Problem 1

Write an N-body code for integrating solar system dynamics. Use the leap-frog method (or better) to integrate the orbits of \( N \) bodies under their mutual self-gravity. You can assume \( N \) is small and evaluate the gravitational accelerations by direct summation.

Note that if you can implement a fourth-order Runge-Kutta method instead of the leap-frog, it will be more accurate and decrease the computing time required for this project.

Problem 2

Test the method on a system with \( N = 2 \) where the mass of the central object (e.g. the sun) is much, much larger than the satellite (e.g. the earth). Use a circular orbit and check to see how much the radius of the satellite changes after five orbital periods. If this changes too much (i.e. more than about 1% per orbit), you will need to decrease the time step of your integration. Also monitor the total energy (kinetic plus potential) of the system.

Problem 3

Many extrasolar planetary systems observed to date have Jupiter-mass planets in very elliptical orbits. Set up a hypothetical solar system composed of three bodies: (1) a one solar mass central star, (2) an earth-mass planet with a circular orbit at 1 A.U. (astronomical units), and (3) a jupiter-mass planet with a semi-major axis of 4 A.U. (similar to, but slightly lower than Jupiter’s) and an eccentricity of \( e = 0.6 \). Integrate the system for as many years (i.e. earth orbits) as you can, but at least one hundred. What happens? What does this imply for the existence of life in these systems?