MECH 7710 Homework Assignment #4
Nonlinear Estimation

Due Friday 5/6

1. Develop a model for a pendulum with inertia $J_p = 2.5\frac{Nm}{rad/s\text{^}2}$ (at pin), mass $m = 1.6\ kg$, and length $L = 1\ m$. The pin introduces damping in the system that should be modeled as $\tau_b = b\dot{\theta}^3$ where $b = 1.25\frac{Nm}{rad/s}$. The input to the system is a torque at the pin given by $\tau = 12Nm$. Assume system is acted on by a horizontal disturbance force at the end of the pendulum ($f(t) = 5 + \eta$ where $\eta \sim N(0,2)$). The measurement of the angle of the pendulum is corrupted by zero mean Gaussian white noise with variance of 1 degree.
    a. Develop a simulation of the system
    b. Develop an extended Kalman filter to estimate the position and velocity (and any additional needed parameters) of the pendulum given measurement as described
    c. Develop an unscented Kalman filter to estimate the position and velocity (and any additional needed parameters) of the pendulum given measurement as described
    d. Use Monte Carlo simulations to compare the performance of the EKF and UKF. Be sure to compare expected covariance to sampled covariance from Monte Carlo simulations
2. Refer to problem 3 from homework 3 (the "Navigation" filter). Design a particle filter to estimate the East and North position, radar and gyro bias using the data (***hw3_3*** from canvas). Compare the performance of the particle filter to the performance of your estimator from homework 3 using at least 3 different numbers of particle (e.g. N=50, 100,1000). Provide plots of estimation error, analytical covariance (from EKF) and numerical covariance (from particle filter).