DYNAMICS

Planar Kinematics of a Rigid Body (Instantaneous Centre of Zero Velocity)

by:

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Instantaneous Centre of Zero Velocity

- Aims
  - To introduce the Instantaneous Centre of Zero Velocity (IC)
  - To identify the location of IC

- Expected Outcomes
  - Students are able to identify the location of IC
  - Students are able to calculate the velocity or angular velocity using the IC method

- References
  - Engineering Mechanics: Dynamics 12th Edition, RC Hibbeler, Prentice Hall

Contents

- Instantaneous Centre of Zero Velocity (IC)
- How to Identify the Location of IC
- Example Calculation

Instantaneous Centre of Zero Velocity

Velocity of Point *B*

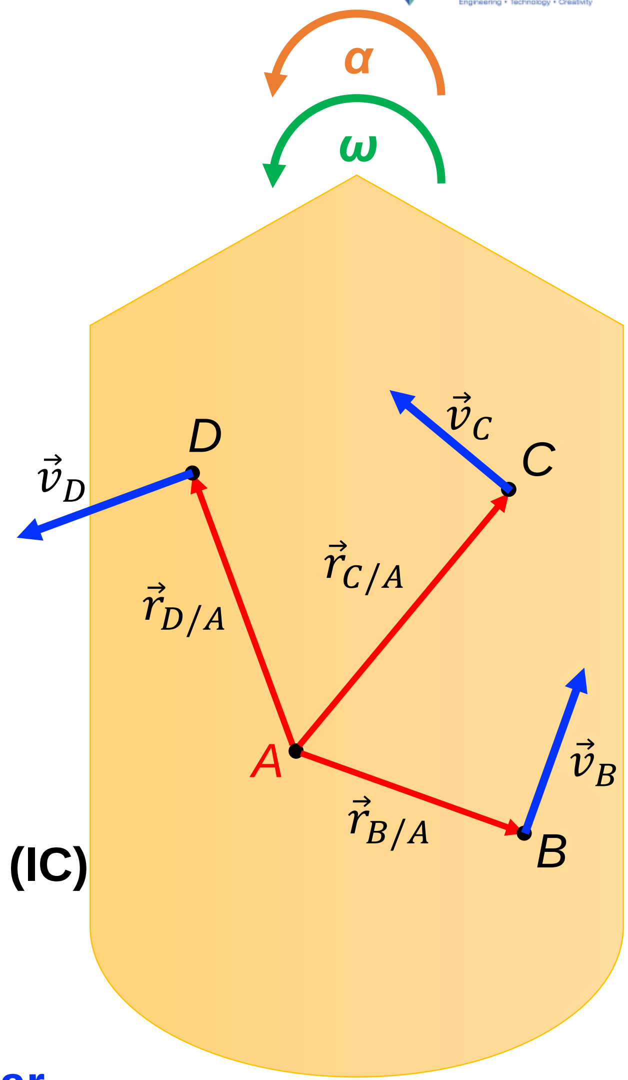
$$\vec{v}_B = \vec{v}_A + \vec{\omega} \times \vec{r}_{B/A}$$

If at an instant $\vec{v}_A = 0$, then

$$\vec{v}_B = \vec{\omega} \times \vec{r}_{B/A}$$

$$\vec{v}_C = \vec{\omega} \times \vec{r}_{C/A}$$

$$\vec{v}_D = \vec{\omega} \times \vec{r}_{D/A}$$



As if the body is making a pure rotation about point *A*

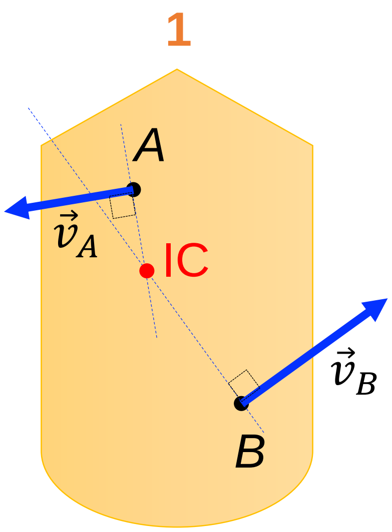
Point *A* → the **Instantaneous Centre of Zero Velocity (IC)**

Why instantaneous?

