UNIT II KINEMATICS OF LINKAGE MECHANISMS

2.1 Displacement, velocity and acceleration analysis in simple mechanisms:

Important Concepts in Velocity Analysis

1. The absolute velocity of any point on a mechanism is the velocity of that point with reference to ground.

2. Relative velocity describes how one point on a mechanism moves relative to another point on the mechanism.

3. The velocity of a point on a moving link relative to the pivot of the link is given by the equation: V =   r, where . = angular velocity of the link and r = distance from pivot.

Acceleration Components

- ***Normal Acceleration:*****A**^{n} = ^{2}r. Points toward the center of rotation
- ***Tangential Acceleration:*****A**^{t} =   r. In a direction perpendicular to the link
- ***Coriolis Acceleration:*****A**^{c} = 2   dr/dt. In a direction perpendicular to the link
- ***Sliding Acceleration:*****A**^{s} = d^2r/dt^2. In the direction of sliding.

A rotating link will produce normal and tangential acceleration components at any point a distance, r, from the rotational pivot of the link. The total acceleration of that point is the vector sum of the components.

A slider attached to ground experiences only sliding acceleration.

A slider attached to a rotating link such that the slider is moving in or out along the link as the link rotates experiences all 4 components of acceleration. Perhaps the most confusing of these is the coriolis acceleration, though the concept of coriolis acceleration is fairly simple. Imagine yourself standing at the center of a merry-go-round as it spins at a constant speed (. You begin to walk toward the outer edge of the merry-go-round at a constant speed dr/ dt. Even though you are walking at a constant speed and the merry-go-round is spinning at a constant speed, your total velocity is increasing because you are moving away from the center of rotation (i.e. the edge of the merry-go-round is moving faster than the center. This is the coriolis acceleration. In what direction did your speed increase? This is the direction of the coriolis acceleration.

The total acceleration of a point is the vector sum of all applicable acceleration components:

$$\mathbf{A} = \mathbf{A}^n + \mathbf{A}^t + \mathbf{A}^c + \mathbf{A}^s$$

These vectors and the above equation can be broken into x and y components by applying sines and cosines to the vector diagrams to determine the x and y components of each vector. In this way, the x and y components of the total acceleration can be found.

2.2 Graphical Method, Velocity and Acceleration polygons :

* Graphical velocity analysis:

It is a very short step using basic trigonometry with sines and cosines to convert the graphical results into numerical results. The basic steps are these:

1. Set up a velocity reference plane with a point of zero velocity designated.

2. Use the equation, V =   r, to calculate any known linkage velocities.

3. Plot your known linkage velocities on the velocity plot. A linkage that is rotating about ground gives an absolute velocity. This is a vector that originates at the zero velocity point and runs perpendicular to the link to show the direction of motion. The vector, $\mathbf{V}_A$, gives the velocity of point A.

4. Plot all other velocity vector directions. A point on a grounded link such as point B will produce an absolute velocity vector passing through the zero velocity point and perpendicular to the link. A point on a floating link such as B relative to point A) will produce a relative velocity vector. This vector will be perpendicular to the link AB and pass through the reference point A) on the velocity diagram.

5. One should be able to form a closed triangle (for a 4-bar that shows the vector equation: $\mathbf{V}_B = \mathbf{V}_A + \mathbf{V}_{B/A}$ where $\mathbf{V}_B$ = absolute velocity of point B, $\mathbf{V}_A$ = absolute velocity of point A, and $\mathbf{V}_{B/A}$ is the velocity of point B relative to point A.

2.3 Velocity and Acceleration analysis of mechanisms Graphical Methods:

Velocity and acceleration analysis by vector polygons: Relative velocity and accelerations of particles in a common link, relative velocity and accelerations of coincident particles on separate link, Coriolis component of acceleration.

Velocity and acceleration analysis by complex numbers: Analysis of single slider crank mechanism and four bar mechanism by loop closure equations and complex numbers.

- ✓ **Velocity Analysis of Four Bar Mechanisms:**
- Problems solving in Four Bar Mechanisms and additional links.
- ✓ **Velocity Analysis of Slider Crank Mechanisms:**
- Problems solving in Slider Crank Mechanisms and additional links.
- ✓ **Acceleration Analysis of Four Bar Mechanisms:**
- Problems solving in Four Bar Mechanisms and additional links.

- ✓ **Acceleration Analysis of Slider Crank Mechanisms:**
- Problems solving in Slider Crank Mechanisms and additional links.
- ✓ **Kinematic analysis by Complex Algebra methods:**
- Analysis of single slider crank mechanism and four bar mechanism by loop closure equations and complex numbers.
- ✓ **Vector Approach:**
- Relative velocity and accelerations of particles in a common link, relative velocity and accelerations of coincident particles on separate link
- ✓ **Computer applications in the kinematic analysis of simple mechanisms:**
- Computer programming for simple mechanisms

2.4 Coincident points, Coriolis Acceleration:

- ***Coriolis Acceleration:*** $A^c = 2$ dr/dt. In a direction perpendicular to the link.

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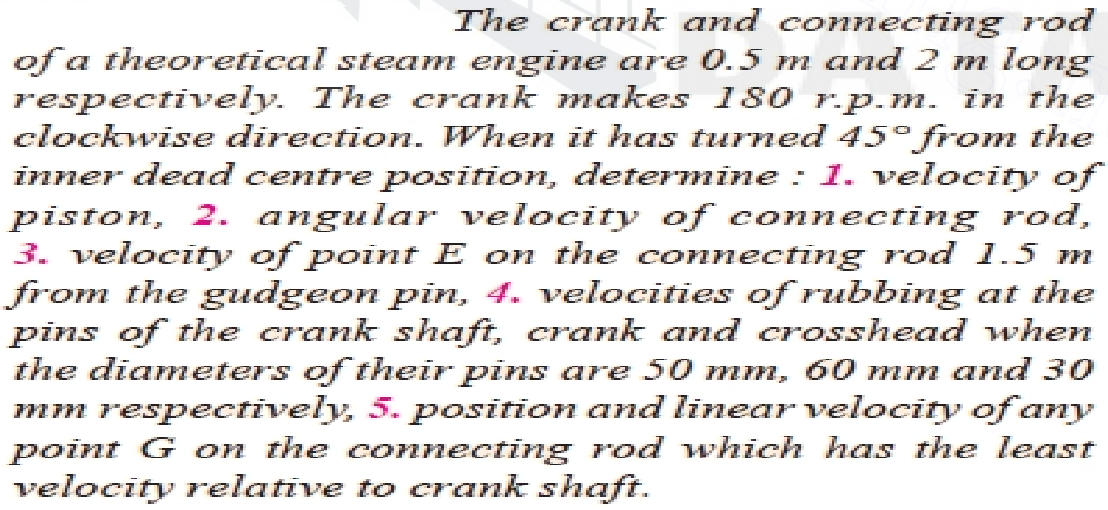
2.5 Linkage Synthesis Problem

Example:1



The crank and connecting rod of a theoretical steam engine are 0.5 m and 2 m long respectively. The crank makes 180 r.p.m. in the clockwise direction. When it has turned 45° from the inner dead centre position, determine : 1. velocity of piston, 2. angular velocity of connecting rod, 3. velocity of point E on the connecting rod 1.5 m from the gudgeon pin, 4. velocities of rubbing at the pins of the crank shaft, crank and crosshead when the diameters of their pins are 50 mm, 60 mm and 30 mm respectively, 5. position and linear velocity of any point G on the connecting rod which has the least velocity relative to crank shaft.