CEE 271 APPLIED MECHANICS II

Lecture 23: Instantaneous Center of Zero Velocity

Department of Civil & Environmental Engineering
University of Hawaiʻi at Mānoa

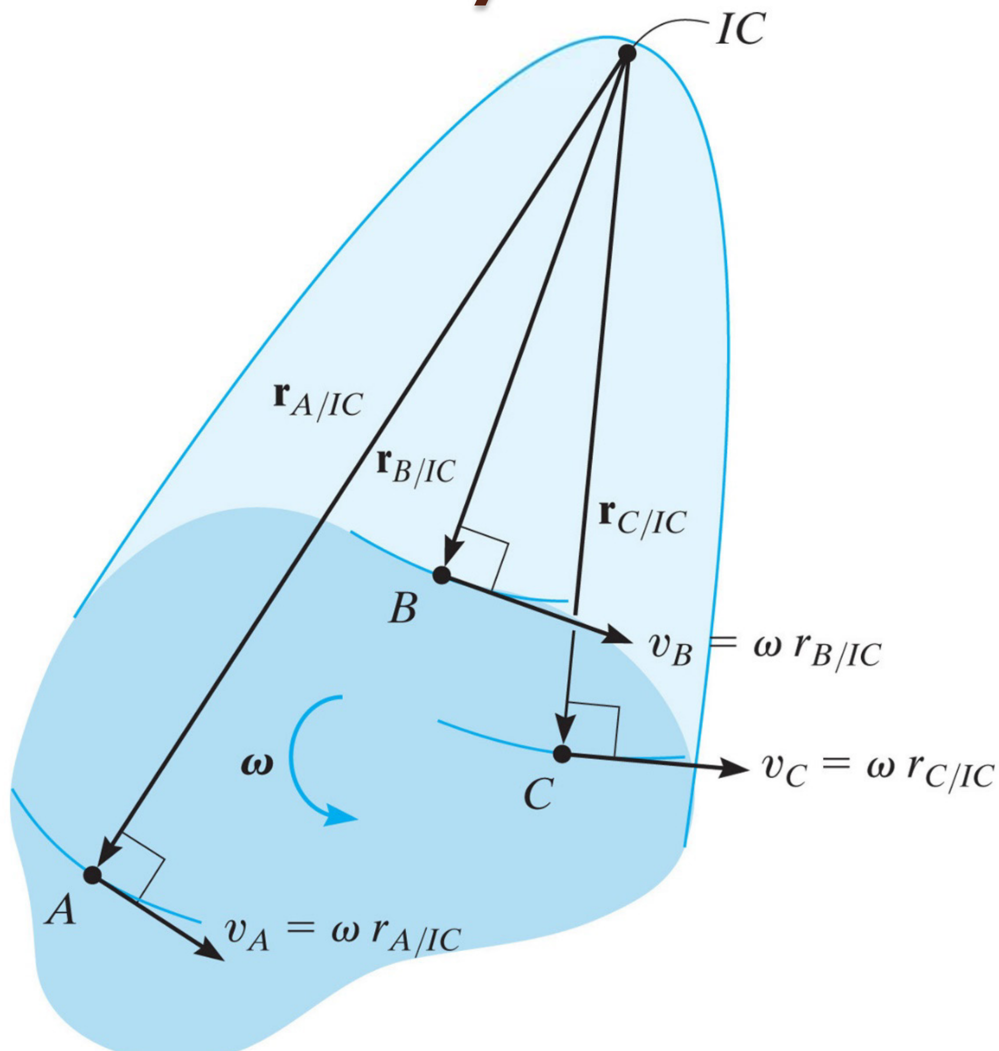
Today's Objectives

- Locate the instantaneous center of zero velocity.
- Use the instantaneous center to determine the velocity of any point on a rigid body in general plane motion.

