Monday, February 2, 2026

Kepler's Laws : Applicability

Apply everywhere

1st Law : All orbits are ellipses, circles, parabolas or hyperbolas.

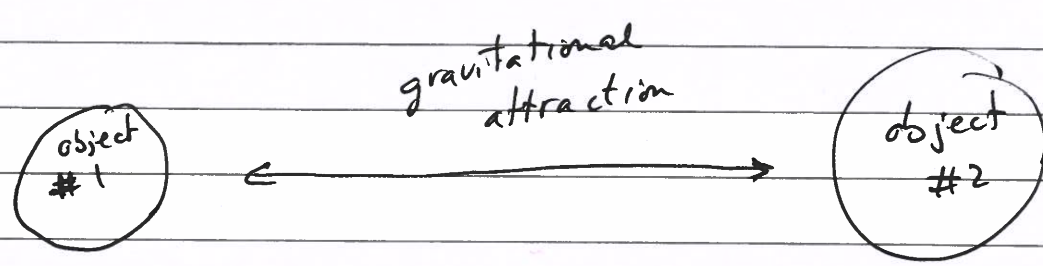
2nd Law : Law of equal areas

3rd Law : $T^2 = a^3$

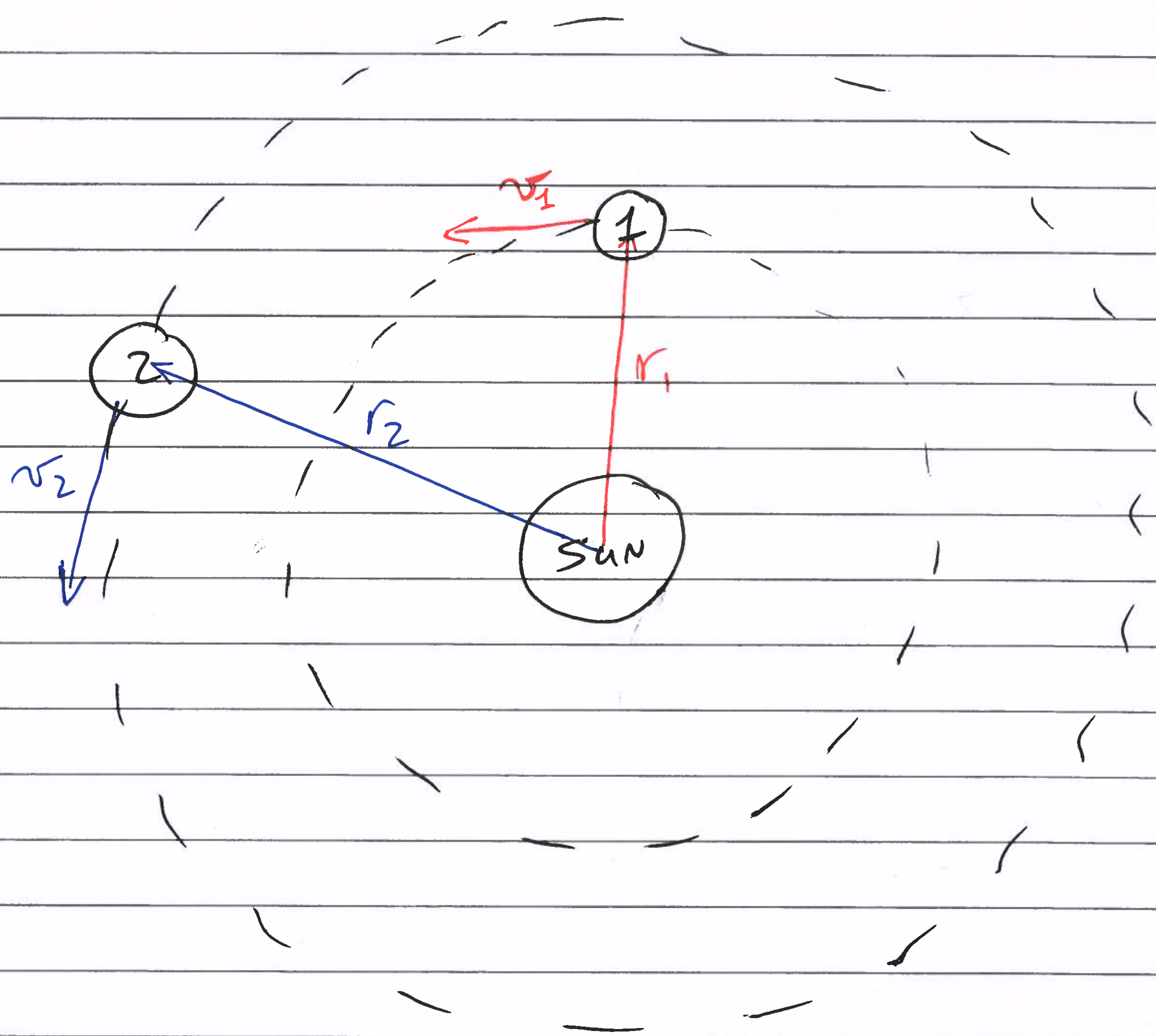
T = orbital period in Earth years

a = semimajor axis in A.U.

It "should" apply everywhere, but units only make it valid for our Solar System



Orbital Speed vs Orbital Distance



Assume circular orbits for simplicity

[good approximation for our solar system]

$$\begin{cases} r_1 = a_1 \\ r_2 = a_2 \end{cases}$$ (semimajor axes)

Let's calculate the velocity/speed:

orbital circumference $= 2\pi r$

orbital period $= T = \frac{2\pi r}{v}$ (1) $\Leftrightarrow v = \frac{2\pi r}{T}$

orbital speed

Kepler's 3rd Law : $T^2 = a^3 = r^3$

$\Leftrightarrow T = r^{3/2} = \sqrt{r^3}$ (2)

combine (1) and (2) : $\frac{2\pi r}{v} = T = r^{3/2}$

$\Leftrightarrow \frac{2\pi r}{v} = r^{3/2} \Leftrightarrow v = \frac{2\pi \cancel{r}}{r^{\cancel{3/2}\ 1/2}}$

$\Leftrightarrow v = \frac{2\pi}{r^{1/2}}$

$\Leftrightarrow \boxed{v = \frac{2\pi}{\sqrt{r_R}}}$ units of AU

units of AU/yr

Conclusion: The further out a planet is, the slower its speed