

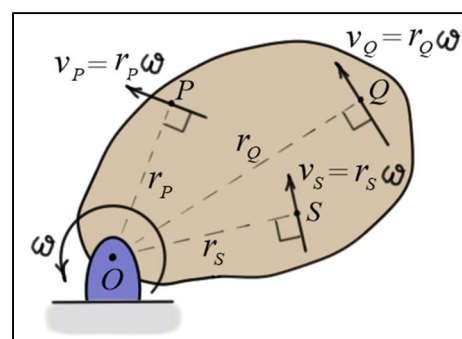
## Elementary Dynamics

### Instantaneous Centers of Zero Velocity

An *instantaneous center* is a point of a rigid body (or rigid body extended) that has **zero velocity** at a *given instant of time*. The *acceleration* of that point is generally **not zero**. The concept of instantaneous centers can be used instead of the relative velocity equation (discussed previously) to solve for the velocities and angular velocities of bodies within a system. As with other *graphical methods*, it is useful to understand (or “see”) the angular motion of a body. Although it applies to velocities and accelerations (linear and angular) of bodies in fixed axis rotation, it only applies to velocities (linear and angular) of bodies in general plane motion.

### Fixed Axis Rotation

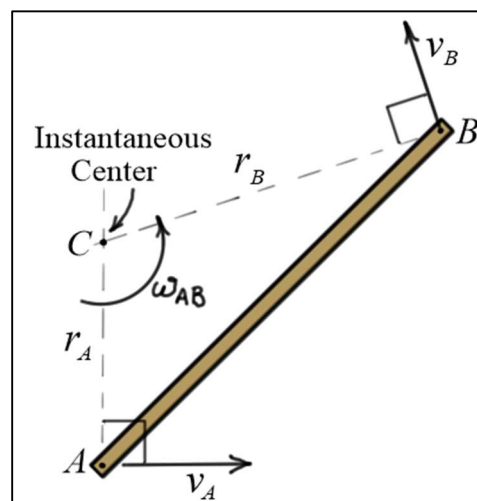
For a body undergoing *fixed axis rotation*, the *fixed-point*  $O$  always has **zero velocity**. It is always the center of rotation of the body, and it has **zero acceleration**. The velocity of any point on the body is equal to the product of the angular velocity and the distance from  $O$  to that point.



For example, the magnitude of the velocity of point  $P$  can be written as  $v_P = r_P \omega$ . The direction of the velocity is perpendicular to the line connecting  $O$  and  $P$ .

### General Plane Motion

In general plane motion, **no point** on the *body* has a **zero velocity** for all *time*; however, a point  $C$  can be identified on the body (or body extended) that has a **zero velocity** at a *given instant of time*.  $C$  can be found by identifying the *point of intersection* of *lines perpendicular* to the *velocities* of *two* (or more) *points on the body*. For the bar  $AB$  shown in the diagram,  $C$  is identified as the intersection point of the two dashed lines  $AC$  and  $BC$ . Line  $AC$  is *perpendicular* to the *velocity of A*, and line  $BC$  is *perpendicular* to the *velocity of B*.



The velocities of the two points are  $v_A = r_A \omega_{AB}$  and  $v_B = r_B \omega_{AB}$ . The *instantaneous center*  $C$  will be in *different locations* from *one instant* to the *next*.

## Rolling without Slipping

For a *rolling* disk, the *velocity* of the *contact point C* between the disk and the ground is *zero*, so it is the *instantaneous center* of the disk at any time. The velocity of any point *P* is in the direction shown and has magnitude  $v_P = r_P \omega$ .

