Dynamics and Control of Planar RRP Robot

The goal of this project is to use Matlab to simulate the dynamics and control of the planar RRP robot.

1. Using Matlab's ode45() solver for differential equations, implement the dynamic model of the planar RRP robot that was provided in class along with DC motors and drives. Assume the following values for parameters of the model. Note we'll include inductance and static friction.
   - $l_{a1} = l_{a2} = l_{a3} = 0.001$ H
   - $r_{a1} = r_{a2} = r_{a3} = 1\Omega$
   - $k_{t1} = k_{t2} = k_{t3} = 0.5$ Nm/A
   - $k_{\beta 1} = k_{\beta 2} = k_{\beta 3} = 0.5$ V/rad/sec
   - $g_{v1} = g_{v2} = g_{v3} = 24$ V/V
   - $k_{r1} = k_{r2} = 100$, $k_{r3} = 100$ (rad/m)
   - $f_{v1} = f_{v2} = 20$ Nm/rad/sec, $f_{v3} = 20$ N/m/sec
   - $f_{s1} = f_{s2} = 1$ Nm, $f_{s3} = 1$ N
   - $m_1 = 15$ kg, $m_2 = 10$ kg, $m_3 = 5$ kg
   - $r_1 = 0.2$ m, $r_2 = 0.1$ m, $r_3 \approx 0$ m
   - $l_1 = 2.0$ m, $l_2 = 1.0$ m, $l_3 = 1.0$ m
   - $g = 9.81$ m/sec^2
   - $I_{xx_1} = (1/2)m_1 r_1^2$, $I_{yy_1} = I_{zz_1} = (1/4)m_1 r_1^2 + (1/12)m_1 l_1^2$
   - $I_{xx_2} = m_2 r_2^2$, $I_{yy_2} = I_{zz_2} = (1/2)m_2 r_2^2 + (1/12)m_2 l_2^2$
   - $I_{xx_3} = 0$, $I_{yy_3} = I_{zz_3} = (1/12)m_3 l_3^2$
2. Start your robot at rest and in the configuration $q = [-\pi/4 \text{ rad}, -\pi/4 \text{ rad}, 0 \text{ m}]^T$ and let it fall ($\vec{v}_c = \vec{0}$) for 10 sec. Turn in a plot of the joint variables and velocities for the 10 sec.
3. Consider the desired initial pose T_{ei} and final pose T_{ef} below. Use your method of choice to create desired trajectories for the joint variables that take the robot from rest at the desired initial pose to rest at the desired final pose.

$$T_{ei} = \begin{bmatrix} 1 & 0 & 0 & -1.4142 \\ 0 & 1 & 0 & 3.4142 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad T_{ef} = \begin{bmatrix} 1 & 0 & 0 & 1.4142 \\ 0 & 1 & 0 & 3.4142 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. Design and implement your joint-controller of choice (pick any of the four we discussed) to get the robot dynamics to track the desired trajectory generated above. Try to have the trajectory complete in 10 sec while keeping the armature voltage v_a less than 24V. Turn in plots of desired and actual joint variables and velocities, tracking errors, and pose of the end-effector versus time as well as snapshots from your visualizer showing the robot's trajectory.