Physics Assignment 3

PHY410: Do problems 1-3
PHY 505: Do all four problems.

Accept the assignment from github classroom: https://classroom.github.com/a/-JYZENPX . You will then get a link to your own github area.
You should submit your code through github classroom. Submit your writeup, and a link to your github classroom area where your code is, on UBLearns.

Problem 1 : Nonlinear pendulum

Start from the “pendulum_nonlinear” python notebook.

a. Generate a bifurcation diagram (as described in class, and here http://en.wikipedia.org/wiki/Bifurcation_diagram) as a function of the input strength of a damped, driven harmonic oscillator for values of F_D between 0.7 and 1.1.
Use these parameters and vary ‘F_D’ appropriately:

```
'tmax':2000.,
'theta_init':0.0,
'omega_init':0.0,
'gamma':0.5,
'omega0':1.0,
'omegaD':2/3
```

Your diagram should transition from one-, two-, four-, cycles etc to chaos. You should throw away ~100 cycles in the Poincare map to get appropriate dynamics.

b. Plot the time series ($\theta(t)$) for specific values of ‘F_D’ corresponding to a one-cycle, a two-cycle, a four-cycle, and chaos. Take the FFT of these and compare these four spectra.

Problem 2 : Perturbed hydrogen atom

Starting with the “schroedinger” python notebook, investigate a quartic and a cubic perturbation to the QHO of the types

$$V_1(x) = \frac{1}{2}m\omega^2\left(\hat{x}^2 + \frac{1}{20}\hat{x}^3\right)$$

$$V_2(x) = \frac{1}{2}m\omega^2\left(\hat{x}^2 + \frac{1}{20}\hat{x}^4\right)$$

Compute the energy levels and eigenfunctions up to $E = 5$. Discuss how each type of perturbation modifies the energy levels and eigenfunctions. Be sure to increase the left and right boundaries if needed!

Problem 3 : Dipole in box

a. Starting with the “poisson” python notebook, use the Jacobi method with vectorization to compute the electrostatic potential due to an electric dipole with charge $q = 10$ (that is, there are two particles each of charge q), located at the center of a two-dimensional grounded metal box of length $L = 1$. The dipole should be parallel to the x axis and have length $d = 0.5$.

b. Compare with the expected exact solution (sum of the Coulomb potentials of the same two point charges) in free space (but only plot within the box of length L=1). Your exact solution should not contain any python loops (i.e. it should be vectorizable).

Problem 4 (505 Only): Wire chamber

In a wire chamber, several parallel wires are passed through a metal box. The wires are kept at a fixed potential V0=5 (not fixed charge), and the box edges are kept at ground.

a. Assuming an infinitely long z-direction (so this reduces to a two-dimensional problem), compute the electrostatic potential for 5 wires equally spaced through a box of x-direction length Lx = 10 and y-direction length Ly=2, with one wire through the origin and all wires on the x axis.
b. Compute the trajectory of a charged particle with charge q=10, mass m=1, initial position at (4,0), with initial velocity (1,1).

For the first part, you will have to adjust the code to handle fixed potential instead of fixed charge, and will have to adjust the size L to not be a 1x1 box.

For the second part, you will have to input the potential function that you have computed in this problem, and numerically take the gradient. It should then be used in the calculation of the acceleration for your derivative method. You may have trouble with adaptive schemes, because you are limited by the precision of your field calculation in part a, so be careful!