Name: ____________________, ____________________

PHYSICS 401 : SPRING SEMESTER 2018

Project #7: N-body simulations

Reference Reading: Sections 8:1-7.

Downloads: Download `NBodyObject.java` and `NBodyApp.java` from my website.

1. Compile `NBodyObject.java`, `NBodyApp.java` and run `NBodyApp` at its default setting.

a) What is the final configuration (end states or fixed points) of the three particles? (Just a description, no need for numerical coordinates.)

b) Now change `nbody` to 4, 5, 7, 8, 12, 13, 14, 21, what are the final configurations now? (Describe the configuration by a set of numbers $(n_0, n_1, n_2...)$ where n_0 is the number of particle at the center, n_1 is the number of particles in the first ring, etc.)

c) Examine the file `NBodyObject.java`. The `nbody` particles are confined by a central potential given by `accel()`. What is the analytical form of this potential? The method `nbaccel()` first call the central `accel()` then compute all the pair-wise forces (or accelerations). What is the force between each pair of particles?

d) How is the apparent cooling achieved?

e) What happens if you replace the current central potential by the harmonic potential (by uncomment out the following two lines)? Describe your observation and final configurations for `nbody=10`.

2. Create another animation window and graph (using `trail`) the kinetic energy, the potential energy, and the total energy as a function of time. Hand in plots of both windows for `nbody=21` after final equilibrium positions have been achieved.

3. Now comment out the two cooling lines, rerun the case of `nbody=21`, and hand in a graph of the energies only for comparable running time.

4. Finally, comment out the central potential, impose minimum distance conventions on a periodic boundary box of $Sx = Sy = 10$ and replace the existing inter-particle potential with that of Lennard-Jones. Adjust the size of your animation window accordingly.

a) First, do a very simple two particle run. Let particle 1 be initially resting at (7.0, 6.0). Let particle 2 collide into it with velocity (0.4,0.0) from initial position (3.0, 6.0). Hand in a graph of the kinetic, potential, total as well as the initial energy. What is kind of collision is this? (Adjust the size of the circle so that it matches the hard core radius during collision.)

b) Now add particle 3 initially resting at (7.0, 7.0) and start off particle 2 from (3.0, 6.5) with velocity (0.4,0.0). By symmetry, the system should remain up-down symmetric, but describe what happened? What causes this symmetry to be broken?