Project 6 (Due date Thursday December 1st 12 a.m.)

The solution of Newton's equation of gravity for three or more gravitating bodies cannot be derived analytically. Some approximations can be used, and techniques, such as perturbation theory, can be used to derived analytical solutions under some restrictions. For this project, I want you to simulate the gravitational interaction between the sun, earth and mars, ignoring all other planets.

Each massive body position is given by a position vector $\mathbf{r}_i(t)$:

$$\mathbf{r}_i(t)=[x_i(t),y_i(t)] \qquad i=1,2,\ldots,N$$

Note that you will work with 2-dimensional gravity in cartesian coordinates. The index "`i`" refers to the body number (Sun, Earth, Mars). The relative distance between mass `i` and `j` is given by:

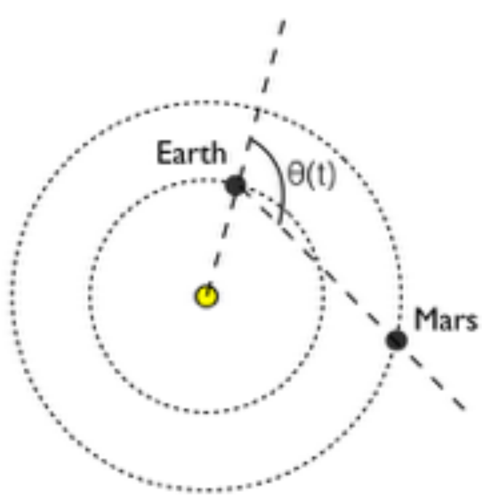
$$\mathbf{r}_{ij}=\mathbf{r}_i-\mathbf{r}_j$$

Newton's law of gravity tells us that the acceleration of body "`i`" is given by:

$$\frac{d^2\mathbf{r}_i}{dt^2} = G\sum_{j\neq i}\frac{M_j}{r_{ij}^3}\mathbf{r}_{ij}$$

where M_j is the mass of body "`j`" and the sum runs over all bodies in the system except "`i`".

Objectives: You will write a code **`solarsystem.py`** which solves for the 3 bodies problem: Sun+Earth+Mars. Your code must generate an animation of Sun+Earth+Mars that runs *over two martian years*. The code should clearly indicate units (for time, mass and distance) so we can check that they are correct. This animation should be called **`solarsystem.mp4`** and should show the time flow in **days**. You will also generate a plot showing the position of planet mars as viewed from planet earth, relative to the direction of the sun given by angle Θ(t) as shown below:



This plot should be called **`retrograde.pdf`** and also covers two martian years in time.

All planets outside Earth's orbit show retrograde motion, this was already known by the greeks and probably way before (although there is no known record of that). In these early days, when the Earth was thought to be at the center of the Universe, explaining the retrograde motion of planets was not trivial and a sophisticated theory was invented to do this, the theory of epicycles. Newton's gravity put a final end to the epicycles and precise measurements of the motion of planets definitely showed that the Sun was close to the center of mass of the entire solar system.

Tips: this project has no particular difficulty. I am not giving you any more information, you will have to find out by yourself what initial condition(s) to use to set your 3 body system in motion so that the Earth and Mars have approximately with the right speed and the right orbit. The only difficulty is to write Newton's law in a way that can be solved with `odeint()`.
For the legend showing the time show, look at the `text` method of the axes subclass of `subplots`.

Bonus: "easy" bonus points if you manage to simulate the whole solar system with 8 planets and the Sun with all gravitational interactions between them and keep your code relatively compact!