PHYS 352 – Assignment 3

Due: Tues., Feb. 1, midnight

Submit code solutions and the .png's, .sh's, .plt's requested below. **Source files for your main executables** should be named "assignment3_X.c", where "X" corresponds to the question numbers. **Your ODE solver code** should be named euler.c, euler.h, *etc.* and placed in the directory structure specified below. Likewise, **you physics specific code** should be named projectiles.c,h, sho.c,h and live in the corresponding directory structure described below. Include your name enclosed in C comment tags (ie: `/*YourName*/`) at the top of each program. Create a zip archive containing all of your files, name it "assignment3_YourLastName.zip" (with the appropriate name replacement) and copy it to your `/projects/e20271/student/[netID]/homework` directory by midnight on Tuesday, Feb. 1.

1. **libODE.a, libphysics.a (5 pt.)**

   First, create a directory named `assignment3_<LastName>` and `cd` to it. Write ODE solvers for the radioactive decay problem using the Euler method, the second-order Runge-Kutta and the fourth-order Runge-Kutta methods. Each should have its own interface header and source implementation. Create a directory named `ode` and sub-directories named `src` , `include` and `lib.` Copy your 3 .c files to `ode/src` and your 3 header files to `ode/include.` Next, write a bash build script named `build.sh` or a Makefile, located at the same level as the `ode/` directory. Use this script compile each of your implementations into object files in `ode/lib` and then build a `libODE.a` library, also in `ode/lib.` Follow the same procedure as above for your physics-specific implementations, which should live under another directory named `physics` , with correspond `src` , `include` , and `lib` sub-directories. Use a top-level build script to compile/link your main programs that you will write for the following questions against the libraries you've produced. The lecture7 directory in the git repo provides an example of how to do all of this.

   Produce pngs for the plots requested below. When you've completed all questions, use the `-r` flag with zip to recursively zip your entire `assignment3_<LastName>` directory structure and submit it.

2. **Exercise 2.9 (3 pt.)**

   From the text : Calculate the trajectory of a cannon shell including both air drag and the reduced air density at high altitudes so that you can reproduce the results in Figure 2.5. Perform your calculation for different firing angles and determine the value of the angle that gives the maximum range.

3. **Exercise 3.1/3.2 (3 pt.)**

   In a slight variation on Exercises 3.1 and 3.2 in the text, plot both the angle θ vs. time and the total energy vs. time for the SHO using the Euler (not Euler-Cromer), 2nd-order Runge-Kutta and fourth-order Runge-Kutta methods. It can be difficult to directly compare the accuracy of the two RK methods when they are plotted together with the Euler results, so create a second plot containing just RK results over many periods and comment. Use the relative error with respect to the analytic solution as the basis for assessing accuracy.

4. **Exercise 3.7 (3 pt.)**

   From the text : Numerically investigate the linear, forced pendulum with friction of (3.14). Show numerically the existence of the resonance, and confirm the dependence of the resonant amplitude on the driving angular frequency Ω_D, and on the friction parameter q.

   In your investigations, it may be helpful to first allow any transient behavior of the system settle away by analyzing only data computed after many (say, 500) initial iterations. In terms of fixed parameters, take $F_D = 0.2$, $\Omega_D = 0.667$, and for the second part, $q_0 = 1.0$