# PHYS 35100 – FALL 2024

## Homework Set 4

Due Nov 18th via Blackboard submission, before 12:00 pm.

Instructions: Prepare responses to the following questions. Each one is worth the same amount. [A] means that a problem is meant to be done *analytically*, i.e. with paper and a pencil. [C] means that the problem is meant to be done with *computationally*, i.e. with software* Homework sets will be submitted electronically. Please submit one pdf document that contains all the work you want me to see. For the [A] ones, please scan your original, handwritten work and include in the pdf. For [C] problems, save your code/notebook as a pdf (not a screenshot) and include that pdf in the submission. Also link to the Colab notebook online and make sure it is viewable/commentable by me (jhedberg@ccny.cuny.edu). Please title your submission `PHYS35100-HW4-LASTNAME-FIRSTNAME.pdf` .

1. 1P/Halley

Halley's Comet is the most famous comet. Look up (and cite your sources, I like the <u>JPL Small-Body Database</u> ) its parameters to calculate the following quantities.

    a. Total Energy
    b. Angular Momentum
    c. And confirm that Kepler's 3rd law holds true for this object.

2. Effective Potential [C]

This is the equation we derived for the effective potential for a two body system of gravitationally interacting masses.

$$U_{\text{eff}} = \frac{l^2}{2\mu r^2} - \frac{Gm_1 m_2}{r} \tag{1.1}$$

Look up the relevant data regarding Mars & the Sun and recreate the following two plots (with your own code and styles). Things your plots should have:

    a. The Effective Potential vs. distance between Mars and Sun for an object with the angular momentum ($l$) of the Mars.
    b. A horizontal line (check out `ax.axhline(y=#)`) that shows the total energy ($E$) of Mars in its orbit
    c. A zoom in region showing where the effective potential and total energy lines cross, and mark these as the aphelion and perihelion
    d. Labels on all axes and legends for each component
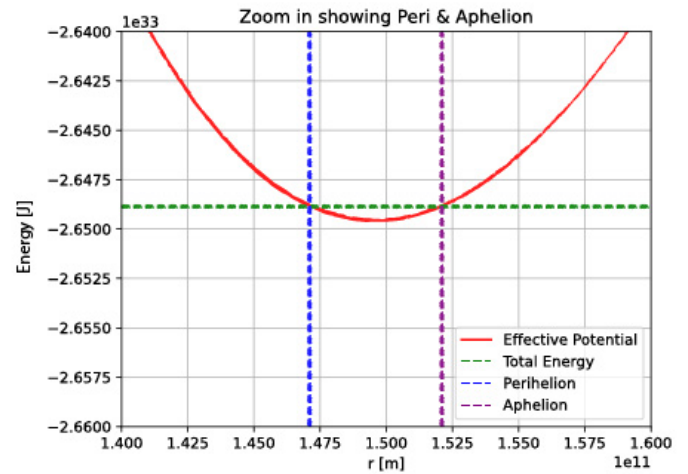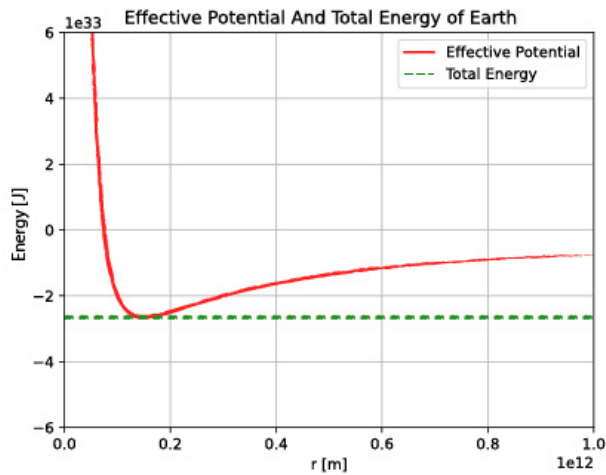
Tips: this is tricky, but doable if you're careful. You will need to get values for things like the universal gravitational constant and the masses of Mars and Sun. Keep as many significant figures as you can during the calculations since the zoom in region is very small and slight rounding errors will lead to problems. Pay attention to the set_xlim() and set_ylim() values you choose to set the ranges of your plots.

## 3. Spring and 2 masses [A]

There are two masses connected via a spring (spring constant = $k$) with the usual spring force ( $F = -kx$, Hooke's law) acting between the two masses. (You can call them $m_a$ and $m_b$). *In the center of mass frame* (CM):

1. construct the Lagrangian for this system using the relative positions **R** and **r**.
2. Find the equation of motion for $r$ and use that to find the frequency of oscillation.

## 4. Ping... Ping... Ping...

A derelict communications satellite was observed by ground based measurements to reach a minimum height of 270 km above the earth's surface (i.e. its perigee). It's speed was estimated to be 8700 m/s. Figure out:

1. Its orbital eccentricity,
2. Its altitude above the surface of the Earth at apogee,
3. The period of the orbit.

* This means that I'd like you to extend the techniques we use, and not use other software, libraries, etc. That means for plotting, use matplotlib, not plotly for example.