# MMAN2300
# Engineering Mechanics 2

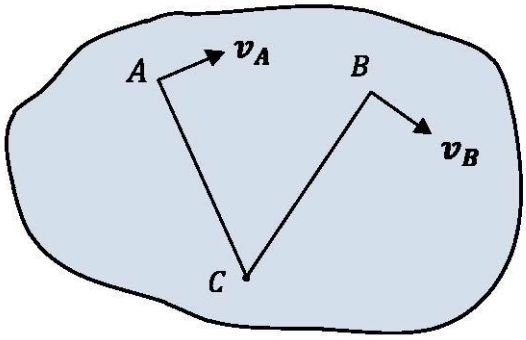
## Part A: Week 3

## Method of instant centres

(Chapter 5/5 Meriam & Kraige,
Chapter 4 Waldron & Kinzel)

1. Instantaneous centres of zero velocity

At every instant during the motion of a rigid body in a plane there exists a point that is instantaneously at rest. This point is called the instantaneous centre of zero velocity.




The body rotates about *C* instantaneously.

Note:

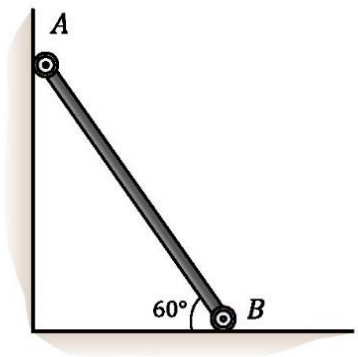
(1) The location of an instantaneous centre can be determined by the directions of two velocities.
(2) Point *C* may lie on or off the body and *C* may not be fixed.
(3) At the instant shown, $\boldsymbol{v}_C = 0$ m/s. Point *C* is called the instantaneous centre of zero velocity.

Applications of the instantaneous centre of zero velocity:

- To determine the linear velocity of any points in the body;
- To determine the direction of the instant velocity of any points in the body.

*Example 1*

Given: *AB* = 4 m and $\boldsymbol{v}_A = 2\ m/s \downarrow$
Find $\boldsymbol{v}_B$ and $\boldsymbol{\omega}_{AB}$. Use the method of instantaneous centre of zero velocity.



2. Instant Centres

Definition: Given two bodies 2 & 3 moving with planar motion relative to each other in a reference frame *R*, there is, in general, one and only one location in the plane motion where the coincident points at a given instant have the same velocity with respect to the reference *R*. One coincident point is in body 2 and the other in body 3. This location is called the instant centre of velocity for bodies 2 & 3, and is represented by 23 or 32.

$$\boldsymbol{v}_{23(2)} = \boldsymbol{v}_{23(3)}$$

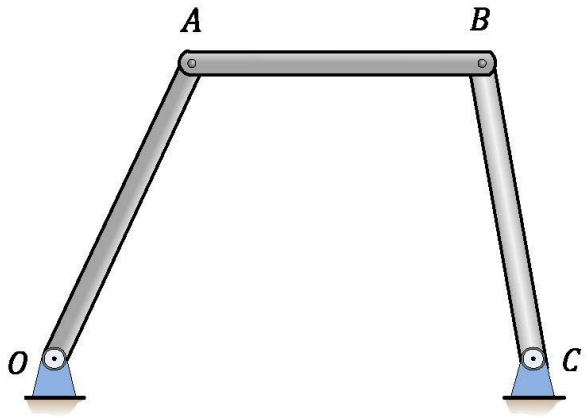
i.e., At any instant we can find a common point to two bodies which has the same instantaneous velocity in each body.

$$\boldsymbol{v}_{23(2)} = \omega_2(\overline{12-23})$$

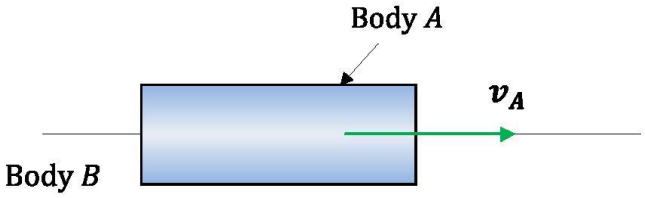
$$\boldsymbol{v}_{23(3)} = \omega_2(\overline{13-23})$$

$$\Rightarrow \omega_2(\overline{12-23}) = \omega_3(\overline{13-23})$$

*Example 2*: Locate instant centres (common points)

