Project 3

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Physics 480: Computational Physics
(Dated: April 16, 2018)

Summary, numbers.

I. INTRODUCTION

motivation, explain structure of report.

II. THEORY

The physics background required for this project is not very extensive, as the only force involved is gravity. To start simply, consider two celestial bodies with masses M_1 and M_2 at the locations (x_1, y_1) and (x_2, y_2) on the x-y plane. We can obtain two coupled differential equations for the motion of M_2

$$\begin{aligned}\frac{d^2x_2}{dt^2} &= \frac{GM_1(x_1 - x_2)}{((x_1 - x_2)^2 + (y_1 - y_2)^2)^{3/2}} \\ \frac{d^2y_2}{dt^2} &= \frac{GM_1(y_1 - y_2)}{((x_1 - x_2)^2 + (y_1 - y_2)^2)^{3/2}}\end{aligned} \tag{1}$$

using Newton's second law. Now add more planets with masses $M_3, M_4,$ ..., M_n into the system. Then to find the equations of motion for the j^{th} planet, we need to sum over the interactions between M_j and all the other M_k's:

$$\begin{aligned}\frac{d^2x_j}{dt^2} &= \sum_{\substack{k=1 \\ k\neq j}}^{n} \frac{GM_k(x_k - x_j)}{((x_k - x_j)^2 + (y_k - y_j)^2)^{3/2}} \\ \frac{d^2y_j}{dt^2} &= \sum_{\substack{k=1 \\ k\neq j}}^{n} \frac{GM_k(y_k - y_j)}{((x_k - x_j)^2 + (y_k - y_j)^2)^{3/2}}\end{aligned} \tag{2}$$

This can easily be extended into three dimensions:

$$\begin{aligned}\frac{d^2x_j}{dt^2} &= \sum_{\substack{k=1 \\ k\neq j}}^{n} \frac{GM_k(x_k - x_j)}{r^3} \\ \frac{d^2y_j}{dt^2} &= \sum_{\substack{k=1 \\ k\neq j}}^{n} \frac{GM_k(y_k - y_j)}{r^3} \\ \frac{d^2z_j}{dt^2} &= \sum_{\substack{k=1 \\ k\neq j}}^{n} \frac{GM_k(z_k - z_j)}{r^3} \\ r &= \sqrt{(x_k - x_j)^2 + (y_k - y_j)^2 + (z_k - z_j)^2}\end{aligned} \tag{3}$$