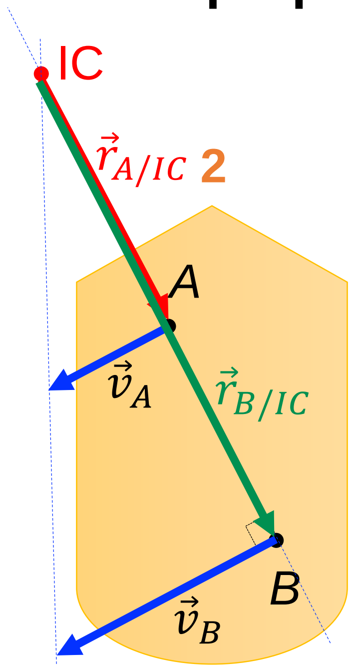
Because the zero velocity **only occurs at that particular instant**, not every time!

How to identify the IC?

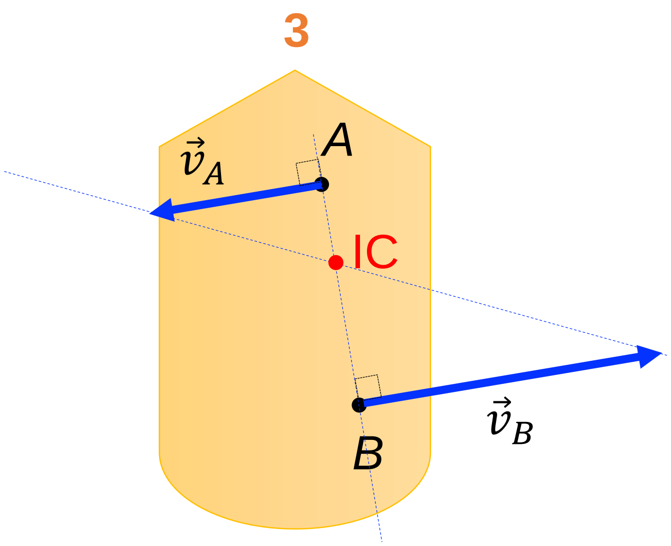
- The **velocity vector** of Point *X* must be **perpendicular** to the **position vector** of Point *X* with respect to IC.
- The **velocity magnitude** must be **proportional** to the **relative distance**.



Velocity directions are not parallel to each other

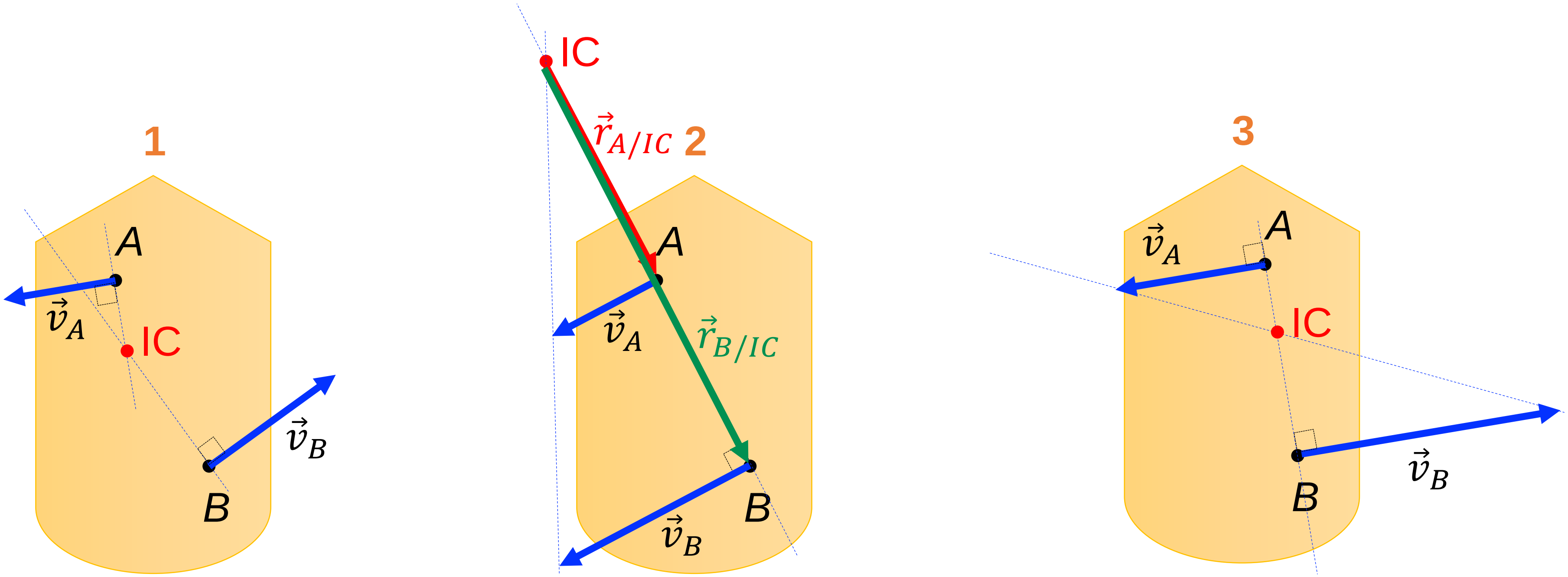


Velocity directions are parallel to each other in the same direction



Velocity directions are parallel to each other in the opposite direction

How to identify the IC?



