Question 8

Minimum Energy Elliptical Trajectory [10]: Define a piecewise continuous trajectory consisting of four waypoints: [0, 0, 1, 0], [2, 1, 1, 0], [0, 2, 1, 0], [-2, 1, 1, 0] (position, heading). To do so, generate an optimal (minimum energy) trajectory that visits the four waypoints (returning to the first; forming an ellipse) with an initial velocity of zero and an end velocity of 1 m/s at the first waypoint. The robot will start at rest, track the elliptical trajectory, and arrive at the starting location at a non-zero velocity (1 m/s). Generate a second trajectory phase given the same waypoints that starts with a 1 m/s velocity tangent to the ellipse and similar velocities at the other waypoints (all tangent to the ellipse in the direction of motion). To solve for the optimal trajectory, formulate the problem as a Quadratic Project (QP) and solve for the appropriate polynomial coefficients. Generate error plots that depict the tracking performance (using PD control). Generate a *cumulative error distribution* plot. How does the tracking performance change given differing velocity profiles?

Q8 Performance

8.1 Below are the figures showing the trajectory, as well as the errors in pose and velocities.

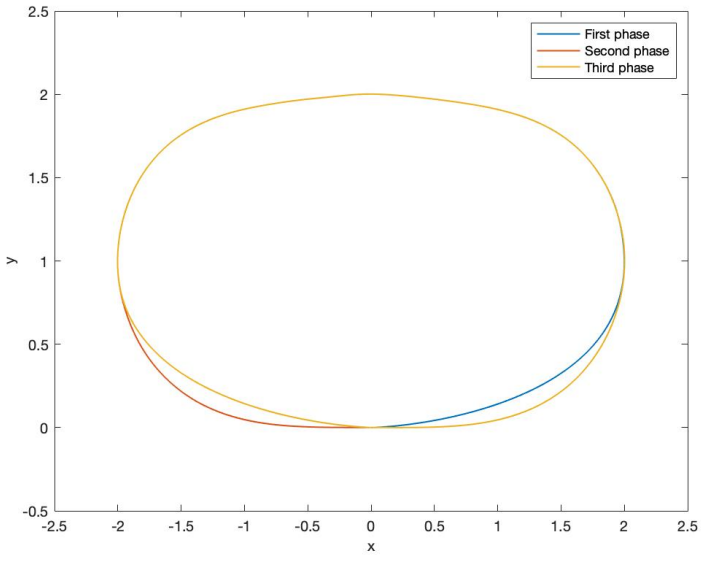


Figure 1. Actual trajectory

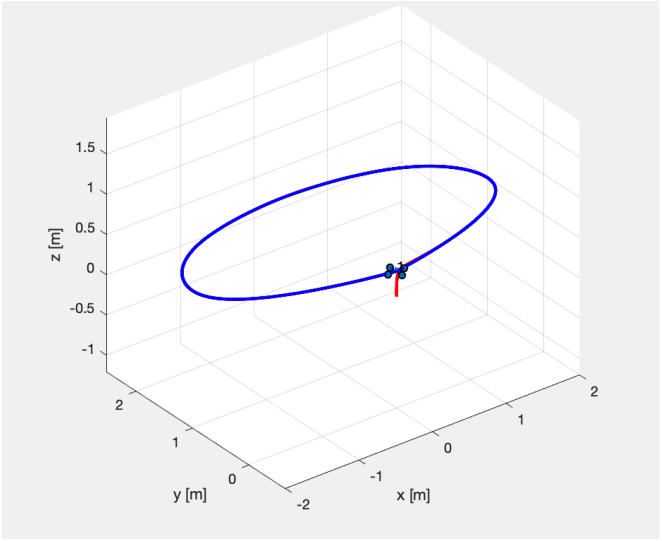


Figure 2. 3D actual trajectory

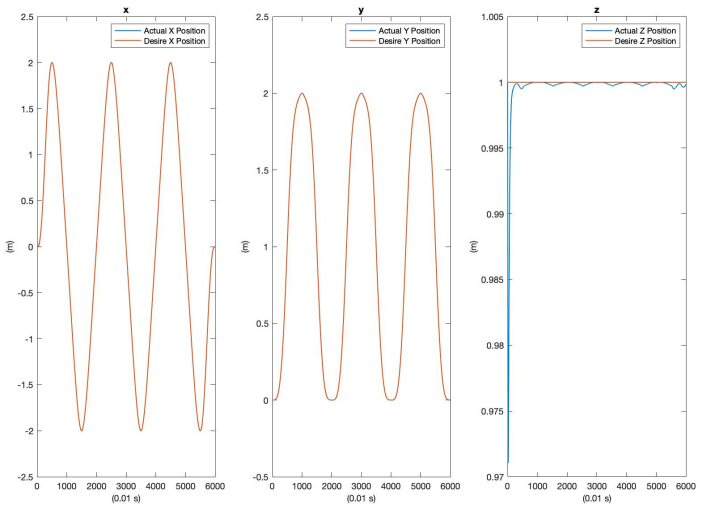


Figure 3. Actual Position vs Desired Position

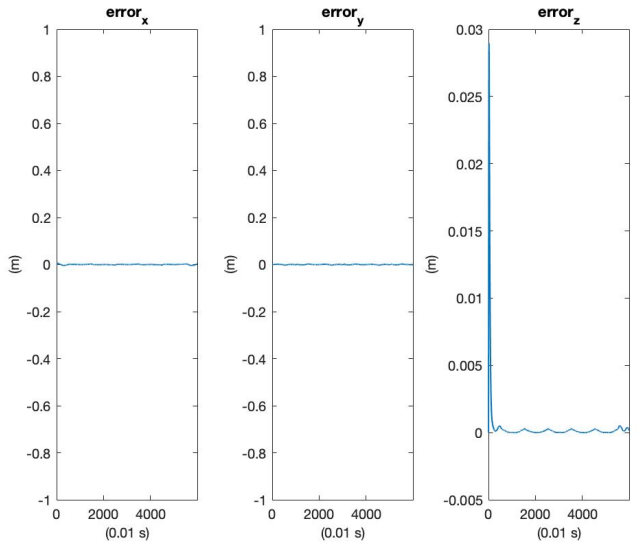


Figure 4. Position Error

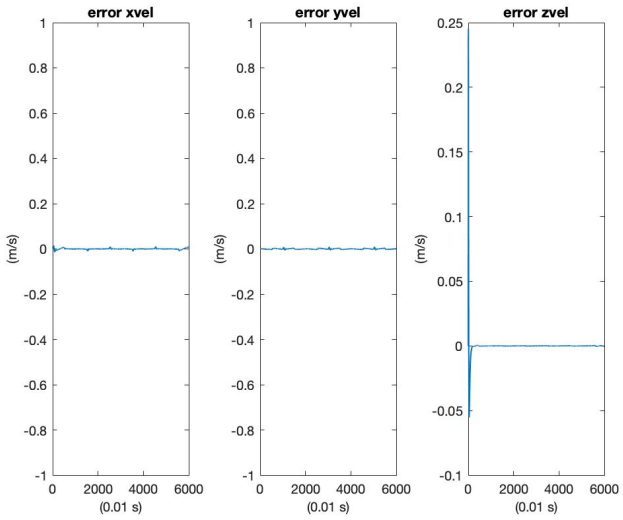


Figure 5. Linear Velocity Error

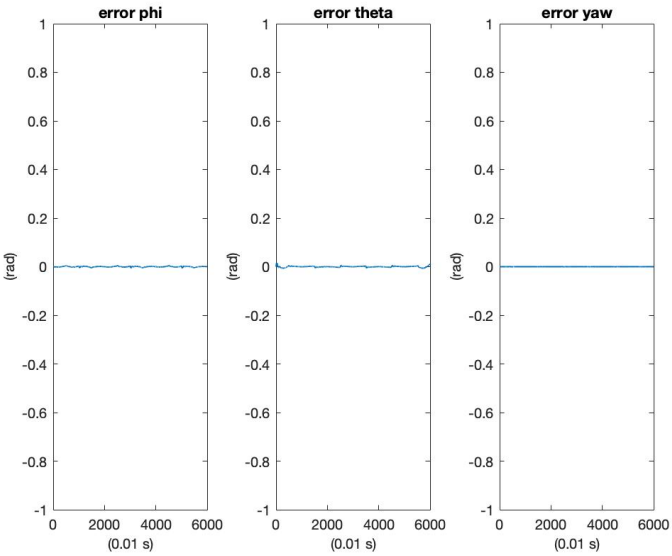
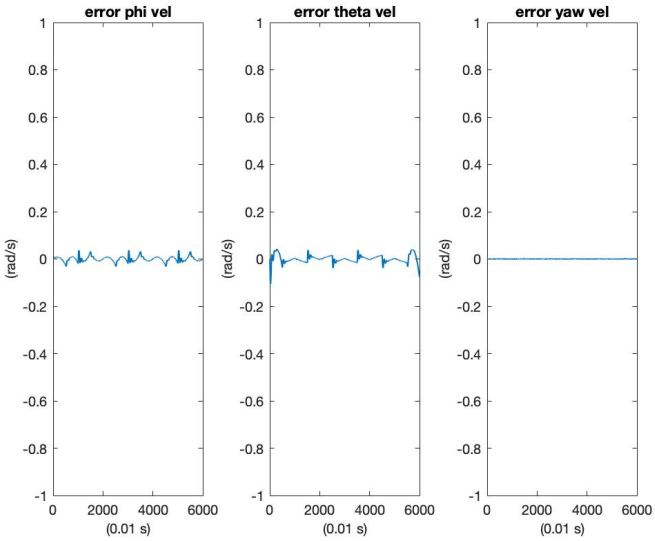


Figure 6. Rotaiton Error


error phi vel
error theta vel
error yaw vel
(rad/s)
(0.01 s)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
2000
4000
6000