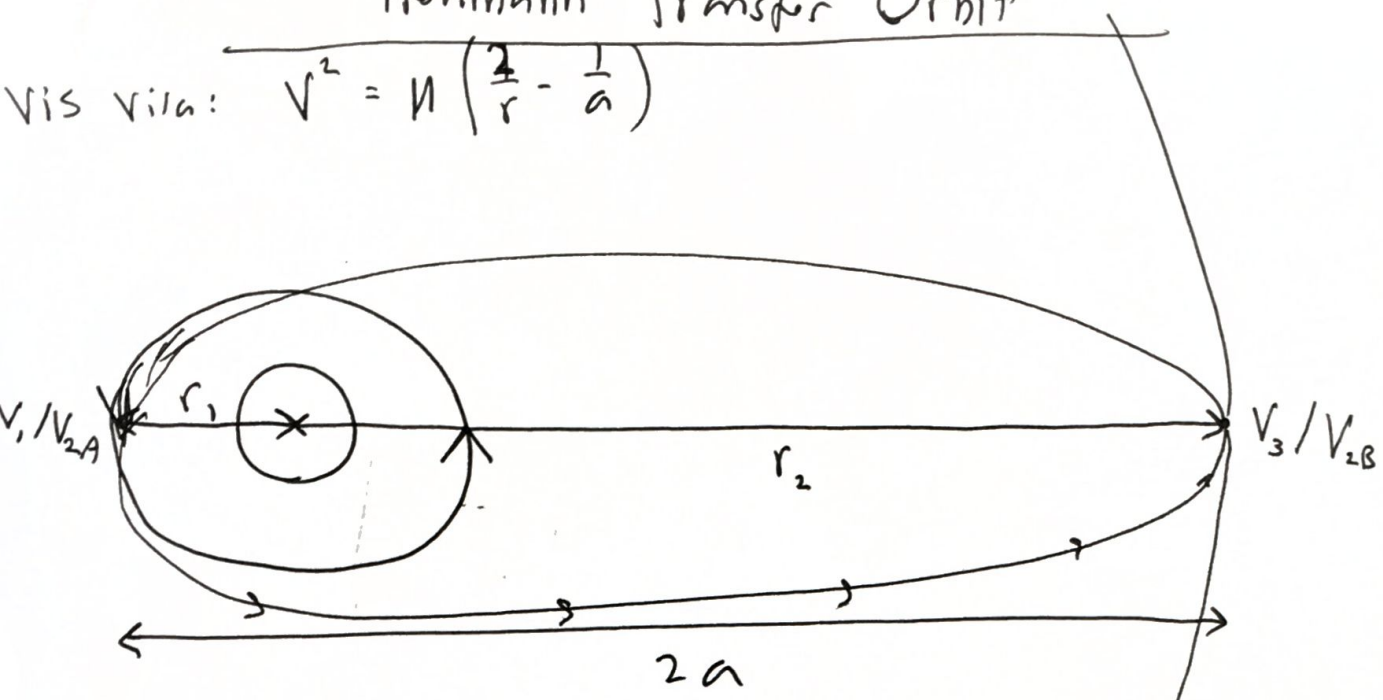
Hohmann Transfer Orbit

Vis viva: $V^2 = \mu\left(\frac{2}{r} - \frac{1}{a}\right)$



Earth circular: $r = r_1$, $a = r_1$

$$V_1^2 = \mu\left(\frac{2}{r_1} - \frac{1}{r_1}\right)$$

$$\boxed{V_1^2 = \frac{\mu}{r_1}}$$

Earth elliptical $r = r_1$, $a = \frac{r_1 + r_2}{2}$

$$V_{2A}^2 = \mu\left(\frac{2}{r_1} - \frac{2}{r_1 + r_2}\right)$$

$$V_{2A}^2 = \mu\left(\frac{2r_2}{r_1(r_1 + r_2)}\right)$$

$$\Rightarrow \Delta V_A = V_{2A} - V_1 = \sqrt{\mu\left(\frac{2r_2}{r_1(r_1 + r_2)}\right)} - \sqrt{\frac{\mu}{r_1}} = \sqrt{\frac{\mu}{r_1}}\left(\sqrt{\frac{2r_2}{(r_1 + r_2)}} - 1\right)$$

Moon circular orbit $r = r_2$, $a = r_2$:

$$V_3^2 = \frac{\mu}{r_2}$$

Moon elliptical orbit, $r = r_2$, $a = \frac{r_1 + r_2}{2}$

$$V_{2B}^2 = \mu\left(\frac{2}{r_2} - \frac{2}{r_1 + r_2}\right)$$

$$= \mu\left(\frac{2r_1}{r_2(r_1 + r_2)}\right)$$

$$\Rightarrow \Delta V_B = -\left(\sqrt{\frac{\mu}{r_2}\left(\frac{2r_1}{r_1 + r_2}\right)} - \sqrt{\frac{\mu}{r_2}}\right)$$

$$= \sqrt{\frac{\mu}{r_2}}\left(1 - \sqrt{\frac{2r_1}{r_1 + r_2}}\right)$$