# PH4390 Computational Methods in Physics

Assignment 08: Two-Dimensional Quadratic Drag

Fall 2017

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A local team of professional pumpkin chuckers has contacted the university physics department for assistant for the upcoming, now cancelled, "World Championship Punkin Chunkin" contest in November. The team uses a pneumatic cannon to launch their pumpkins and they require some assistance to calibrate their launching capabilities. The year before the team had contracted a team from Northern Michigan University (NMU) and their simulations provided less than desirable results. The director himself could not believe the numbers NMU provided, but the team ran out of time due to budget cuts and time constraints.

## Details

The cannon is five meters tall and launches pumpkins with an average radius of 0.20 meters. It has an adjustable barrel which can launch at any angle, with a minimum speed of 10 m/s and maximum of 350 m/s. The average temperature around this time of year in Dover, Delaware is 50F and the city is at sea level.

# Coding

Using the Runge-Kutta fourth-order method, solve/calculate the following:

† The trajectory of the pumpkin with and without fluid resistance at the maximum cannon speed and using the optimum drag-less launch angle (Longest Distance). Graph both trajectories together.

† Provide a graph of the trajectories for the following angles (15, 30, 45, and 70 degrees) at the maximum cannon velocity with drag.

† Provide a function that provides the angle of launch to the team that allows them to maximize their distance for the pumpkins for any given velocity.

# Data & Graphs

† Graph of X vs. Y Trajectories with and without drag.

† Graph of X vs Y Trajectories of pumpkins at maximum velocity using the following angles 15,30,45, and 70 degrees.

† Graph of $\Theta$ vs. Speed where the launch distance for each combination has been maximized.

† Function fit to the previous graphs data, $\Theta$(speed).

# Question

1. What could be included in the simulations to provide more accurate results, explain.

# Formulas

## Equations of Motions

The equations of motion for a two-dimensional projectile with a quadratic drag force acting upon it is:

$$m\dot{v_x} = -c[v_x^2 + v_y^2]^{\frac{1}{2}} v_x$$
$$m\dot{v_y} = -mg - c[v_x^2 + v_y^2]^{\frac{1}{2}} v_y$$

Where c is given by the following:

$$c = \frac{1}{2} C_D A \rho$$

Where $C_D$ drag coefficient, specific to the shape of the object, A is the cross-sectional area, and $\rho$ is the fluid density.