using convenient units can simplify

III. METHOD

A. Forward Euler

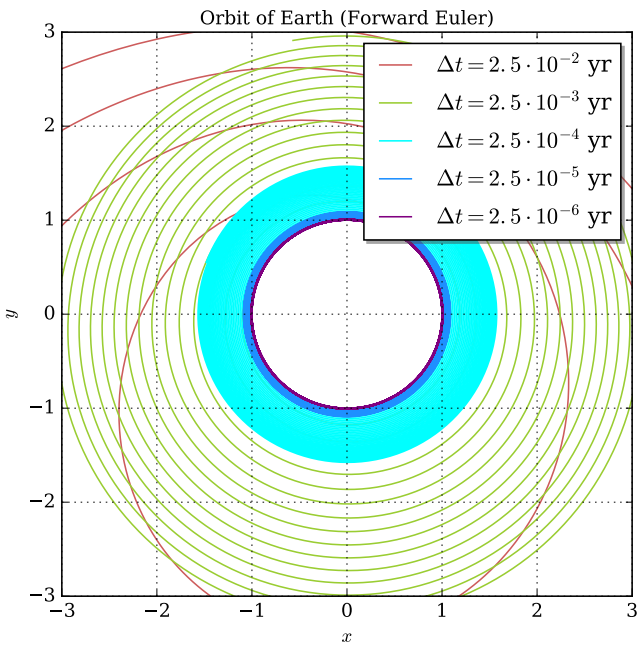
B. Velocity Verlet

IV. IMPLEMENTATION

V. TESTS

VI. RESULTS

VII. CONCLUSION



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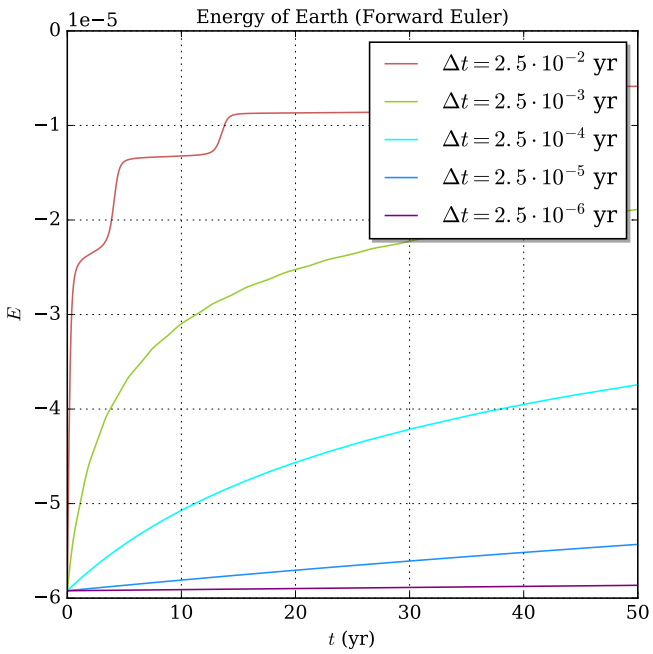

(b) A subfigure

FIG. 1: A figure with two subfigures

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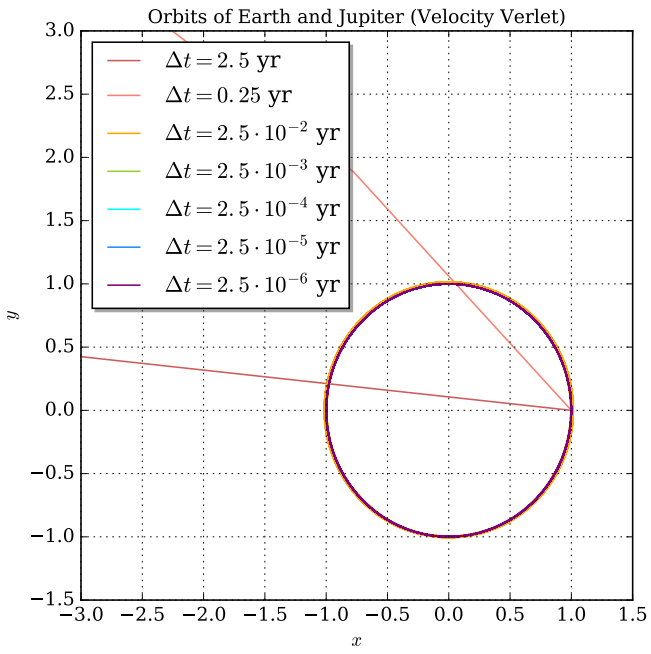
[1] M. Hjorth-Jensen. "Computation Physics, Lecture Notes Fall 2015". University of Oslo. August 2015.



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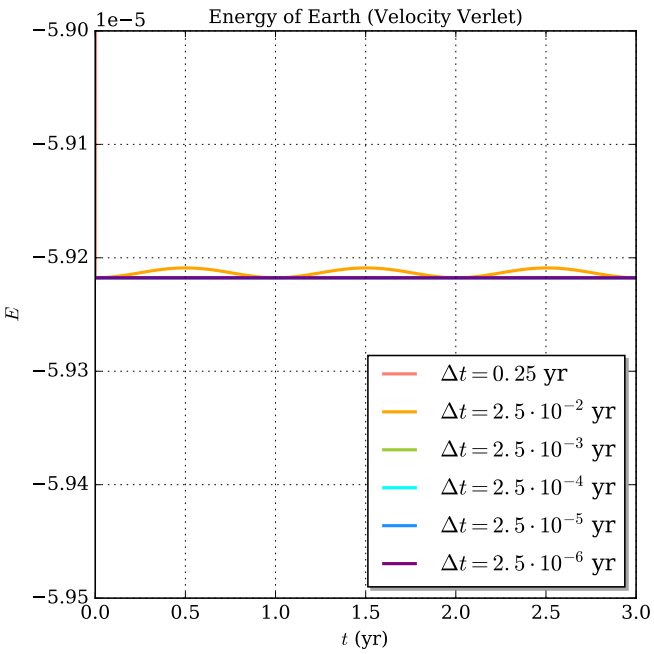

