PHYS 305: Computational Physics II

Winter 2018

Homework #4

(Due: March 5, 2018)

Each problem is worth 10 points. E-mail your solutions to `steve@physics.drexel.edu` *with a subject including PHYS 305 and the Homework number. The e-mail should have as an attachment a zip (or tar) file containing a PDF document containing all discussion, results, and graphs requested, and files containing Python scripts for all programs written.*

1. (a) Incorporate variable time steps, as implemented in the solution to Exercise 6.6, into the N-body calculation described in Homework 3, problem 3, with the following changes. (i) Each of the two subsystems should have only $N = 50$ particles (NOTE: each subsystem has mass 1, so the total mass of the full system is 2); (ii) take $\epsilon = 0.001$ to increase the dynamic rage of the calculation; (iii) do not plot the quantity R defined in Homework 3, but instead plot both the total potential energy U of the system and the "virial radius" R_v defined by

$$R_v \;=\; -\frac{GM^2}{2U},$$

   where M is the total mass; and (iv) don't plot snapshots at various times.

   Implement variable steps by multiplying the parameter τ returned by the integrator by a time step parameter η (set by default and/or on the command line), which can be varied to control the accuracy of the calculation. Print out the time and energy error $|E - E_0|$ at intervals of 1 time unit, and find a value of η that ensures an energy error of less than 10^{-4} throughout the run. How many total time steps does the calculation take?

   (b) Repeat part (a) using the fixed timestep scheme of Homework 3, problem 3. Find a value of δt that ensures an energy error of less than 10^{-4} throughout the run. How many total time steps does the calculation take?

2. (a) Do Exercise 6.7 on the course web page. Specifically, implement a step-doubling scheme for the two-body problem with the given initial conditions, and find the value of the control parameter dE_{tol} needed to ensure an energy error of less than 10^{-4} throughout the entire run.

3. Repeat problem 1(a) with a step doubling scheme. Find the value of dE_{tol} needed to ensure an energy error of less than 10^{-4} throughout the entire run, and compare the total number of steps to the values found in parts 1(a) and 1(b).