

# Solar System Unit 2: Core Integration Loop

Computer Modelling

Due: 16:00 Monday, Week 3, Semester 2

## Aims

In this second unit of the project you will modify the main Verlet integration loop from exercise 3 so that it works for multiple bodies not just two.

Your code should use your `Particle3D` class, the Velocity Verlet integrator you wrote in semester 1. Check the feedback you got on those exercises on LEARN, and fix any issues identified.

Document your code as you go along using both docstrings for functions and inline `#` comments explaining what you are doing.

# 1 Preparation

Start from the code template for this part, available on Learn, your Particle3D class, and your basic functions from unit 1.

You will notice code in the template that creates a mini test-system, of the Sun, Mercury, Earth, and the moon. You will use this test system to ensure that your integration is working correctly.

# 2 Simulation code

Now you have your basic functions you can use them, and more code that you will write, to modify your Verlet code to use an arbitrary number particles in a list instead of just two. Represent the full system as a list of particles, where e.g. `particles[i]` is a `Particle3D` instance.

Go through the template code and replace all the items listed as “TODO” with working code. You will need to:

- subtract the system’s centre-of-mass velocity at the start
- use your unit 1 functions to compute separations and forces
- write new code to update all the particle positions and velocities
- write code to store the trajectories in an array and plot them.
- write code to compute the total energy and store it in an array.

# 3 Expected Results

If your code is working then we expect that the plots should show:

- Mercury’s x location oscillating in about 88 days. Don’t worry about a slight drift that can occur for this time step.
- Earth’s trajectory forming a circle.
- Total energy being conserved to less than 0.1%. Check the top left of the axis label of the energy plot for the scale.

- The Sun moving only slightly compared to the planets.
- The Moon orbiting the sun about every 28 days.

## 4 Submission

### 4.1 Submitting

Submit a zip file through Learn as explained in the background briefing by **16:00 Thursday, Week 3, Semester 2**. Successful submissions are emailed a receipt.

Always check your code runs one final time before submitting.

#### 4.1.1 What to submit

Ensure you submit at least:

- the main python file.
- the particle3D file.
- any other python files needed to run the code - e.g. a basic functions file if you kept it separate.

### 4.2 Marking Scheme

This assignment counts for 10% of your total course mark.

1. Correct Verlet algorithm. [7]
2. Correct centre-of-mass subtraction. [1]
3. Feedback from unit 1, if any, correctly implemented. [2]
4. All required plots are created. [3]
5. Plots are accurately labelled. [1]
6. Code is efficient. [2]
7. Code quality, comments, and docstrings [4]

Total: 20 marks.