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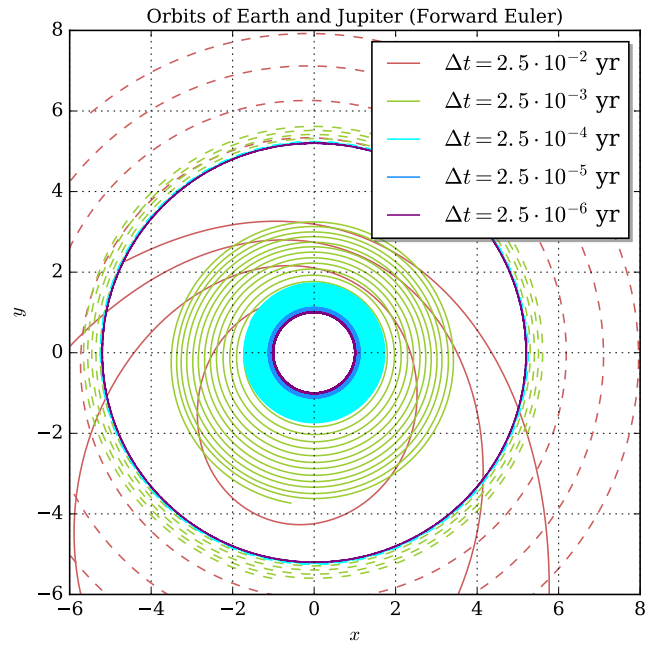
FIG. 2: A figure with two subfigures



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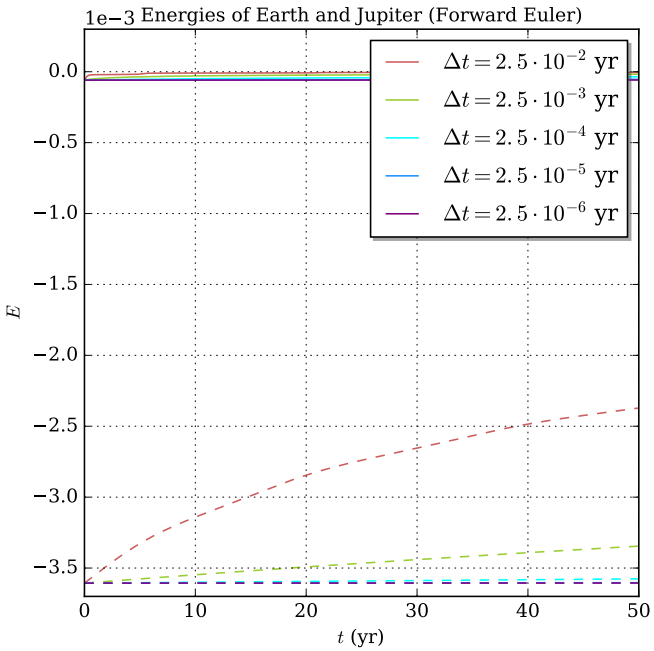

