ME 115(b): Homework #1
(Due Friday, April 08, 2016)

Problem 1 (20 Points): Manipulator Singularities

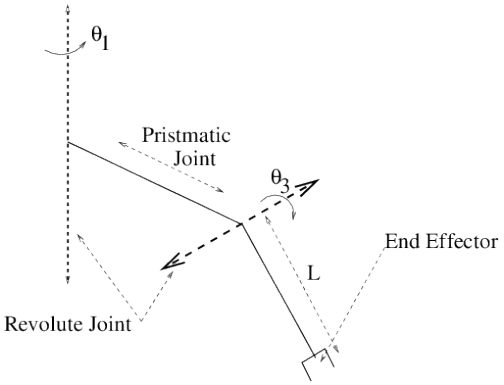

Figure 1: RPR manipulator

Consider the 3-jointed RPR manipulator in Figure 1. Assume that the first axis is vertical. The second (prismatic) axis is orthogonally intersects the first axis. The third axis orthogonally intersects the prismatic joint axis, and is simultaneously orthogonal to the first axis. We are only concerned with position the origin of the end-effector frame.

- **Part (a):** Compute the hybrid Jacobian matrix for this manipulator.
- **Part (b):** Find and describe the singular configurations of this manipulator.

Problem 2 (20 Points): Special Configurations of a linkage. Consider the linkage shown Figure 2. This problem considers the stationary configurations of this mechanism.

In this mechanism, let $|\overline{AB}| = 1$. The dimension $|\overline{AC}| = l_1$ is a parameter, and you will consider its value below.

(a) derive the twist coordinates for the joint axis screws.

(b) It was shown in class that the special (or stationary) configurations for the j^{th} joint occur when the determinant of the cofactor of the (j, j) element of the Grammian matrix:

$$\begin{bmatrix} \xi_1 \cdot \xi_1 & \xi_1 \cdot \xi_2 & \xi_1 \cdot \xi_3 & \xi_1 \cdot \xi_4 \\ \xi_2 \cdot \xi_1 & \xi_2 \cdot \xi_2 & \xi_2 \cdot \xi_3 & \xi_2 \cdot \xi_4 \\ \xi_3 \cdot \xi_1 & \xi_3 \cdot \xi_2 & \xi_3 \cdot \xi_3 & \xi_3 \cdot \xi_4 \\ \xi_4 \cdot \xi_1 & \xi_4 \cdot \xi_2 & \xi_4 \cdot \xi_3 & \xi_4 \cdot \xi_4 \end{bmatrix}$$

becomes zero (where ξ_j denotes the twist for joint axis j).

Develop an expression for the stationary configurations of the joint B. What are the necessary conditions (in terms of link lengths, etc.) for joint B to have a stationary configuration?

(c) Do any other joints have stationary configurations?

Problem 3 (15 Points): Problem 21(a,b,c), Chapter 3 of MLS.

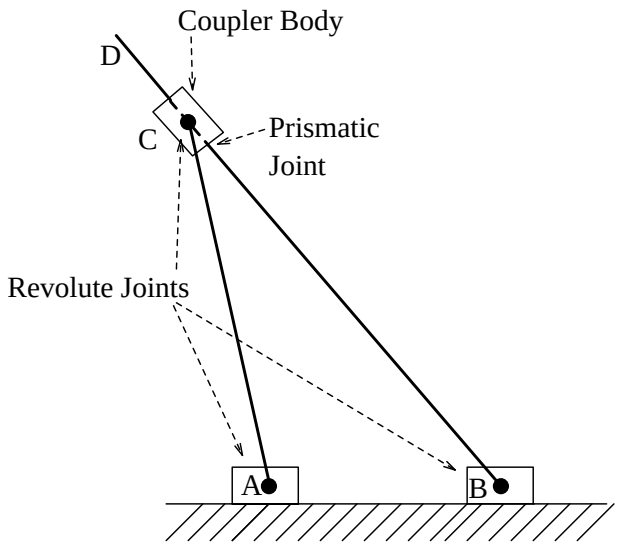

Figure 2: Planar Closed Loop Mechanism