Velocity directions are not parallel to each other

Velocity directions are parallel to each other in the same direction

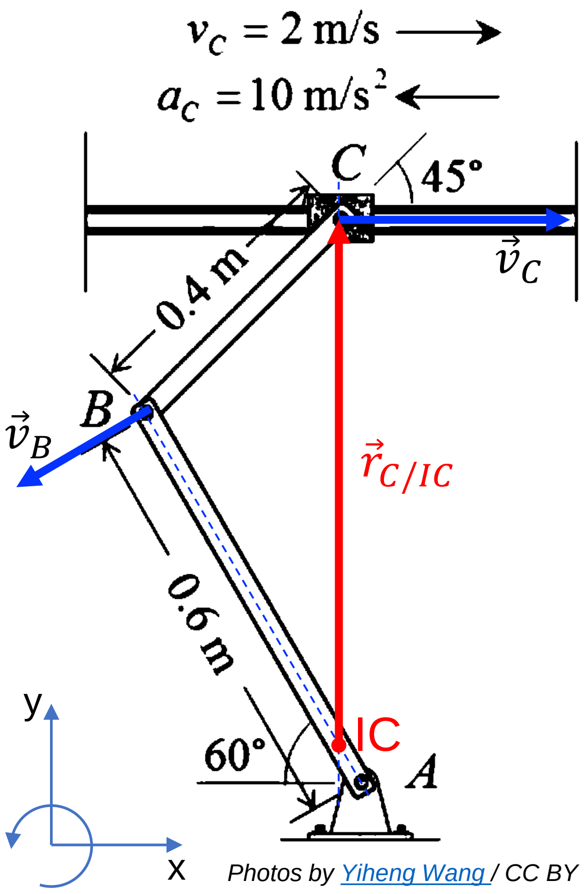
Velocity directions are parallel to each other in the opposite direction

$$\frac{v_{A/IC}}{r_{A/IC}} = \frac{v_{B/IC}}{r_{B/IC}} = \omega$$

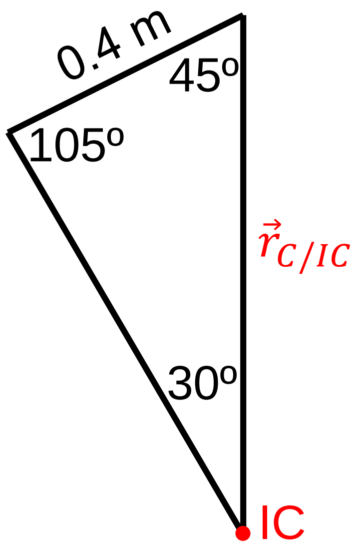
Using the **IC method**, calculation normally in **scalar**, not in vector format.

Example calculation

If the collar *C* slides with linear velocity and accelerations as shown, determine the angular velocity and angular acceleration of rod *BC* at the instant shown using the IC method.



Photos by Yiheng Wang / CC BY



$$\frac{v_{A/IC}}{r_{A/IC}} = \frac{v_{B/IC}}{r_{B/IC}} = \omega$$

$$\omega_{BC} = \frac{v_C}{r_{B/IC}}$$

Using sin rule,

$$\frac{\vec{r}_{C/IC}}{\sin 105°} = \frac{0.4}{\sin 30°}$$

$$\vec{r}_{C/IC} = 0.7727$$

$$\omega_{BC} = \frac{2}{0.7727} = 2.588 \text{ rad/s}$$

Since point *C* is moving to the right, clockwise about *IC*, therefore the direction of rotation is actually **clockwise**.

Conclusions

- In the case of a rigid body undergoing general plane motion, the instantaneous centre of zero velocity is the location at which, at that particular moment, the body can be considered as rotating purely about the IC.
- There are 3 methods to determine the location of IC.
- If the location of IC can be determined, the complexity of the calculation can be reduced.

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"If I have seen further it is by standing on the shoulders of Giants."

– *Sir Isaac Newton*