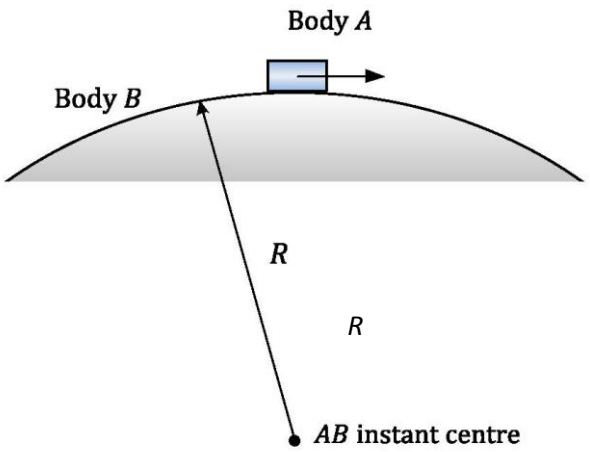


- Location of an instant centre can tend toward infinity




- An instant centre needs not be physically located on each link. It may be located on an imaginary extension to a link

- An instant centre can also be considered as a point about which one body rotates relative to another body at a given instant




Body *A* is a block moving on a circular arc on body *B*.

The centre of the arc (*AB*) is the instant centre of both bodies.

3. Three Centre Theorem (Kennedy's Theorem)

   Kennedy's Theorem consists of two major components:

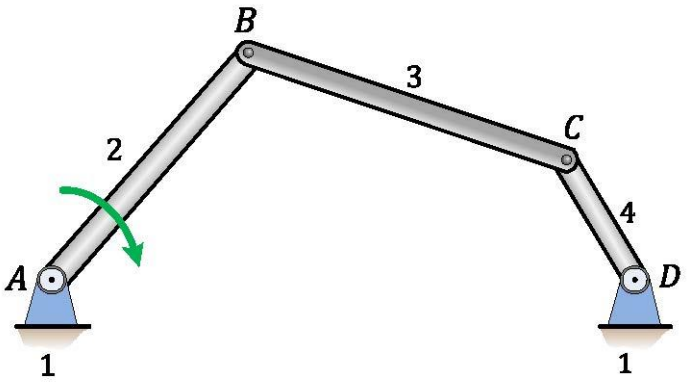
   (a) If there are n bodies and we take them two at a time, the total number of instant centres are:

$$N_{Ic} = \frac{n(n-1)}{2}$$

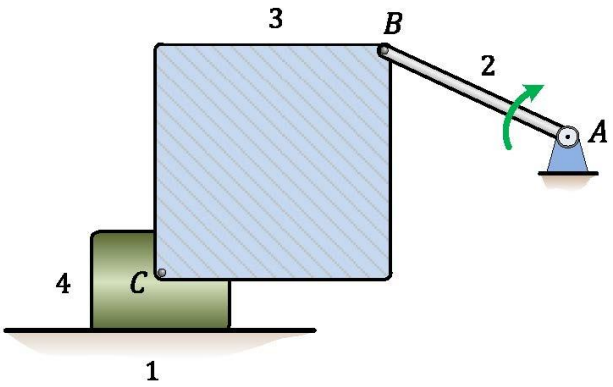
   (b) Three Centre Theorem: The 3 instant centres for 3 independent bodies in plane motion will lie on a straight line.

*Example 3:* Locate all instant centres for the following mechanisms

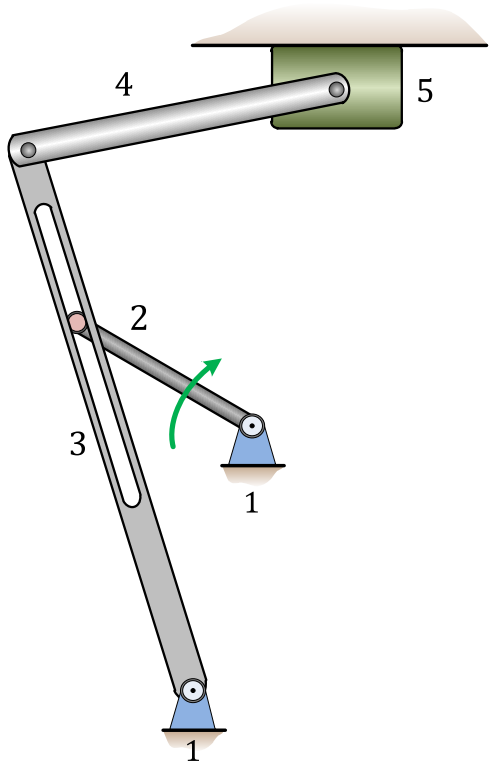
(a)



(b)



(c)



*Example 4*

At the instant shown, bar *AB* has a clockwise angular velocity of $\omega = 4$ rad/s. Using the method of instant centres, calculate:

(a) the velocity of point *C*,

(b) the angular velocities of links *BC* and *CD*.