Solution to Problem Set #1

Problem 1:

Part (a):

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} l_1 \cos\theta_1 + l_2 \cos(\theta_1+\theta_2) + l_3 \cos(\theta_1+\theta_2+\theta_3) \\ l_1 \sin\theta_1 + l_2 \sin(\theta_1+\theta_2) + l_3 \sin(\theta_1+\theta_2+\theta_3) \end{bmatrix}$$

Part (b):

$$J = \begin{bmatrix} -(l_1 s_1 + l_2 s_{12} + l_3 s_{123}) & -(l_2 s_{12} + l_3 s_{123}) & -l_3 s_{123} \\ (l_1 c_1 + l_2 c_{12} + l_3 c_{123}) & (l_2 c_{12} + l_3 c_{123}) & l_3 c_{123} \end{bmatrix}$$

where $s_1 = \sin(\theta_1)$, $s_{12} = \sin(\theta_1+\theta_2)$, etc.

Part (c): My Mathematica code for this solution is attached. I chose $\omega = \pi/2$. The joint angles and end-effector trajectory is shown below.

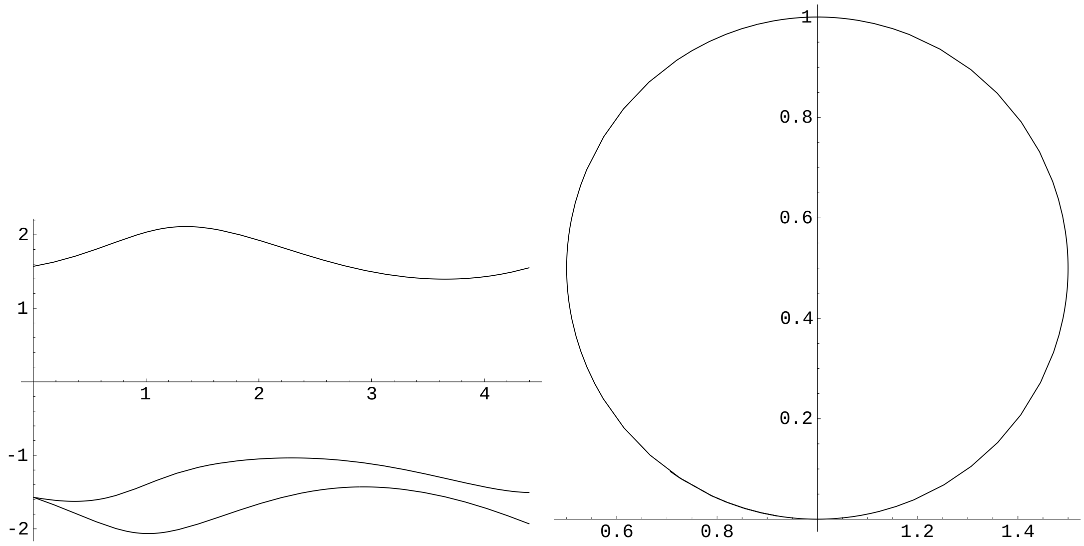

Figure 1: Joint Angle Trajectories and End-Effector Trajectory

In general, the solution will not be cyclic. For some particular choices of initial conditions, the solution may be a cycle.

Note, my solution used Mathematica's NDSolve numerical integration routine to integrate the pseudo-inverse redundancy resolution scheme. As a result, my end-effector trajectory tracking was extremely good. If you used simple Euler integration, your answer will likely have some end-effector error.