Lesson 8

Velocity Analysis *- Instantaneous Centre Method*

Velocity analysis (Instantaneous Centre ...)

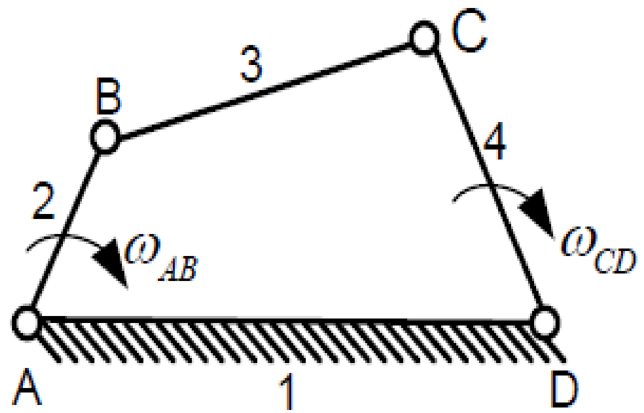
An Instantaneous (I-centre) is a centre of rotation of a moving body relative to another body.

I-centre can be ..

a point on a member which another member rotates around, permanently or instantaneously;

a point in common place between two members

The velocities are equal (both in direction and magnitude) at the I-Centre



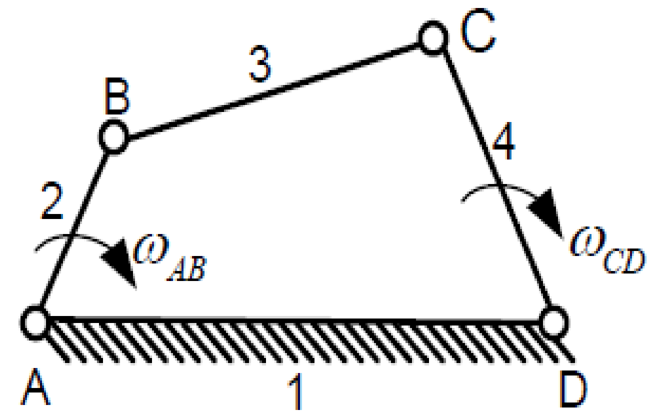
Velocity analysis (Instantaneous Centre …)

Number of instantaneous centres in a mechanism …

The number of instantaneous centers (N) in a kinematic chain is equal to the number of possible combinations of two links.

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

Where n = number of links.



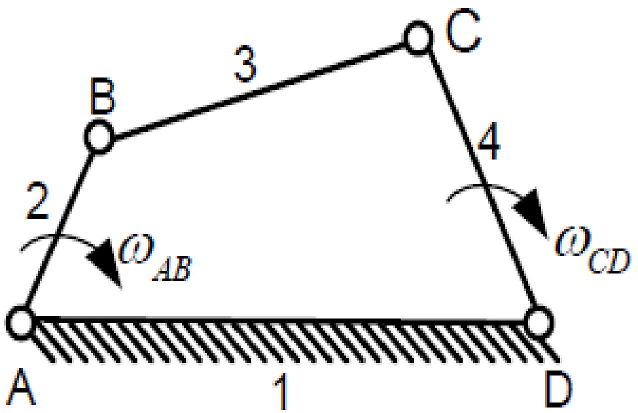
Velocity analysis (Instantaneous Centre …)

Properties of the instantaneous centre …

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

The *two rigid links have no linear velocity relative to each other* at the instantaneous centre.

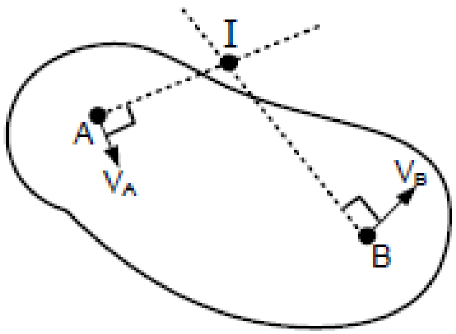
At this point the *two rigid links have the same linear velocity relative to the third rigid link*.



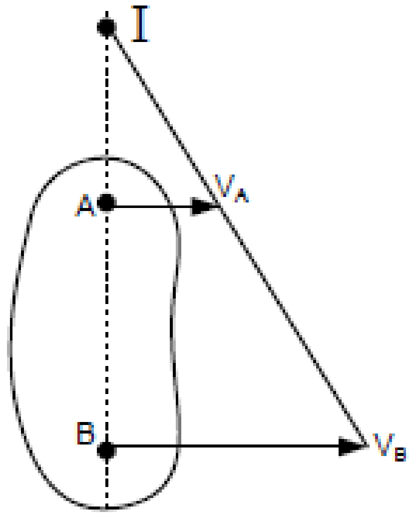
Velocity analysis **(Instantaneous Centre …)**

Rules to Locate Instantaneous Centres by Inspection…

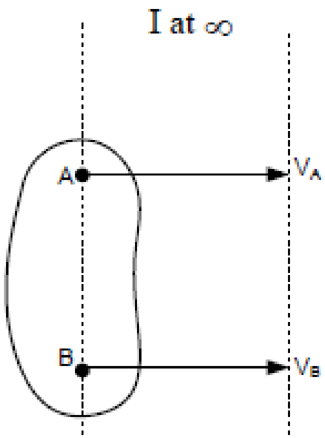
In a pivoted joint, the centre of *the pivot* is the I-centre for the two links of the pivot.



When V_A is NOT parallel to V_B



When V_A IS parallel to V_B



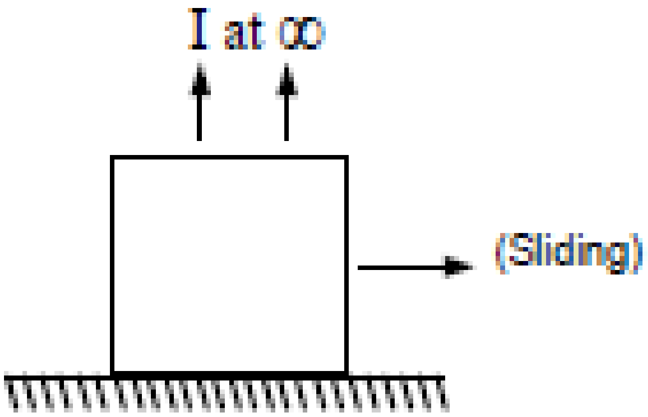
When V_A is parallel to V_B and V_A=V_B

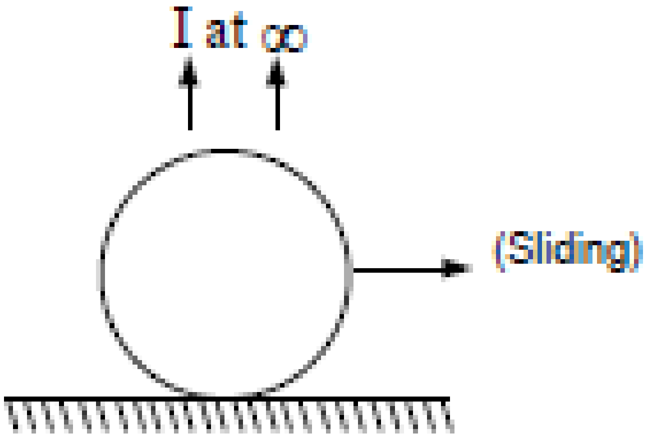
Velocity analysis (Instantaneous Centre ...)

- Rules to Locate Instantaneous Centres by Inspection…

  In a sliding motion, the I-centre lies at infinity in a direction perpendicular to the path of motion of the slider.

  This is because the sliding motion is equivalent to a rotary motion of the links with the radius of curvature as infinity.

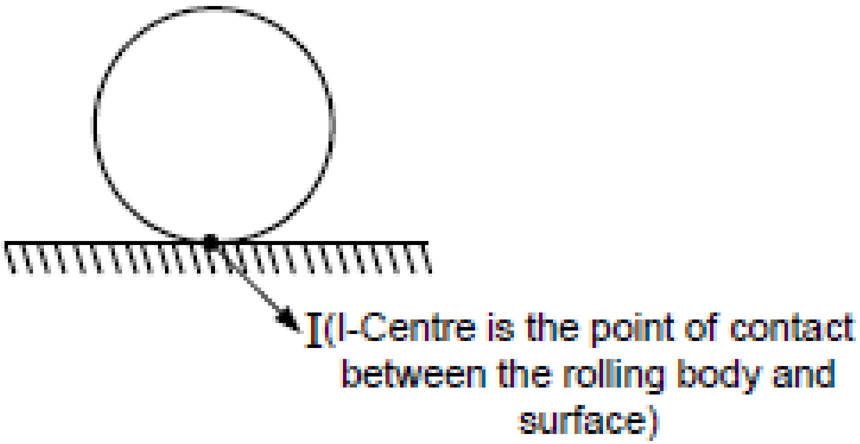




Velocity analysis (Instantaneous Centre …)

Rules to Locate Instantaneous Centres by Inspection…

In a pure rolling contact of the two links, the I-centre lies at the point of contact at the given instant. It is because the two points of contact on the two bodies have the same linear velocity and thus there is no relative motion of the two at the point of contact which is the I-centre



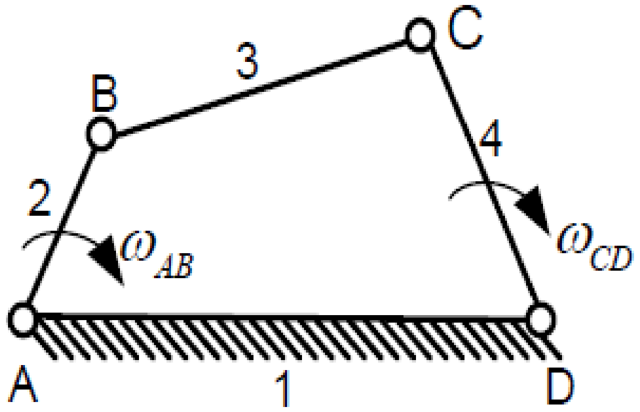
Velocity analysis (Instantaneous Centre …)

Types of Instantaneous Centres …

The instantaneous centres for a mechanism are of the following types.

Fixed Instantaneous centres
Permanent Instantaneous centres.
Neither fixed nor permanent instantaneous centres

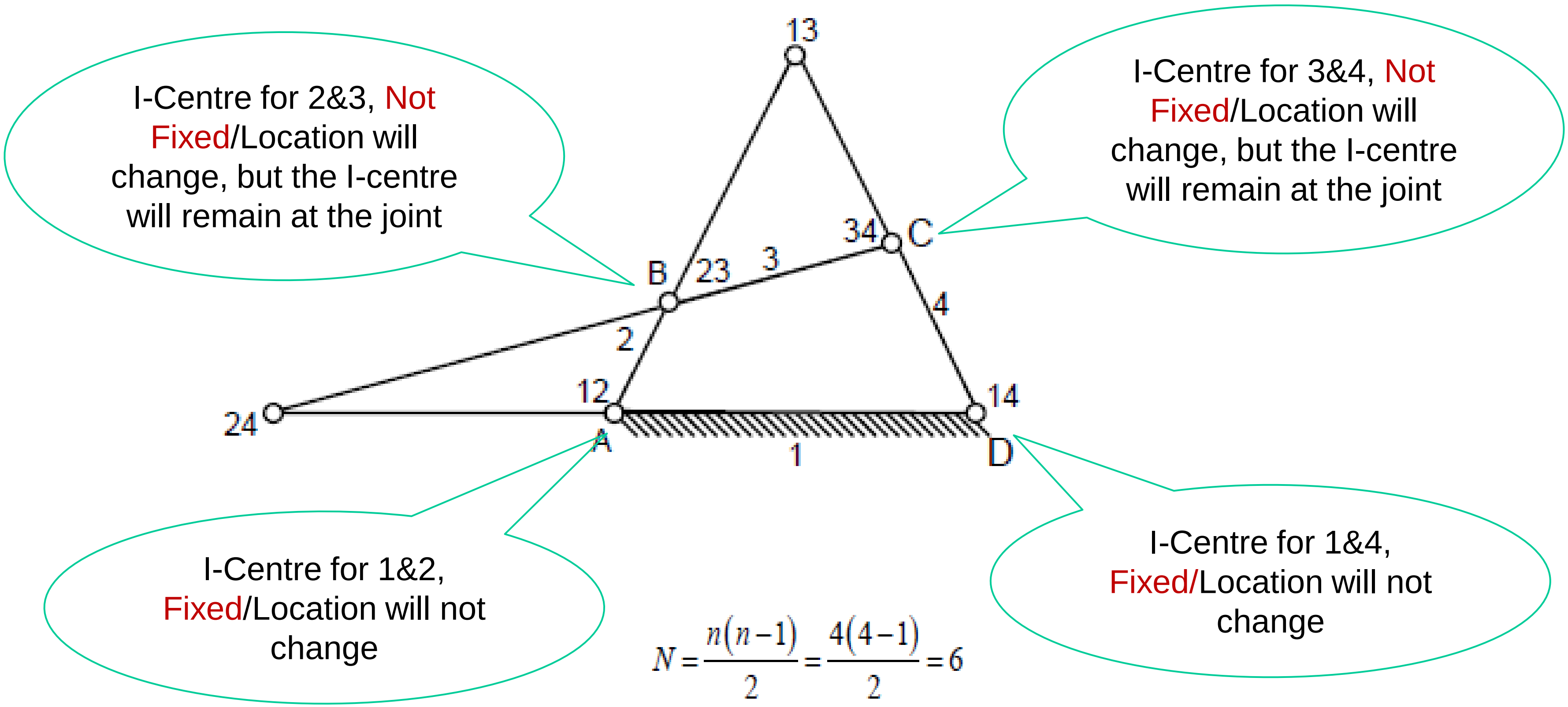
The first two types are together known as primary instantaneous centres and third type is known as secondary instantaneous centres.



Velocity analysis (Instantaneous Centre ...)

Example

Consider the 4-bar mechanism shown below. The I-centres 12, 14, 23 and 34 are permanent (i.e., are at the joints), and can be located by inspection.



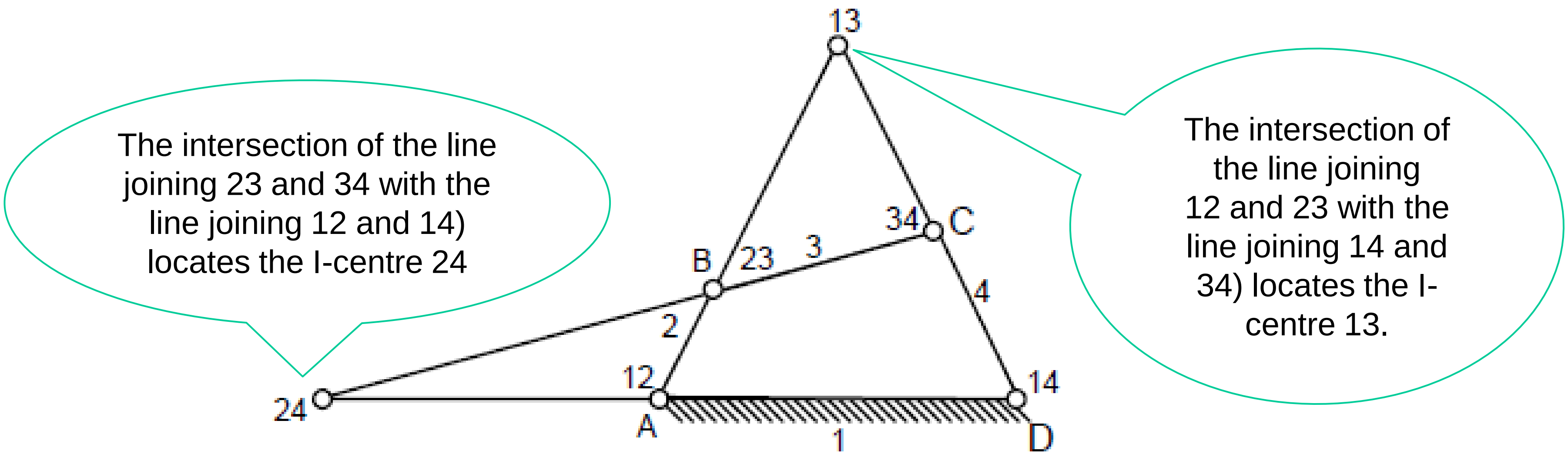
$$N = \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$$

Velocity analysis (Instantaneous Centre …)

Kennedy's theorem

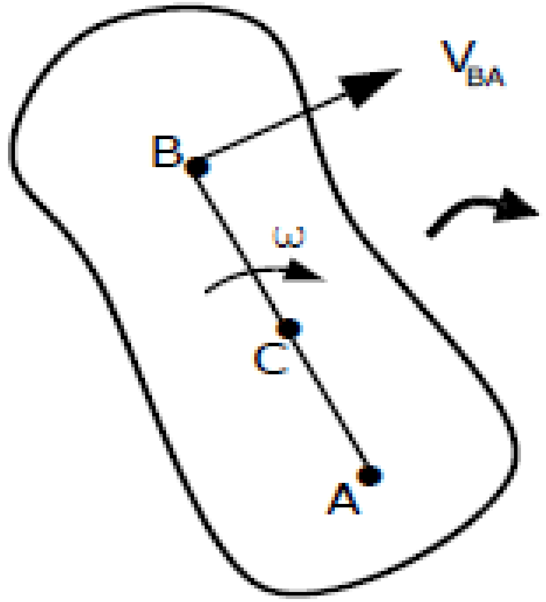
If three plane bodies have relative motion among themselves, their I-centre must lie on a straight line.

The I-centres 13 and 24 are neither fixed nor permanent can be located by applying Kennedy's theorem



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

Velocity analysis (Angular Velocity Ratio Theorem…)



Velocity of any point on a link with respect to another point on the same link is always perpendicular to the line joining these points.

Let ω = angular velocity of link AB about A. Velocity of point B with respect to A,

$$V_{BA} = \omega.AB$$

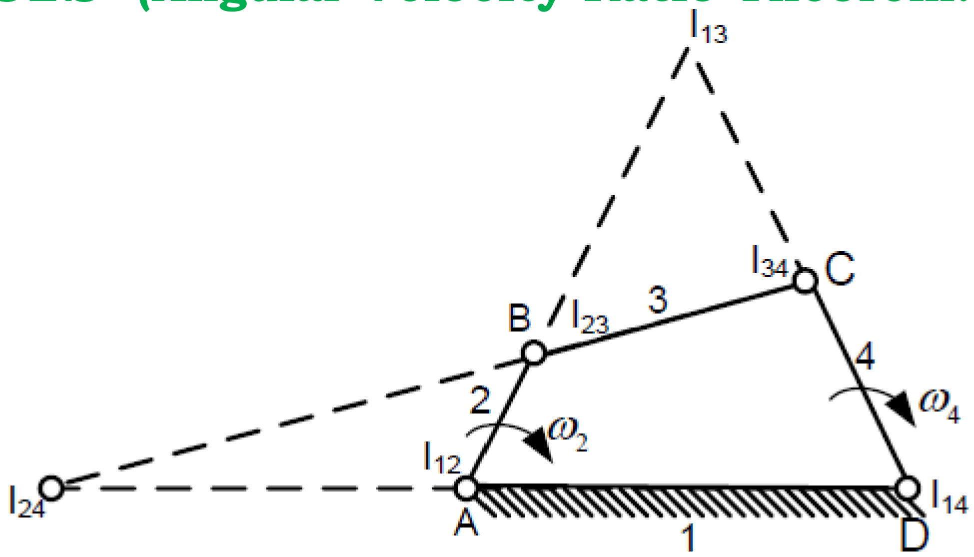
Similarly the velocity of any point C on AB with respect to A,

