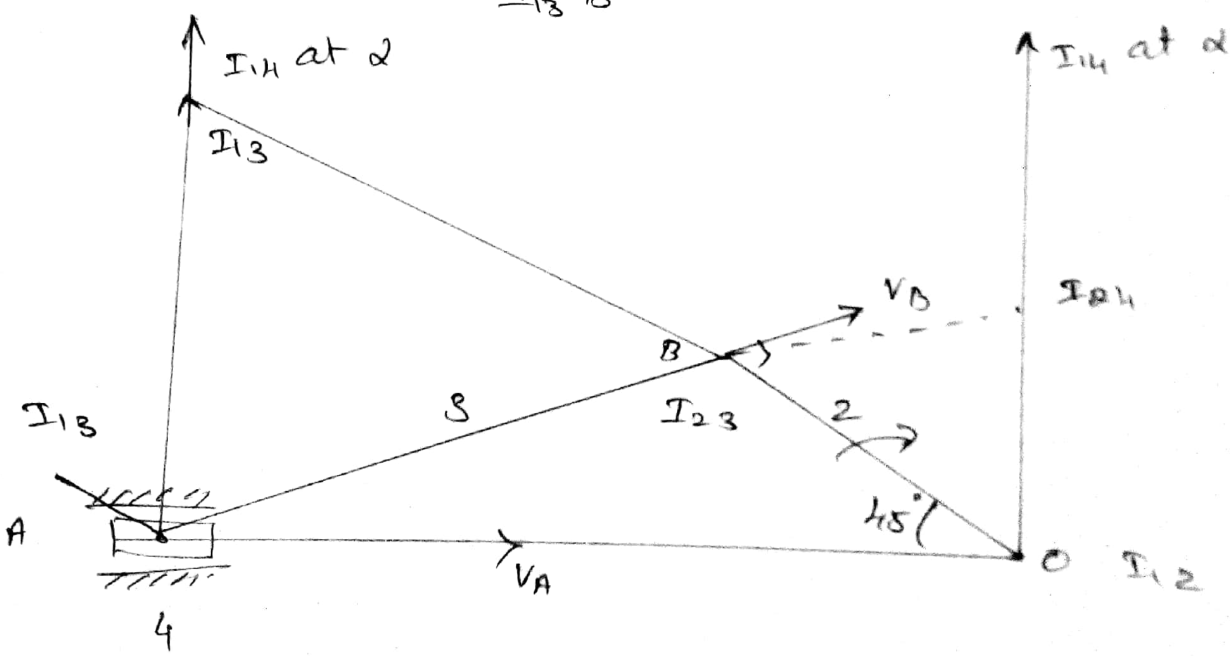
$$= 1 \times \frac{0.46}{0.56}$$

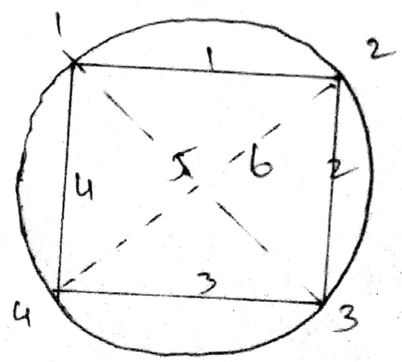
$$= 0.82 \text{ m/s}$$

Angular velocity of Connecting rod AB :- (ω_{AB})

$$\frac{V_A}{I_{13}A} = \frac{V_B}{I_{13}B} = \omega_{AB}$$

$$\omega_{AB} = \frac{V_B}{I_{13}B} = \frac{1}{0.56} = 1.78 \text{ rad/s}$$





Coriolis Component of acceleration :-

* When a Point on one link is Sliding along another rotating link, such as in quick return motion mechanism, then the coriolis Component of the acceleration must be calculated.

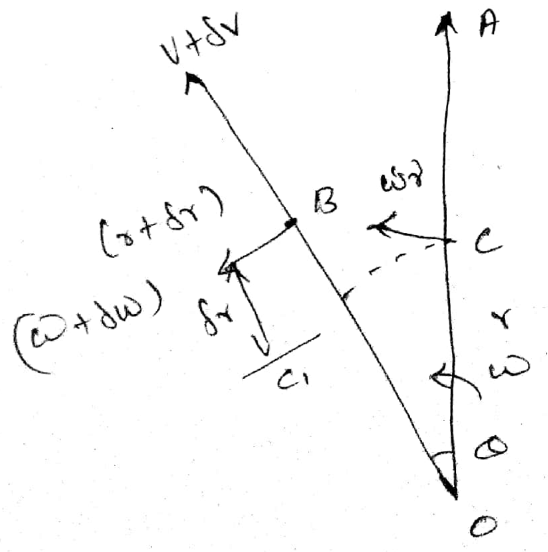
* Consider a link OA & a slider B as shown in fig.

* The slider B moves along the link OA. the Point C is the Coincident Point on the OA.

ω - angular velocity of link OA at time(t)

V - Velocity of the Slider B along the link OA.

ω.r - Velocity of the Slider B.



* This tangential Component of acceleration of the slider B w.r.t. Coincident Points C on the link

Introduction of linkages:-

* A Mechanical linkages is an assembly of bodies Connected to manage forces & movement

* the movement of a body or link is studied using geometry so the link is considered to be rigid.

* The Connection b/w links are molded as Providing ideal movement, Pure rotation or Sliding for eg. and are Joints.

* A linkage molded as network of rigid links & ideal joints is called kinematic Chain

* linkages may be Constructed from open Chains, Closed chains or Combination of open & closed Chains.