Calculation of the Martian Year

Given the mass of the Sun as $M = 1.9891 \times 10^{30}$ kg, the eccentricity of the elliptical orbit of Mars as $e = 0.093$, and the minimum distance from Mars to the Sun as 1.382 AU, we aim to calculate the number of Earth years in a Martian year. It is important to note that distances are given in Astronomical Units (AU), where 1 AU is the average distance from the Earth to the Sun, and the units of the universal gravitational constant G are $\mathrm{m^3kg^{-1}s^{-2}}$.

Methodology

To find the semi-major axis a of Mars' orbit, we use the relationship given by:

$$a = \frac{r_{\min}}{1-e}$$

where $r_{\min} = 1.382\,\mathrm{AU}$ is the perihelion distance (the minimum distance from Mars to the Sun), and $e = 0.093$ is the eccentricity of Mars' orbit.

Next, applying Kepler's Third Law, which relates the orbital period of a planet to the semi-major axis of its orbit:

$$T^2 = \frac{4\pi^2}{G(M+m)} a^3$$

Assuming the mass of Mars m is negligible compared to the mass of the Sun M, and converting a from AU to meters (knowing $1\,\mathrm{AU} = 1.496 \times 10^{11}\,\mathrm{m}$), we can calculate the orbital period T of Mars.

Calculation

Substituting the given values into the equation for a:

$$a = \frac{1.382}{1-0.093} = \frac{1.382}{0.907}\,\mathrm{AU}$$

Then, converting the semi-major axis to meters and substituting into Kepler's Third Law:

$$T^2 = \frac{4\pi^2}{G(M+m)} \left(a \times 1.496 \times 10^{11}\right)^3$$

Given $G = 6.674 \times 10^{-11}\,\mathrm{m^3kg^{-1}s^{-2}}$ and the mass of the Sun, we can find T in seconds and convert this to Earth years by dividing by 3.156×10^7 s/year.

Conclusion

This process allows us to calculate the number of Earth years in a Martian year, using the given orbital parameters of Mars and applying Kepler's laws of planetary motion.