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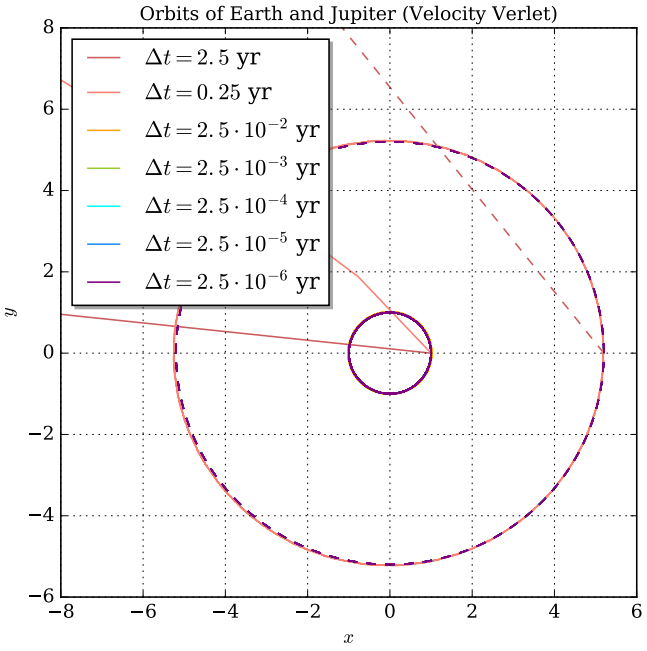
FIG. 3: A figure with two subfigures



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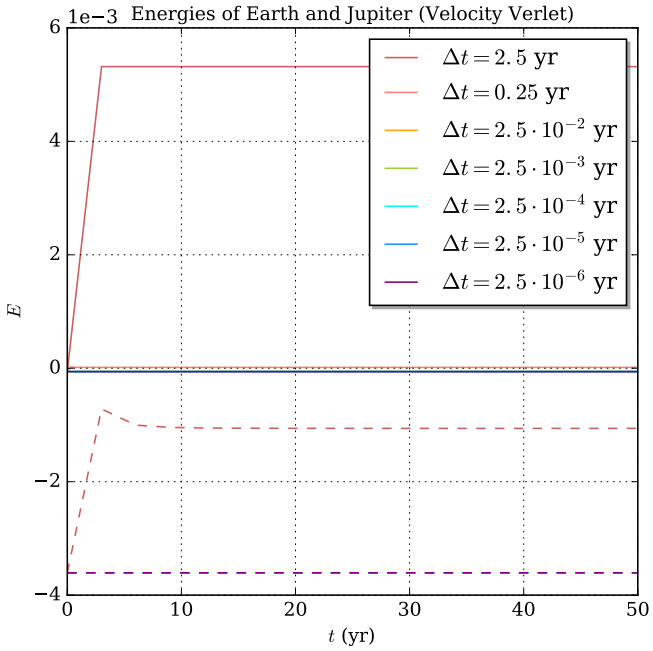

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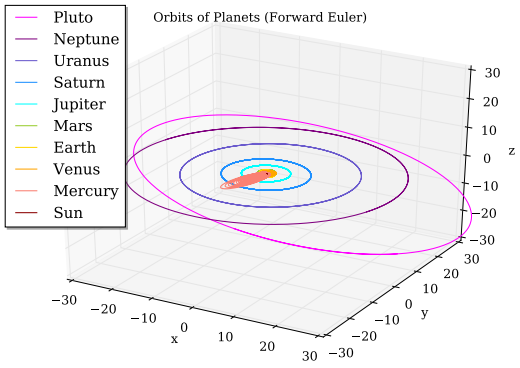
FIG. 4: A figure with two subfigures