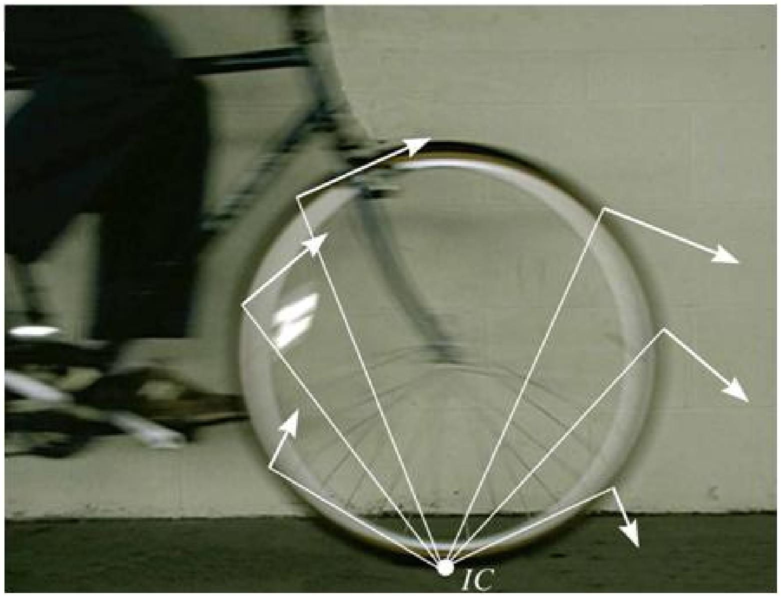
Outline (Pre-Job Brief)

- Location of the Instantaneous Center
- Velocity Analysis
- Examples and Questions
- Summary and Feedback

Instantaneous Center of Zero Velocity



Applications

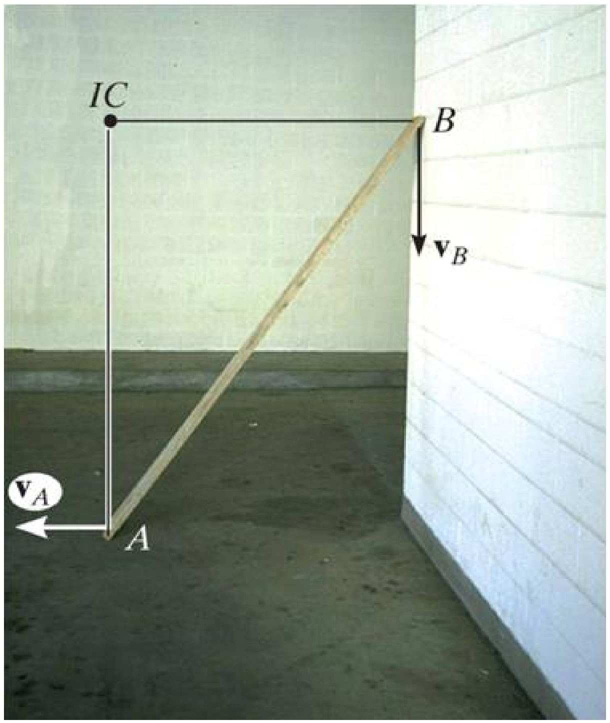


The instantaneous center (IC) of zero velocity for this bicycle wheel is at the point in contact with ground. The velocity direction at any point on the rim is perpendicular to the line connecting the point to the IC.

Which point on the wheel has the maximum velocity?

Does a larger wheel mean the bike will go faster for the same rider effort in pedaling than a smaller wheel?

Applications (continued)



As the board slides down the wall (to the left), it is subjected to general plane motion (both translation and rotation).

Since the directions of the velocities of ends A and B are known, the IC is located as shown.

How can this result help you analyze other situations?

What is the direction of the velocity of the center of gravity of the board?

