Practice Problems

1. Choosing Loop Vectors

Draw loop vectors for the following mechanisms, and identify the variables that will be unknowns during position, velocity and acceleration analysis. Clearly show angles of vectors, and arrowheads.

a) Telescoping Link (telescoping link extends at constant speed) – write velocity and acceleration equations in matrix-vector form.

![Telescoping Link Diagram](image1)

b) RRPP Mechanism (revolute-revolute-prismatic-prismatic). Link 2 is input. Write velocity and acceleration equations in matrix-vector form.

![RRPP Mechanism Diagram](image2)
2. Choosing Loop Vectors

Draw loop vectors for the following mechanisms, and identify the variables that will be unknowns during position, velocity and acceleration analysis. Clearly show angles of vectors, and arrowheads.

a) Scotch Yoke (crank is input). Write equations for position analysis.

b) Quick-Return Mechanism. Link 2 is input. Two loops are required to find position, velocity and acceleration of point D (link 6). Write equations for position analysis to find position of link 6. Identify outputs of the first loop. Identify inputs and outputs of the second loop.
3. A shop crane schematic is shown below. Load would hang from point D.

Link 2 extends at a known rate. Therefore, \( r_2, \dot{r}_2, \ddot{r}_2 \) are known at all times.

a) Draw position loop vectors, clearly indicating their directions and defining their angles. Write your loop closure equation. Write position equations in a form suitable for Matlab implementation, such that for any value of \( r_2 \), the x and y coordinates of D can be found.

b) Differentiate your loop closure equation and write velocity and acceleration equations in matrix-vector form. These equations, if solved, would give you angular velocity and acceleration of link 3. Calculation of velocity and acceleration of point D would then be easy.

Position equations are tricky for this problem. Your vector loop will be a triangle, and you could use sine and cosine law for triangles to get your unknown position variables (lengths or angles) as a function of known positions. Or, you could follow something similar to the four-bar position analysis derivation in the Waldron and Kinzel handout.
Credit Problem

A level-luffing crane (left) is designed to keep the load moving horizontally as the jib is rotated. A skeletal representation of a level-luffing crane is shown below.

The jib is rotated by extending the actuator at a constant velocity of 1 ft/sec. The goal is to find the velocity vector of the load, and investigate the extent to which it moves horizontally.

a) Draw loop vectors, clearly indicating vector numbers, angles, and directions to allow calculation of vector $\vec{v}_G$.  
b) Write equations for position analysis, in the correct order for Matlab implementation.  
c) Implement your position equations in Matlab, for actuator extension from 20 to 30 feet. Generate a plot of $r_{Gx}$ vs. $r_{Gy}$.  
d) Differentiate your loop and coupler point equations, and implement them in Matlab. Generate a plot of the magnitude of $\vec{v}_G$ vs. time.

Those plots will allow you to trace the path of point G, which is intended to be a horizontal line, but likely won’t be. Hopefully it’s close. Also, you can track the change in load velocity for a given constant actuator extension velocity.

Coordinates relative to point B: A(8,25), D(18,-12).
Drawing is to scale (pretty close, anyway). Angle CDE is 30°.