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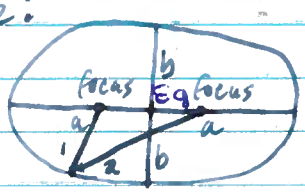
1/12 Astrophysics Notes

- Nicolaus Copernicus introduced Heliocentrism
- The retrograde motion of Mars was evidence for heliocentrism
- Giordano Bruno was executed for his heliocentric assertions by the Roman Catholic Church
- Galileo Galilei used observational evidence such as the faces of Venus to further substantiate heliocentrism
- Galileo was the first astronomer to use a telescope
- Johannes Kepler used Tycho Brahe's data to support heliocentrism

Kepler's System

- Kepler realized that planets follow elliptical orbits
- ellipse:



- the distance of the focus from the center is defined as the eccentricity, εa
- $1 + 2 =$ constant value

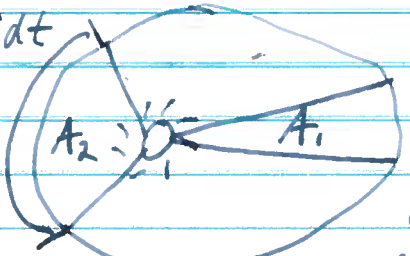
Kepler's Laws

I: Planets follow elliptical orbits
II: planets sweep out equal areas in equal times

$\vec{e} = \vec{v}\,dt$

$\text{area} = \frac{1}{2}|\vec{r} \times \vec{e}|$

$\frac{1}{2}|\vec{r} \times \vec{v}| = \text{const.}$



$\frac{dA}{dt} = \text{constant}$

- this follows from the conservation of angular momentum

$\vec{L} = \vec{r} \times \vec{p}$
$= m \cdot \vec{r} \times \vec{v}$

- The conservation of angular momentum is due to the invariance of physical laws under rotation

III: $a^3 \sim T^2$

- Using a circular approximation, this can be defined as follows:

$$v = \frac{2\pi r}{T}$$

$$m\frac{v^2}{r} = \frac{G M_{sun} m}{r^2} \rightarrow r^3 = \frac{G M_{sun}}{v^2}$$

$$\rightarrow \frac{G M_{sun} T^2}{4\pi^2 v^2}$$

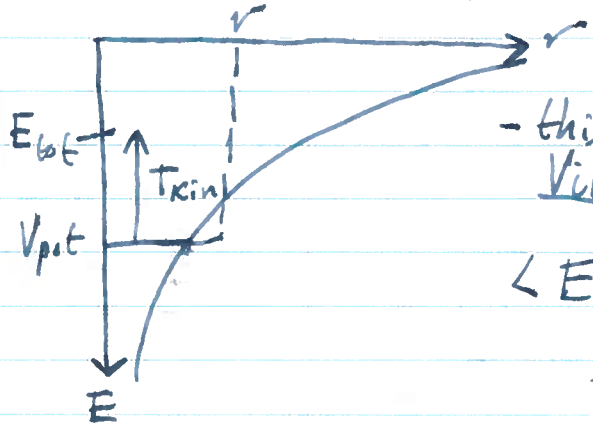
$$mv^2 = \frac{G M_{sun} m}{r} = -V_{pot}$$

$$|T_{kin}| = \tfrac{1}{2}|V_{pot}| \quad \therefore \quad T_{kin} + V_{pot} = \tfrac{1}{2} V_{pot}$$

(both sides are negative!)

$$E_{tot} = T_{kin} + V_{pot} = \tfrac{1}{2} V_{pot}$$

potential diagram:



- this is an example of the Virial Theorem

$$\langle E_{tot} \rangle = \tfrac{1}{2} \langle V_{pot} \rangle$$