**Problem 3:**

Below are my 6 plots showing the position, velocity, and acceleration for the origin of the bar reference frame (O’) and point Q on the bar. In looking at these plots, it is clear that I ran into an issue with using a DP1 constraint as a driving constraint. This is due to the fact that, in this case, the DP1 constraint can be satisfied with either a positive or negative ϴ. As ϴ approached zero, there were two solutions that satisfied Φ(q,t) = 0. The first, and the physically correct, solution is for ϴ to become negative and the pendulum to continue swinging in the same direction. The second, and still mathematically correct, solution is for ϴ to remain position and the pendulum to begin to swing towards its initial starting point. The plot for the position of point O’ shows that my implementation resulted in the second solution, where it can be seen that the y-value for the position of O’ remains positive at all times. This issue with the position solution carried over into the velocity and acceleration analyses and resulted in errors of the y-component of the velocity and acceleration. I attempted to implement a couple different tricks to overcome this issue with using a DP1 constraint as a driving constraint, but I have not found a successful solution yet.

In the final 3 plots it can be seen that, while all components of the position, velocity, and acceleration of point Q are extremely close to zero, they are not exactly zero. This stems from the fact that in the position stage, we are using the Newton-Raphson method to numerically approximate q, such that Φ(q,t) ≈ 0. While this approach results in a very accurate approximation of q, it is not perfect. This causes the position of O’ being slightly off the exact solution, which causes the position of point Q to be slightly off [0 0 0]T. This position error carries over to very small errors in the velocity and acceleration of point Q as well. Additionally, machine precision may also play a slight role in the results of point Q. Machine precision limits the number of significant digits used to represent a number, which prevents the position, velocity, and acceleration of point Q from being exactly zero.

NOTE: For color version of these plots, see the plots and this document in my GitHub repository.





