Projects organization

Projects work:

Today you start working on project 1. Create a new directory somewhere in your home directory with the name `yourusername_project_1` to store the files you will create for this project.

Projects submission:

To hand the project in, copy the directory `yourusername_project_1` with your results to `/home2/phys210/yourusername/`.

Important: All the Python codes should be contained in **ONE** python file called **`project1.py`** and other files (text, pdf, etc…) are separate, also part of the submission. All the plots should be part of the submission (in a PDF file) so you can still get the plots points if your code does not work.

Projects Marking

See the separate marking rubric document.

Project 1 (Due date Thursday October 27th 12 a.m.)

Consider a projectile of mass `m` launched at time `t=0` making an angle θ to the horizontal. The equation of motion of the projectile with atmospheric drag is

$$m\frac{d\mathbf{v}}{dt} = m\mathbf{g} - c\mathbf{v}$$

where $\mathbf{v}(t)=(v_x,v_y)$ is the projectile velocity at time `t` and $\mathbf{g}=(0,-g)$ is the acceleration due to gravity. The constant `c` is a positive constant and characterizes the atmospheric friction term. If we call `x(t)` and `y(t)` the position of the projectile at time `t`, the integration of the equation of motion gives:

$$x(t) = \frac{v_0 v_T}{g}\cos\theta\left(1 - e^{-gt/v_T}\right)$$

$$y(t) = \frac{v_T}{g}(v_0\sin\theta + v_T)\left(1 - e^{-gt/v_T}\right) - v_T t$$

where $v_T = mg/c$ is the terminal velocity, and $v_0 = |\mathbf{v}(t=0)|$ is the initial speed.

Objectives:

For this project, you will write a script **`project1.py`** to calculate *numerically* the following quantities:

1- The distance D to impact
2- The maximum height H
3- The time of flight t_{total}
4- The velocity V_{impact} at the impact point $x(t_{total})=D$

You will assume a horizontal terrain. Your script should generate plots of the four quantities as function of θ, i.e. $D(\theta)$, $H(\theta)$, $t_{total}(\theta)$ $V_{impact}(\theta)$ where θ goes from 0 to π/2 for three initial speed v_0: $1 m/s$, $10\ m/s$ and $80\ m/s$. You will consider a projectile of mass $m=1\ kg$ with a friction coefficient, independent of velocity, $c=0.1\ kg/s$ and Earth gravity $g=9.8\ m/s^2$.

The number of plots and how you arrange them is up to you, but all your plots should appear in a single PDF document (with more than one page if necessary).

Answer this question: in order to reach maximum distance, should the launch angle be larger or smaller than π/4? Does this depend on the initial speed? Write your answer in a text file called **`impact.txt`**.

Tips: to solve for the four quantities numerically, you have to use a roots finding routine from **`scipy`** (see root finding at https://docs.scipy.org/doc/scipy/reference/optimize.html). For instance the time of flight to impact is found when $y(t_{total})=0$, from which you get the distance to impact $x(t_{total})$. For the height and impact velocity you have to calculate numerical derivatives of $x(t)$ and $y(t)$.