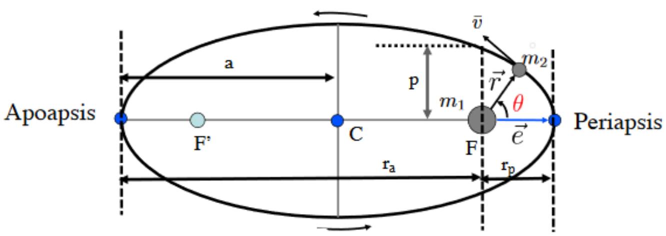
Two-Body Problem

Newton's Law: $\Sigma\vec{F} = \frac{d(m\vec{v})}{dt} = m\vec{a}$
Universal Law of Gravitation: $\vec{F}_g = -\frac{Gm_1m_2}{r^2}\frac{\vec{r}}{|\vec{r}|}$
Apply Newton's Laws to a two-body problem with the assumptions:

1. Only system force: Gravity $\rightarrow$ acts along the line joining the centers of the bodies.
2. Mass of each body is constant.
3. Treat each body as a spherically symmetrical point mass with uniform density.

Orbital Properties:

- a = semimajor axis
- b = semiminor axis
- p = semiperimeter
- r_a/r_p = radii of apoapsis/periapsis
- $\vec{e}$ = eccentricity



Useful Equations:
$a = \frac{1}{2}(r_a + r_p)$
$p = \frac{b^2}{a} = a(1-e^2) = \frac{h^2}{\mu}$
$r_a = \frac{p}{1-e} = a(1+e)$
$r_p = \frac{p}{1+e} = a(1-e)$
$e = \frac{r_a - r_p}{r_a + r_p} = \frac{c}{a} = \frac{\sqrt{a^2-b^2}}{a} = \sqrt{1 + \frac{2h^2\varepsilon}{\mu^2}}$
$b = a\sqrt{1-e^2}$
Angular Momentum: $\vec{h} = \vec{r} \times \vec{v} = \sqrt{\mu a(1-e^2)}$
Eccentricity Vector: $\vec{e} = \frac{\vec{v}\times\vec{h}}{\mu} - \frac{\vec{r}}{r}$
Specific Energy: $\varepsilon = \frac{v^2}{2} - \frac{\mu}{r} = \frac{\mu^2(e^2-1)}{2h^2}$

- $\varepsilon < 0$ Motion of Body 2 is bounded wrt Body 1
- $\varepsilon \geq 0$ Motion of Body 2 is unbounded wrt Body 1

Conic Equation: $r = \frac{h^2/\mu}{1+e\cos\theta} = \frac{p}{1+e\cos\theta}$
Vis-Viva Equation: $v = \sqrt{\frac{2\mu}{r} - \frac{\mu}{a}}$
True Anomaly: