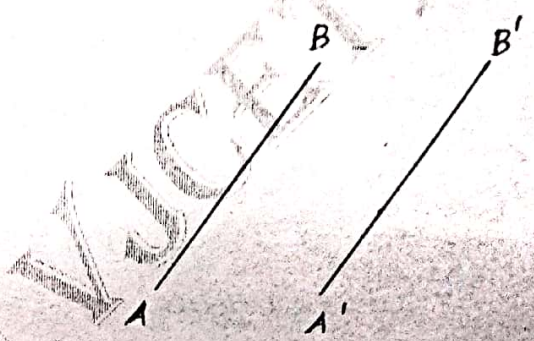
TYPES OF MOTION

A body may have the following types of motion.

(i) Motion of translation or plane motion
(ii) Motion of rotation
(iii) Combined motion of translation and rotation (general plane motion)

(I) Motion of Translation:

If a body moves in such a way that all its particles move in parallel path and travels the same distance, then the body is said to have the motion of translation.

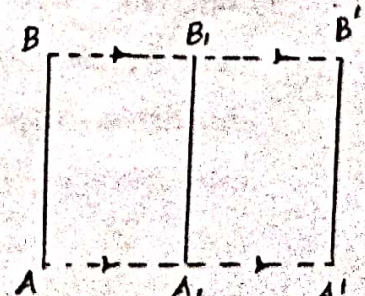


When a rigid body is in translation, all the particles of the body have same velocity and same acceleration at any particular instant. The motion of the rigid link AB from its initial position AB to A'B' shown in figure is an example for motion of translation.

The translational motion can be;
i) rectilinear ii) curvilinear

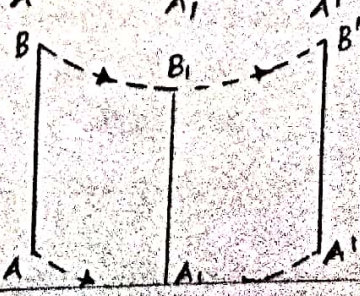
Rectilinear Translation:

In rectilinear translation, the link AB moves straightly to A'B' through A_1B_1



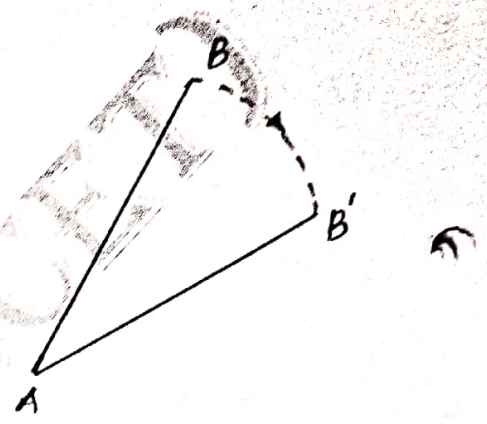
Curvilinear Translation:

In curvilinear translation, the link AB moves in plane such that A&B traces curves AA', and BB'B' respectively. But while moving, link AB is parallel to A_1B_1 and A'B'



(ii) Motion of Rotation:

If a body rotates about a fixed point in such a way that all its particle move in circular path, then the body is said to have motion of rotation. The fixed point about which the body rotates is called centre of rotation, and the axis passing through the fixed point is known as axis of rotation.



The particles lying on the axis of rotation have zero velocity and zero acceleration. The motion of link AB from its initial position to AB' is an example of motion of rotation.

(iii) Combined Motion of Translation and Rotation.

