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In this project, a solar system will be studied. By solar system, I mean a system where only gravitational forces effect the bodies, and where there is a large mass fixed in origo[1]. Newtons gravitational law states that the gravitational force on a body with mass m from another body with mass M and relative position $\vec{r}$ is given by

$$\vec{F}_{\mathrm{G}} = -\frac{GmM}{\|\vec{r}\|^2}\vec{r}$$

where G is the gravitational constant, $6.67 \cdot 10^{-11}\,\mathrm{N\,m^2/s^2}$. The direction of the force is given by the fact that gravity is an attractive force. If one of the objects is the sun, the mass is denoted by $M_\odot$. With the sun placed in origo, r is simply the norm of the position vector of the planet with mass m.

If there are n planets in the solar system, in addition to the sun, the sum of the forces on planet i with mass m_i is

$$\sum \vec{F}_i = \sum_{\substack{j=0 \\ j\neq i}}^{n} \frac{Gm_i m_j}{\left\|\vec{r}_i - \vec{r}_j\right\|^3}\left(\vec{r}_i - \vec{r}_j\right)$$

with $m_0 = M_\odot$ and $\vec{r}_0 = \vec{0}$. From Newton's second law, we know that $\sum \vec{F}_i = m_i \vec{a}_i$, so the acceleration of planet i is given by

$$\vec{a}_i = \sum_{\substack{j=0 \\ j\neq i}}^{n} \frac{Gm_j}{\left\|\vec{r}_i - \vec{r}_j\right\|^3}\left(\vec{r}_i - \vec{r}_j\right) \tag{1}$$

[1]This is a reasonable approximation, as the mass of the sun is much larger than the masses of the planets.

As the sun has been fixed to origo, $\vec{a}_0$ is set to $\vec{0}$.