Solution for assignment 27a and 27b.

The orbit is given by

$$p = r\,(1 + e\,\cos\theta)$$

where

$$r = |\vec{r}| = \sqrt{r_x^2 + r_y^2 + r_z^2} \quad \text{with} \quad \vec{r} = r_x\hat{x} + r_y\hat{y} + r_z\hat{z} = \vec{r}_1 - \vec{r}_2\,,$$

$$p = \frac{L^2}{\mu\alpha} \quad \text{and} \quad e = \sqrt{1 + \frac{2\,E\,L^2}{\mu\,\alpha^2}}\,.$$

$2p$ is called the *latus rectum*, and e *eccentricity*. Their definitions involve the reduced mass μ, the coupling strength α, the center of mass energy E and the magnitude of the angular momentum L:

$$\mu = \frac{m_1 m_2}{m_1 + m_2}\,, \quad \alpha = G\,m_1 m_2\,, \quad E = \frac{\mu\,\vec{v}^{\,2}}{2} + U(r)\,, \quad L = |\vec{L}| \quad \text{with} \quad \vec{L} = \mu\,\vec{r}\times\vec{v}$$

with $v = |\vec{v}|$, $\vec{v} = \vec{v}_1 - \vec{v}_2$. Once r, p and e are calculated, we can solve for θ:

$$\frac{p}{r} - 1 = e\,\cos(\theta) \;\Rightarrow\; \theta = \pm\cos^{-1}\left(\frac{p-r}{er}\right)$$

with $-\pi < \theta \le \pi$ where the sign is that of $\vec{r}_0 \cdot \vec{v}_0$. Numerical values are in the `Kparameters.txt` file.