INSTANT CENTER OF VELOCITY

Today’s Agenda

- Definition (primary and secondary IC)
- Graphical determination of IC
- Kennedy’s Theorem
- Samples Exercises
6.1 Definition of Velocity

**Definition**
- Rate of change of position with time
- Linear velocity: \( V = \frac{dR}{dt} \)
- Angular velocity: \( \omega = \frac{d\theta}{dt} \)

**Of a point in pure rotation:**
- Magnitude: \( V = r\omega \)
- Angle: Perpendicular to radius \( r \)
Definition

**Rigid body:**
- A point of a rigid body whose velocity is zero at a given instant is called instantaneous center.

**Mechanism:**
- A point, common to two bodies (links) in a plane, which point has the same instantaneous velocity in each link.
Because it is possible that each link of a mechanism can have relative motion (instant center) with respect to every other link, each mechanism has several IC’s.

The total number of instant centers $P$ of $n$ links in the plane is:

$$p = \frac{n(n - 1)}{2}$$
In typical analysis not every instant center is used. But every center could conceivably be employed. Therefore it is important to understand the process of locating each center.
LOCATING INSTANT CENTERS

Primary ICs.

Some ICs can be located by simply inspecting the kinematic pairs of a mechanism. These centers are called primary centers.

When locating primary ICs for various types of kinematic pairs, make use of following explanations.
# Locating Instant Centers

<table>
<thead>
<tr>
<th>Type of Kinematic Pair</th>
<th>Location of Instantaneous Center</th>
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<tbody>
<tr>
<td>Turning pair</td>
<td>The instantaneous center coincides with the turning pair.</td>
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<tr>
<td>Sliding pair (curved slide)</td>
<td>The slider is in curvilinear motion with respect to the slide. The instantaneous center is at the center of curvature of the slide.</td>
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<tr>
<td>Sliding pair (straight slide)</td>
<td>The slider is in rectilinear motion with respect to the slide. A straight slide is equivalent to a curved slide of infinite radius. Thus, the instantaneous center is at an infinite distance in a direction perpendicular to the sliding motion.</td>
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LOCATING INSTANT CENTERS

Rolling pair

The instantaneous center is at the point of contact, this being the only point where the two links have the same velocity.

Two degree of freedom pair

Relative motion takes place along the common tangent between the two links at the point of contact. Consequently, the instantaneous center lies on the common normal. Its position on the common normal depends on the ratio of the sliding and angular velocities.
LOCATING INSTANT CENTERS

(a)  

(b)  

Common normal  

Common tangent
Kennedy’s Theorem

- Instant Centers that cannot be found by simple inspection of the kinematic pairs a mechanism are determined using the *Kennedy’s theorem*. 
Kennedy’s Rule

Any three links, designate as \( I, j, \) and \( k \), undergoing motion relative to one another, will have exactly three associated IC’s, \( P_{ij}, P_{ik}, \) and \( P_{jk} \), and they will lie on the same straight line.
Instant Center Diagram

- ICs diagram is a graphical method used to track ICs that have been located and those that still need to be found. It indicates the combinations of ICs that can be used in applying Kennedy’s theorem.

- The method uses *auxiliary polygon* or *dual diagram*.
Example 1: Finding ICs of a 4-bar

\[ p = \frac{n(n - 1)}{2} \]

\[ p = \frac{4(4 - 1)}{2} = 6 \]

In a Dual, lines become points, and points become lines.
IC’s Can Be At Infinity

The IC of a slider joint is at infinity along the line perpendicular to the direction of sliding.

(b) Crank-rocker linkage

(c) Slider-crank linkage
Example 2: IC’s of a Slider-Crank Linkage

Dual Graph

[Diagram of a Slider-Crank Linkage with IC’s indicated]
Instant Centers of a Cam and Follower

Finding IC’s using Effective linkage

(b) The linkage graph

(c) The instantaneously equivalent "effective linkage"
Instant Centers of a Cam and Follower

Finding IC’s without using effective linkage
Summary

- Instant Centers locations and diagram
- Kennedy theorem
Home work

- Do problems 2:14 and 2:17
- Remember to print out the figures from text
- DVD/CD