# PHY407: Lab 6

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**Work Distribution:** We worked on this assignment together in-person, so it was split quite evenly. We brainstormed pseudocodes, and then the base code for each question was collaborated upon. We reused the code we wrote as necessary to answer all of the questions. We alternated between parts for these questions, and then switched and checked each other's work at the end.

*All Python code and outputs are included in the Quercus submission as .py files.

## Question 1

### a) Written Answer

We know that:

$$a = F/m = -\frac{dV}{dr}/m$$

Therefore, by using equation 1 in the lab handout. we get:

$$a(r) = 4((\frac{12}{r^{13}}) - (\frac{6}{r^7}))$$

To get the x and y components, we need to consider the x and y distances between the particles ($r_x$ and $r_y$), therefore we get:

$$a(x) = 4((\frac{12}{r^{13}}) - (\frac{6}{r^7})) * \frac{r_x}{\sqrt{(r_x)^2 + (r_y)^2}}$$

$$a(y) = 4((\frac{12}{r^{13}}) - (\frac{6}{r^7})) * \frac{r_y}{\sqrt{(r_x)^2 + (r_y)^2}}$$

*Note: this is for m = 1 and both epsilon and sigma = 1.

## b) Plots and Pseudocode

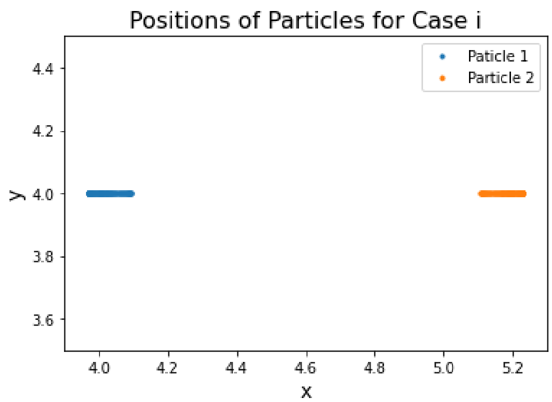
**PSEUDOCODE**

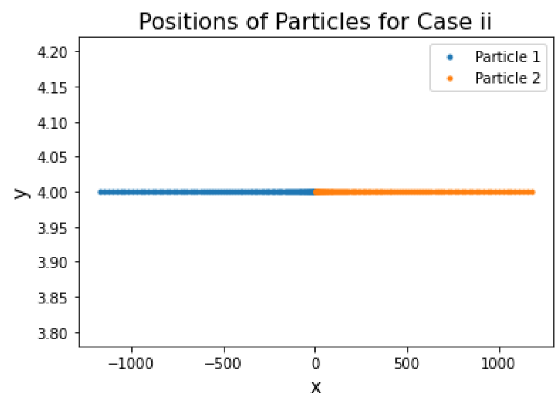
1. Define given constants
2. Define time step and number of iterations
3. Define r1 and r2
4. Define arrays for the x and y positions, velocities, and accelerations for both particles
5. Define array that stores times
6. Define the Verlet function that will use the Verlet algorithm to calculate the motion of the particles

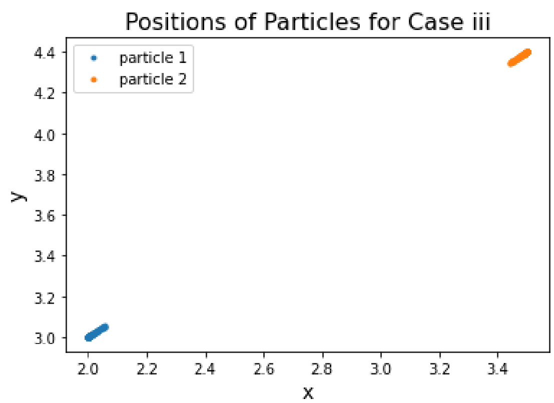
IN THE VERLET FUNCTION——
7. If the case inputted is i set required initial conditions and calculate r1 and r2
8. Repeat for the ii case
9. Repeat for the iii case
10. Otherwise, tell the user to input i, ii, or iii
11. Begin loop through N
12. Calculate rx and ry as described in part A
13. Calculate r for each particle
14. Define accelerations of each particle
15. If i = 0, use the Euler-Cromer method to find the 2nd positions and velocities for each particle
16. Otherwise, use the Verlet method to do this
17. Update the times
18. Return positions, velocities and times

OUTSIDE VERLET FUNCTION—–
19. Plot trajectories for each case.

**PLOTS**




### c) Written Answer

Case i will lead to oscillatory motion, as the particles are close enough together to be trapped in each other's potential wells. This means at an initial velocity of zero, they have some potential energy, which gets converted to kinetic as they attract each other, and then back to potential, and then back to kinetic as they repel each other, and so on.

## Question 2

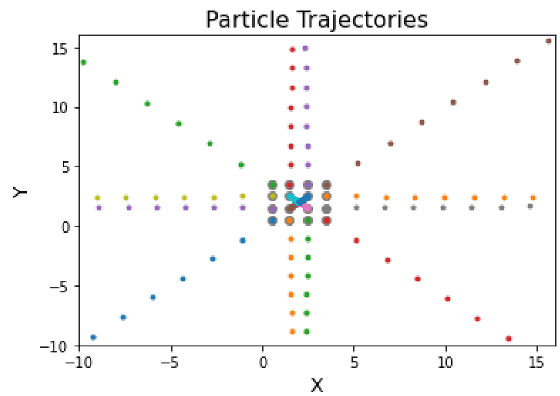
### a) Pseudocode and Plot

**PSEUDOCODE**

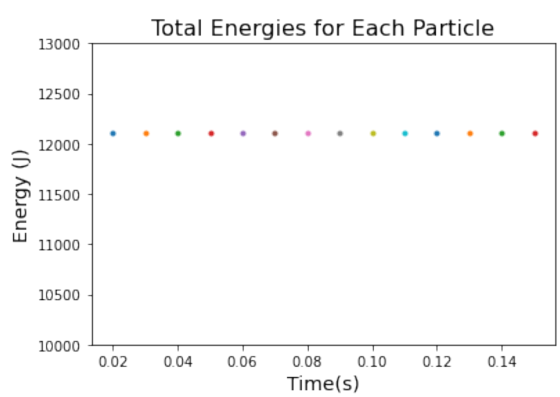
1. Import libraries
2. Initialize N, dt, T, U, K
3. Create arrays for the xs, ys, rs, velocities and accelerations
4. Define constants
5. Set initial positions of particles

6. Plot initial positions
7. Define a function that will calculate the acceleration of the particles
8. Loop through the particles
9. For particle 1, update its x, y, accelerations, and velocities
10. Repeat for particles 2-16
11. Plot trajectories

**PLOT**




## b) Plot




As you can see, the total energy for each particle is the same and thus energy was conserved for the system.