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 phases 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, $\varepsilon = \frac{c}{a}$
  - $1 + \varepsilon = \text{constant value}$

Kepler's Laws
I: Planets follow elliptical orbits
II: Planets sweep out equal areas in equal times

\[ \frac{dA}{dt} = \text{constant} \]

\[ \text{Area} = \frac{1}{2} a b \sqrt{x_1} + x_2 \]

\[ \frac{1}{2} a b \sqrt{x_1} + x_2 = \text{constant} \]

\[ L = m \mathbf{r} \times \mathbf{v} = \text{conservation of angular momentum} \]
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:

\[
v = \frac{2\pi r}{T}
\]

\[
m\frac{v^2}{r} = \frac{GM_{\text{sun}}}{r^2} \quad \rightarrow \quad r^3 = \frac{GM_{\text{sun}}}{v^2}
\]

\[
\rightarrow \quad \frac{GM_{\text{sun}} T^2}{4\pi^2 r^2}
\]

\[
m v^2 = \frac{GM_{\text{sun}} m}{r} = -V_{\text{pot}}
\]

\[
|T_{\text{kin}}| = \frac{1}{2} |V_{\text{pot}}| \quad \therefore \quad T_{\text{kin}} + V_{\text{pot}} = \frac{1}{2} V_{\text{pot}}
\]

\[
E_{\text{tot}} = T_{\text{kin}} + V_{\text{pot}} = \frac{1}{2} V_{\text{pot}}
\]

- this is an example of the Virial Theorem

\[
\langle E_{\text{tot}} \rangle = \frac{1}{2} \langle V_{\text{pot}} \rangle
\]