$$V_{CA} = \omega.AC$$

Thus, $$\frac{V_{CA}}{V_{BA}} = \frac{\omega.AC}{\omega.AB} = \frac{AC}{AB}$$

Velocity analysis (Angular Velocity Ratio Theorem…)

When the angular velocity of a link is known and it is required to find the angular velocity of another link:



a) locate common I-centre.

b) the velocity of this I-centre relative to a fixed third link is the same if the I-centre is considered on the first or the second link.

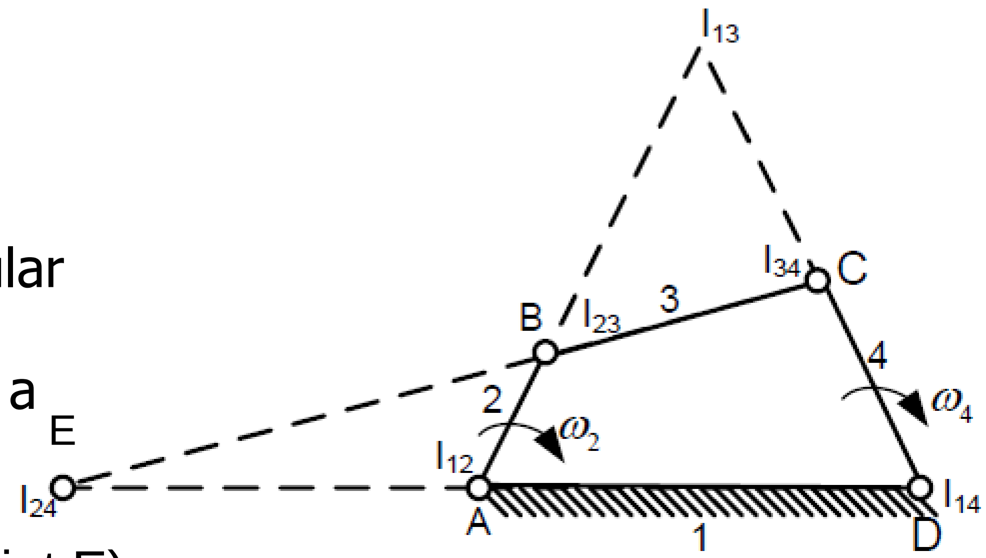
c) first consider the I-centre to be on the first link and obtain the velocity of the I-centre.

d) then, consider the I-centre to be on the second link and find its angular velocity.

Velocity analysis (Angular Velocity Ratio Theorem...)

Example

If it is required to find the angular velocity of the link 4 when the angular velocity of the link 2 of a four-link mechanism is known:



- locate the I-centre 24 (Point E).
- Imagine link 2 to be in the form of a flat disc containing point 24 and revolving about point A.

$$v_{24} = \omega_2.(AE)$$

- Now, imagine the link 4 to be large enough to contain point 24 and revolving about point D.

