ME 115(b): Homework #3

(Due Tuesday, February 8, 2000)

Problem 1: This problem is basically the extra credit problem from homework set #2. For the same manipulator, repeat your simulation from homework set #2, only now let the desired end-effector trajectory be a circle centered at $(x, y) = (1.5, 0.0)$, with a radius of 1.49. This circle can be parametrized by:

$$\begin{bmatrix} x(t) \\ y(t) \end{bmatrix} = \begin{bmatrix} 1.5 - 0.5\cos(\omega t) \\ 0.0 - 0.5\sin(\omega t) \end{bmatrix}$$

where ω controls the speed of the trajectory. Pick ω to be a reasonble number, such as π, or $\pi/2$, or whatever you used in homework #2. Further, used the damped pseudo-inverse. Try 2 different damping parameters. Like homework #2, the output of your simulation consist of:

(1) A plot of the joint angles versus time.

(2) A plot of the actual end-effector position versus time.

Qualitatively compare your results with homework #2.

Problem 2: Problem 10, Chapter 3 of MLS.

Problem 3: (Special Configurations of a linkage). Consider the linkage shown Figure 1.

In this mechanism, let $|\overline{AB}| = 1$. The dimension $|\overline{AC}| = l_1$ is variable, and will be determined below.

This problem considers the stationary configurations of this mechanism. One

(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 jj 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 joint 1. What are the necessary conditions (in terms of link lengths, etc.) for joint 1 to have a stationary configuration?

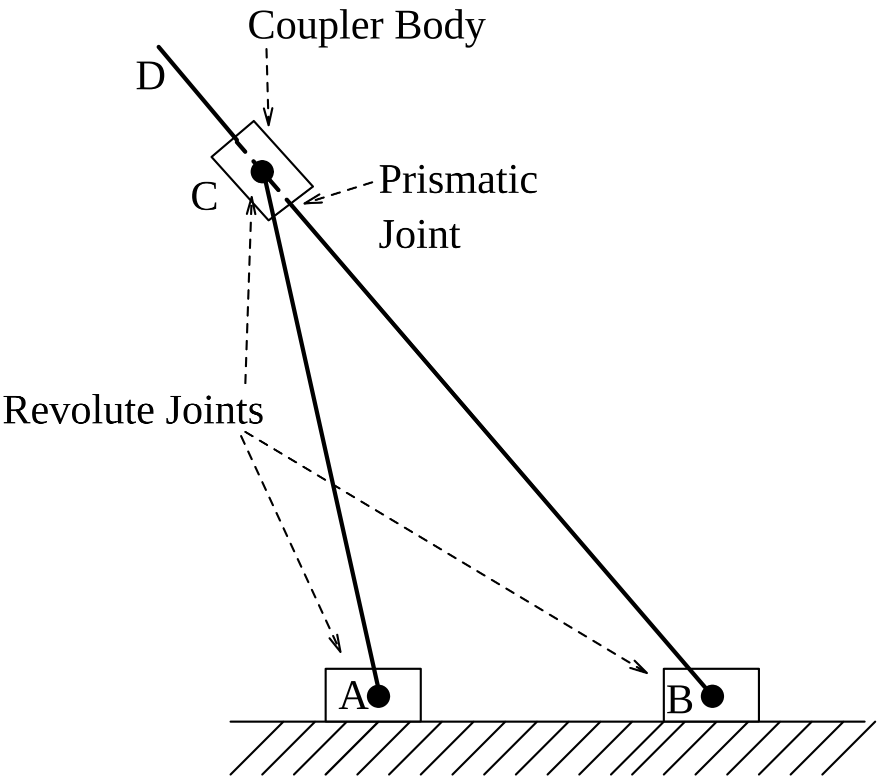

Figure 1: Mechanism

(c) Do any other joints have stationary configurations?

Problem 4: Problem 21(a,b,c), Chapter 3 of MLS.