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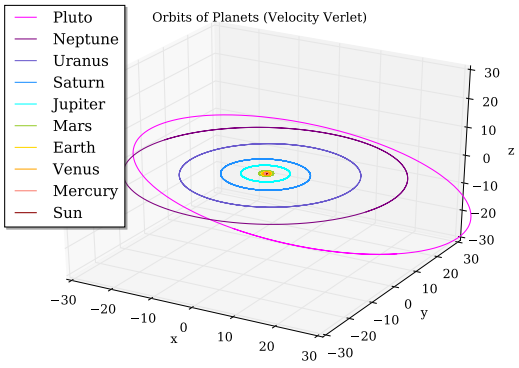
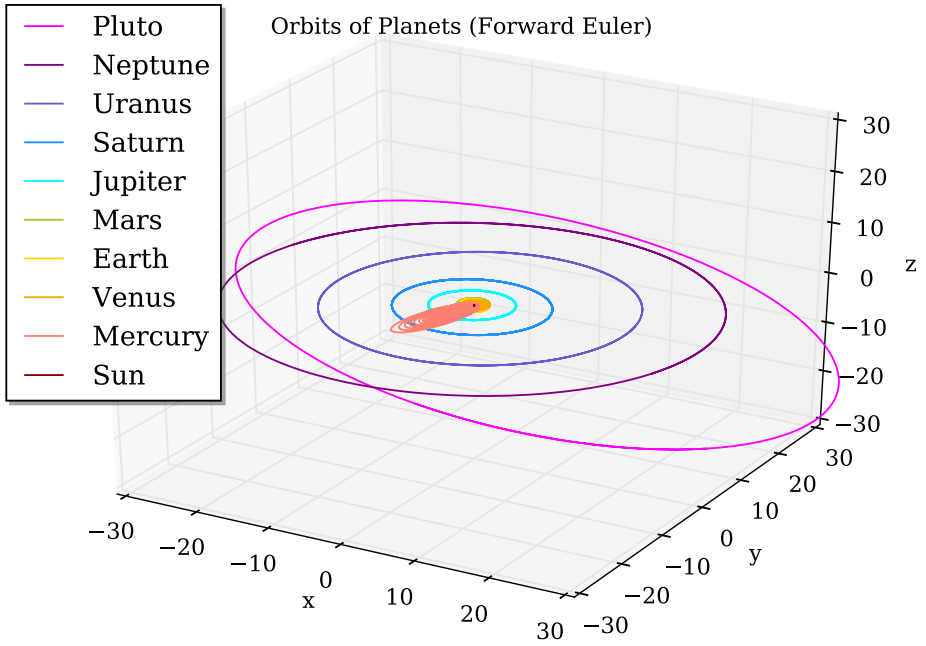
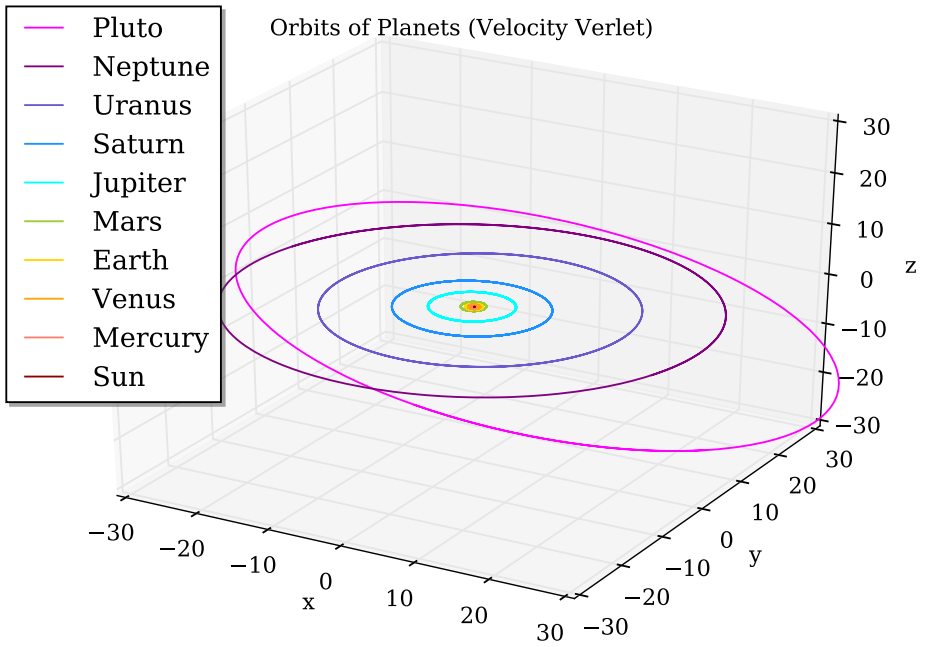


(b) A subfigure

FIG. 5: A figure with two subfigures


Orbits of Planets (Forward Euler)
Pluto
Neptune
Uranus
Saturn
Jupiter
Mars
Earth
Venus
Mercury
Sun
x
y
z


Orbits of Planets (Velocity Verlet)
Pluto
Neptune
Uranus
Saturn
Jupiter
Mars
Earth
Venus
Mercury
Sun
x
y
z