Phys 256 — Homework 6

Student Name

Instructions

- You may use AI assistants to help write, test, and debug code, but you must understand your implementation and use your own scientific judgment to assess its validity. **Do not use AI to write the report.**
- Submit a PDF report containing in-line code snippets, plots, numerical results, explanations, and descriptions of relevant test cases. Submit your Python code separately.
- In your report, we are looking for you to **exercise and demonstrate your independent scientific judgment.** Thoughtful reports with careful, critical discussion of the results will receive a higher grade than those that simply run the AI-generated code and paste in the results.
- Submit each coded problem in a separate file named `p1.py`, `p2.py`, etc. You may import functions from previous problems. Include all necessary files in one ZIP archive.
- Use NumPy, SciPy, and Matplotlib where appropriate. Fix random seeds or specify them so that stochastic results can be reproduced. Label all plot axes.

Problem 1: 15 queens puzzle (10 points)

This is variation of the eight queens puzzle[1] but you need to place 15 queens on a 15x15 chess board so none of the queens share the same row, column, or diagonal.

You can encode the queens positions as 15 dimension vector $\vec{x} = [x_0, x_1, x_2, x_3, ..., x_{14}]$ with $x_i = 0, 1, 2, \cdots, 14$ in each components representing in which row the i_{th} queen stands. For the cost function count how many queens share the same row, column, or diagonal. During $\vec{x}$ update displace a random queen by 1 row (or use any other ways which you find suitable). **Make cost function responsible for keeping queens on the board**, do not worry about it during new $\vec{x}$ generation.

Display listings of the cost function and generation of new $\vec{x}$ in your report. Discuss your strategies.

Use algorithm of your choosing which uses the above cost function and new $\vec{x}$ generation and find a queen's arrangement which satisfies the problem. Display this arrangement as a figure with 15x15 grid and markers showing queen's locations. You do not need to be fancy, any marker will do. Display this arrangement in your report.

Problem 2: Projectile motion with drag (10 points)

During 4th of July celebration someone fired a rifle straight up. Find the height of the bullet vs time of flight, assume that the rifle was fired straight up and the bullet initial speed $v_0 = 715$ m/s. Recall that the projectile motion is governed by the following equation

[1] https://en.wikipedia.org/wiki/Eight_queens_puzzle

$$a_y = -g - \frac{v_y}{|v_y|}\frac{1}{2m}\rho c_d A v_y^2$$

where g acceleration due to gravity, a_y and v_y are acceleration and velocity along y coordinate, $\rho = 1.2$ kg/m^3 is the density of air, $c_d = 0.09$ is the drag coefficient, $m = 0.008$ kg is the mass of the projectile, $A = 4.6 \times 10^{-5}$ m^2 area of the bullet.

For your report convert the above equation into a set of 1st order ODEs in canonical form using $x, y_1, y_2, \cdots$ and $\vec{f}$.

Display the listing which is able to calculate y and v_y vs time. Keep you algorithm general, i.e. do not hardcore physical variable until the very end.

Plot y and v_y vs time for any $y > 0$.

What is the speed of the bullet when it is impacting the ground.

Does the bullet reach the terminal velocity?