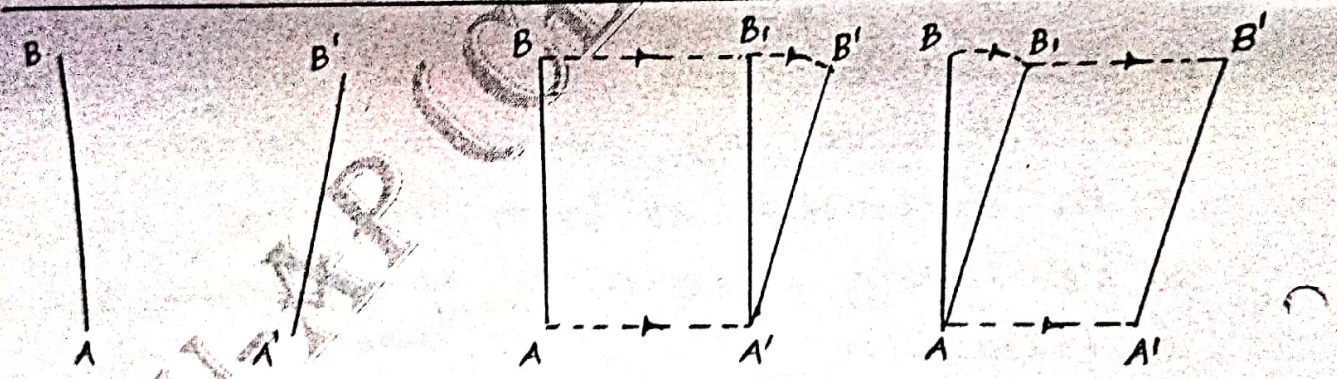


fig (a) fig (b) fig (c)

Consider a link AB which moves from its initial position AB to final position A'B' in a short interval of time as shown in figure (a). The link has neither entire motion of translation nor entire motion of rotation, but a combination of the two.

If we split up the motion of link AB, we will find that the link have first motion of translation from AB to A'B, and then motion of rotation about A' till it occupies the final position A'B' as shown in fig (b).

The motion of the link AB may also be considered to have first the motion of rotation from AB to AB_1 about A and then motion of translation from AB_1 to A'B' as shown in fig (c). Such a motion of the link from AB to A'B' is an example of combined motion of rotation and translation, it being immaterial whether the motion of rotation takes place first or the motion of translation.

INSTANTANEOUS CENTRE OF ROTATION:

The combined motion of rotation and translation of link AB from its initial position AB to the position A'B' may be assumed to be a motion of rotation about some centre. As the position of the link AB goes on changing, the centre about which the motion of rotation is assumed to takes place also goes on changing. Such a centre which goes on changing from instant to instant is known as instantaneous centre. The instantaneous centre of rotation is instantaneously at rest and has zero velocity. Hence this point is also known as instantaneous centre of zero velocity. The link may seems to be rotating about one point at one instant of time and about another point at the next instant. The locus of the instantaneous centre as the link goes on changing its position is called centrode.

Determination of the position of the instantaneous centre

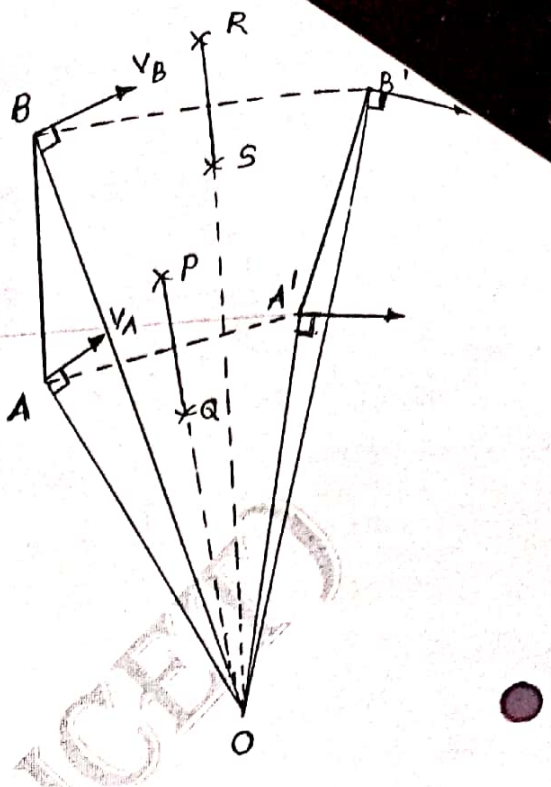
The position of the instantaneous centre may be located graphically as below:

(i) Draw the initial and final position of the rigid link; AB and A'B' respty.

(ii) Join AA' and BB'

(iii) Draw PQ, perpendicular bisector of AA' and RS, the perpendicular bisector of BB'

(iv) Extend the two perpendicular bisectors PQ and RS so as to meet at point O, which is the required centre of rotation or instantaneous centre.



Let ω → angular velocity of the link AB about O

V_A → Linear velocity of point A

V_B → Linear velocity of point B.