$$v_{24} = \omega_4.(DE)$$

$$\omega_2.(AE) = \omega_4.(DE)$$

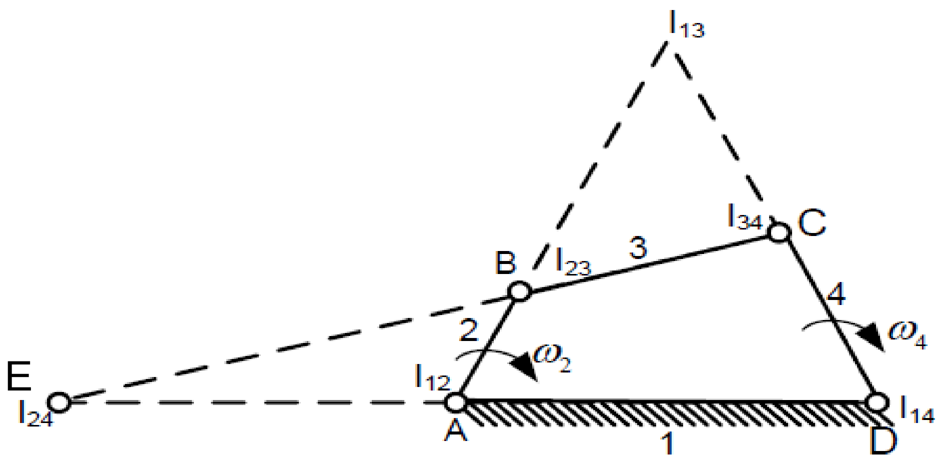
$$\omega_4 = \omega_2.\frac{(AE)}{(DE)}$$

Velocity analysis (Angular Velocity Ratio Theorem...)

Recall

$$\omega_2.(AE) = \omega_4.(DE)$$

$$\omega_4 = \omega_2.\frac{(AE)}{(DE)}$$



The above equation is known as the angular-velocity ratio theorem.

- In words, the angular velocity ratio of two links relative to a third link is inversely proportional to the distances of their common I-centre from their respective centre of rotation.

Velocity analysis (Rubbing Velocity ...)

The velocity of rubbing of the two surface will depend upon the angular velocity of a link, relative to the other.

Consider <u>two links</u> of a mechanism,
where,
ω_1 = Angular Velocity of link 1
ω_2 = Angular Velocity of link 2
r = Radius of pin joint between 1 & 2

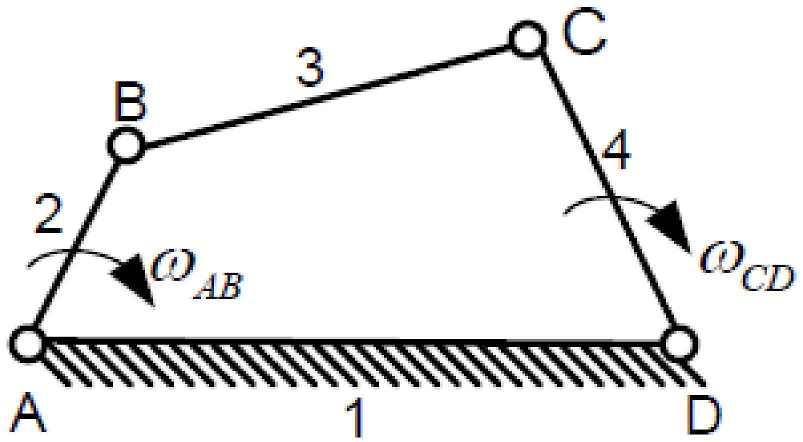
The rubbing velocity of joint between link 1 & 2 is given by

$$v_{rb} = r.(\omega_1 \pm \omega_2)$$

+ → If ω_1 & ω_2 rotates in anti clock wise direction
- → ω_1 & ω_2 rotates in clock wise direction

Velocity analysis (Rubbing Velocity …)

Consider a 4-link bar shown below. Rubbing velocity at all joint is given as :



At point A $= r_a.\omega_{AB}$

r_a = radius of the hole at joint A.

At point C $= r_c.(\omega_{BC} + \omega_{DC})$

r_c= radius of the hole at joint C.

At point B $= r_b.(\omega_{AB} + \omega_{BC})$

r_b = radius of the hole at joint B.

At point D $= r_d.\omega_{CD}$

r_d = radius of the hole at joint D.

End...

Any Questions?