EE 6383 Nonlinear Control Systems
HW 3 – Monte Carlo Analysis

Asst. date: 29 May 2019 – Due date: 3 June 2019

Department of Electrical & Computer Engineering
University of New Brunswick

We are going to do a 1000-trial monte carlo study of the accuracy of a projectile (fired from a long-range gun) to see how simulations are performed and statistical analysis carried out. A projectile is fired from the origin ($x = y = 0$) at an elevation angle θ_0 with muzzle velocity v_0; the initial condition is defined statistically by $E[\theta_0] = 45$ deg, $E[v_0] = 200$ m/sec and the standard deviation on each is 3 %. The **time of impact** is random; to handle this set $\dot{x} = 0$ as soon as the vertical height is zero. (This is a lot easier than using state-event handling – remember that from 2018? Just use `ode45`.)

1. Define your states to be $x(1)$ = vert. position, $x(2)$ = vert. velocity, $x(3)$ = horiz. position, $x(4)$ = horiz. velocity. Complete the state-space model by including linear and square-law drag, i.e., the friction force opposing motion is $B * v + D * |v|^2$ where $B = 0.01$ N-sec/m, $D = 3.0e{-}5$ N-sec^2/m^2. This force must be resolved into horizontal and vertical components, of course, and you must include g in the vertical dynamics. Take $M = 1$ kg as the projectile mass.

2. Now, perform a Monte Carlo study for the initial conditions specified, using 1000 trials but calculating the cumulative statistics after each hundred trials; plot the mean and sigma of the impact distance for 100, 200, ..., 1000 trials and also plot the confidence bands for each (using kurtosis = 3) so you can see the convergence of the impact point statistics (see sample results below; use + signs for the confidence bands, not I-bars). The materials I handed out should be all you need to solve this problem; to show what the final results should look like I'm including my plots for this problem. (Hints: this is simplified by the fact that only the initial condition is random, in other words you don't need to call the random number generator in your model and use `eurand` – also be **sure** you simulate past the impact time ... use `tspan = [ 0 40 ]`.)