V_A = Distance of point A from the centre of rotation × angular velocity

ie, $\boxed{V_A = OA \times \omega}$ → (1)

Also, $\boxed{V_B = OB \times \omega}$ → (2)

$\frac{(1)}{(2)} \Rightarrow \boxed{\frac{V_A}{V_B} = \frac{OA}{OB}}$

The direction of velocity at A will be right angles to OA, whereas the direction of velocity at B will be right angles to OB. Thus if directions of velocities at A and B are known, then the instantaneous centre of AB is obtained by drawing perpendiculars to the directions of the velocities at A and B. The point where these two perpendiculars meet is the instantaneous centre.

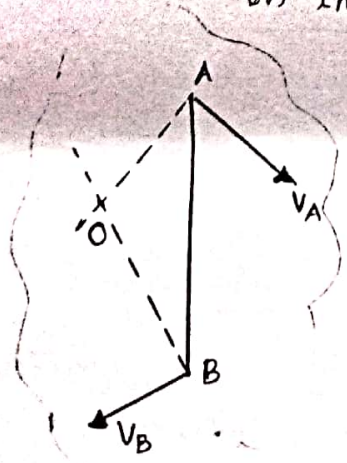
Properties of Instantaneous Centre:

I) The linear velocity of a point on the body is proportional to the distance of the point from the instantaneous centre and the angular velocity of the body.

II) When the direction of linear velocities of 2 points of a body is known, then the location of instantaneous centre can be found out by drawing perpendicular to the direction of linear velocities.

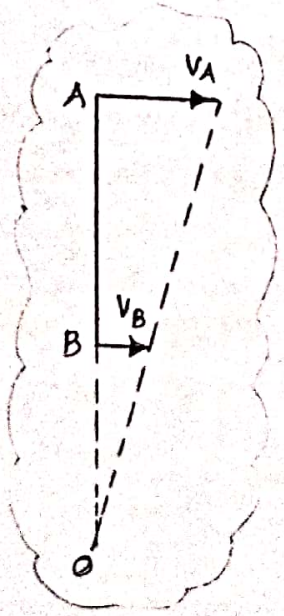
Location of instantaneous centre for some general cases:

Case I: When the direction of velocities of any 2 point on the body are known.

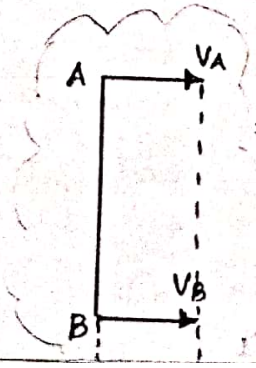


In this case, the instantaneous centre will be the point of intersection of the lines drawn perpendicular to the direction of velocities.

Case II: When the direction of velocities are parallel and unequal but in same direction

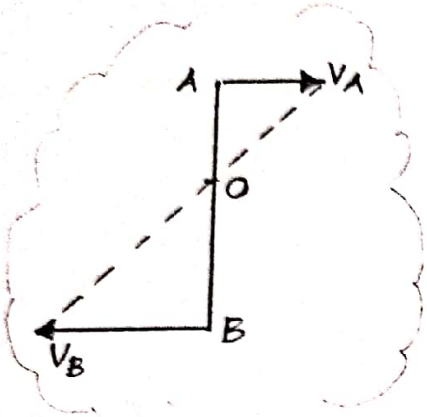


In this case the instantaneous centre will be the point of intersection of line joining the tip of the velocity vectors and the extension of the line joining the points

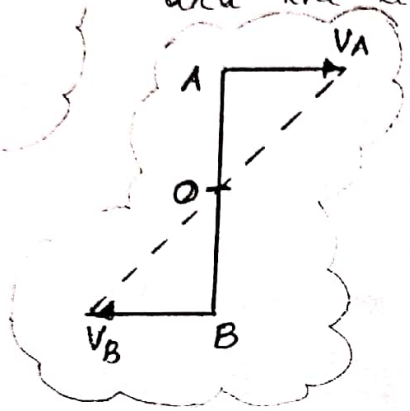


$\Rightarrow$ Motion of translation (direction of velocities parallel, equal in magnitude, same direction)

Case III: When the directions of velocities are parallel, unequal and opposite.



In this case, the instantaneous centre will be the point of intersection of the line joining the tip of the velocity vectors and the line joining the points.



⇒ Motion of pure rotation (Directions of velocities are parallel, equal but in opposite direction)

Characteristics of the instantaneous centre:

1. The instantaneous centre may be located inside or outside of the body.
2. The location of the instantaneous centre changes at every instant and the path traced by it is called centrode.
3. The instantaneous centre is having no velocity.
4. It is used only for velocity calculation.