Instantaneous Center of Zero Velocity

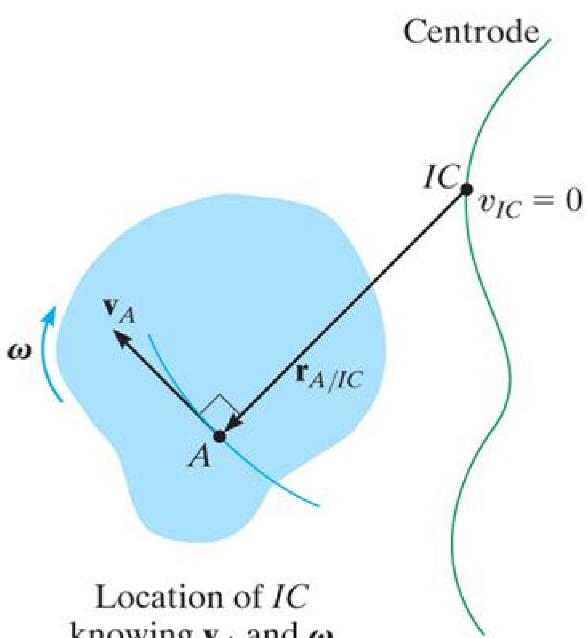
For any body undergoing planar motion, there always exists a point in the plane of motion at which the velocity is instantaneously zero (if it is rigidly connected to the body).

This point is called the instantaneous center (IC) of zero velocity. It may or may not lie on the body!

If the location of this point can be determined, the velocity analysis can be simplified because the body appears to rotate about this point at that instant.

Instantaneous Center Location

To locate the IC, we use the fact that the velocity of a point on a body is always perpendicular to the relative position vector from the IC to the point. Several possibilities exist.



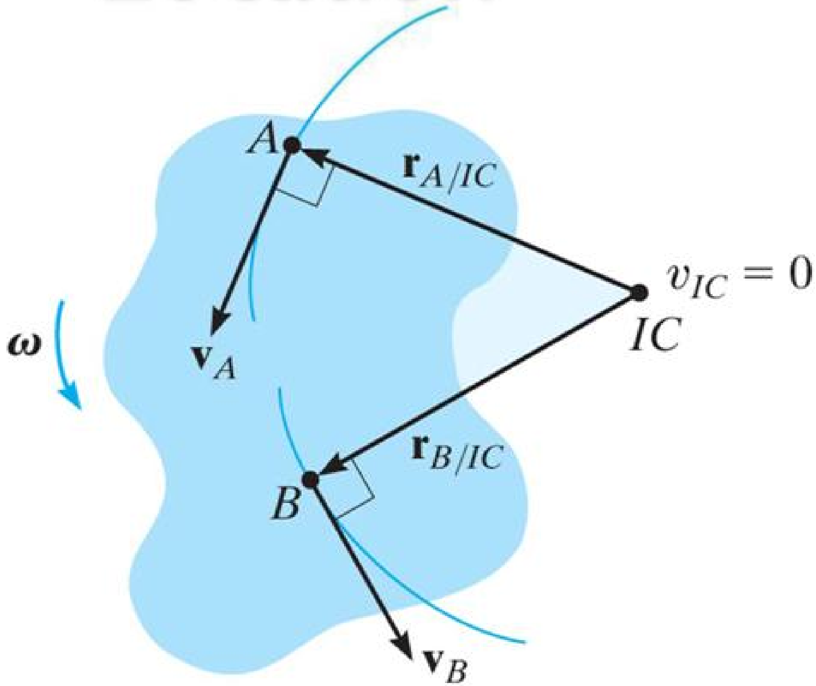
Location of *IC* knowing $\mathbf{v}_A$ and $\boldsymbol{\omega}$

First, consider the case when velocity $\boldsymbol{v}_A$ of a point A on the body and the angular velocity $\boldsymbol{\omega}$ of the body are known.

In this case, the IC is located along the line drawn perpendicular to $\boldsymbol{v}_A$ at A, a distance $r_{A/IC} = v_A/\omega$ from A.

Note that the IC lies up and to the right of A since $\boldsymbol{v}_A$ must cause a clockwise angular velocity $\boldsymbol{\omega}$ about the IC.

