FYS-4096 Computational Physics, exercise 10

Return your solution to project `exercise10` under your GitLab group for this course by Friday 5 AM.

Tag the final version with `final` keyword, and make sure to include a file `problems_solved` in the repository. The `problems_solved`-file should be a comma separated list of problems you have solved.

Problem 1 (2 XP)

Solve and visualize the solution for the following ODE using `scipy`

$$\left\{ \begin{array}{rcl} \dot{x} &=& 10(y-x) \\ \dot{y} &=& x(28-z)-y \\ \dot{z} &=& xy - 8z/3 \end{array} \right.$$

starting from the initial condition $(x, y, z) = (1, 1, 1)$.

What phenomenon can you notice?

Problem 2 (5 XP)

Let's simulate the sun-earth-moon system.

We'll model the system by considering a heliocentric plane in 2D cartesian coordinates. The sun's position is (initially) at $(x, y) = (0, 0)$, and we model Earth and Moon as point-like objects **on this 2D plane**.

Take Earth's initial position at its orbit perihelion where its distance to Sun is 147 098 291 km and orbital speed $\sim$ 30.28 km/s.

Moon's initial position is 385,000 km away from Earth, on the opposite side as the Sun. Moon's orbital speed **around Earth** is $\sim$ 1 km/s.

1. Implement **velocity Verlet** algorithm for time-propagation,
2. simulate a 2 year long trajectory, and
3. visualize the trajectories of Sun, Earth, and Moon
4. visualize the trajectory of Moon around Earth

Problem 3 (3 XP)

Solve the following ODE numerically using `scipy`

$y''(x) + \cos[y(x)]y(x) = \exp\left(-\frac{x}{30}\right)\sin(x)$, $x \in [0, 30]$

with initial conditions $y(0) = 0$ and $y'(0) = 2$, and visualize your solution.