Instantaneous Center Location

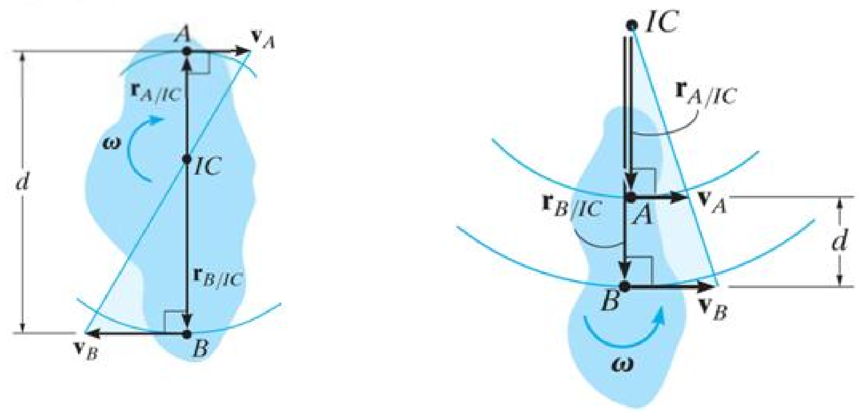


Location of *IC* knowing the directions of $\mathbf{v}_A$ and $\mathbf{v}_B$

A second case occurs when the lines of action of two non-parallel velocities, v_A and v_B, are known.

First, construct line segments from A and B perpendicular to v_A and v_B. The point of intersection of these two line segments locates the IC of the body.

Instantaneous Center Location



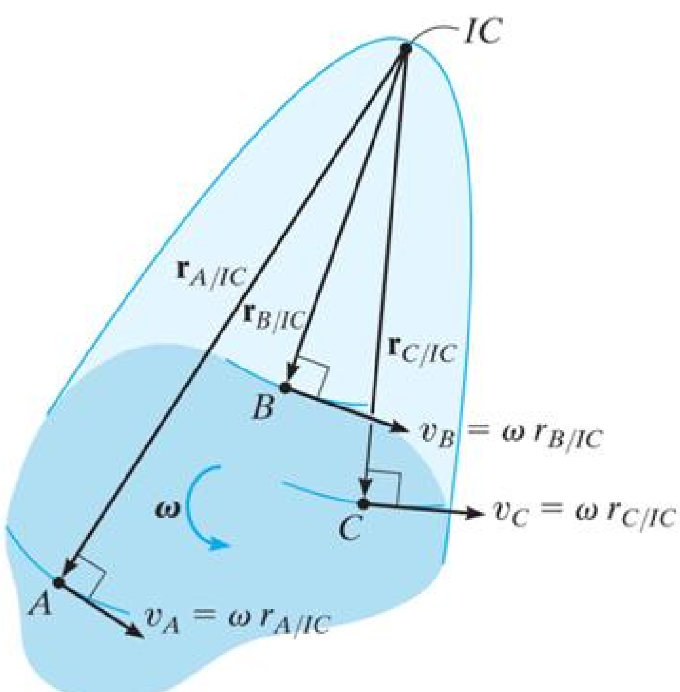
Location of *IC* knowing $\mathbf{v}_A$ and $\mathbf{v}_B$

A third case is when the magnitude and direction of two parallel velocities at A and B are known. Here the location of the IC is determined by proportional triangles.

As a special case, note that if the body is translating only ($\boldsymbol{v}_A = \boldsymbol{v}_B$), then the IC would be located at infinity. Then ω equals zero, as expected.

Velocity Analysis

The velocity of any point on a body undergoing general plane motion can be determined easily, often with a scalar approach, once the instantaneous center of zero velocity of the body is located.



Since the body seems to rotate about the IC at any instant, as shown in this kinematic diagram, the magnitude of velocity of any arbitrary point is $v = \omega\, r$, where r is the radial distance from the IC to the point.

The velocity's line of action is perpendicular to its associated radial line.

Examples & Questions

Learning Catalytics™

- Please sign in:
  - www.learningcatalytics.com