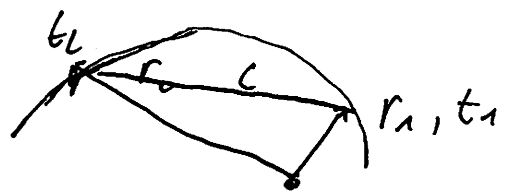
$$n(t_2 - t_1) = (\alpha - \sin\alpha) - (\beta - \sin\beta)$$

$$\sin\frac{\alpha}{2} = \pm\sqrt{\frac{r_1 + r_2 + c}{4a}}$$

$$\sin\frac{\beta}{2} = \pm\sqrt{\frac{r_1 + r_2 - c}{4a}}$$

T.O.F $\Delta t = t_2 - t_1$ depends on: Lambert Theorem

$r_1 + r_2$, a, c



$$\mathcal{E} = -\frac{\mu}{r} + \frac{v^2}{2} > 0$$

for hyperbola

$$\Rightarrow \quad v^2 > \frac{2\mu}{r} = V_{esc.}^2$$

"escape velocity"

Surface of the Earth:

$V_{esc.} \approx 11\ \mathrm{km\ s^{-1}}$

Surface of the Moon

$V_{esc.} \approx 2.4\ \mathrm{km\ s^{-1}}$

$$\mathcal{E} > 0$$
$$\mathcal{E} = -\frac{\mu}{2a} \Rightarrow a < 0$$

$e \geq 1$

$$r = \frac{p}{\underbrace{1 + e\cos f}_{>0}}$$

$1 + e\cos f = 0 \Rightarrow r \to \infty$

$$\cos f_{\pm\infty} = -\frac{1}{e}$$

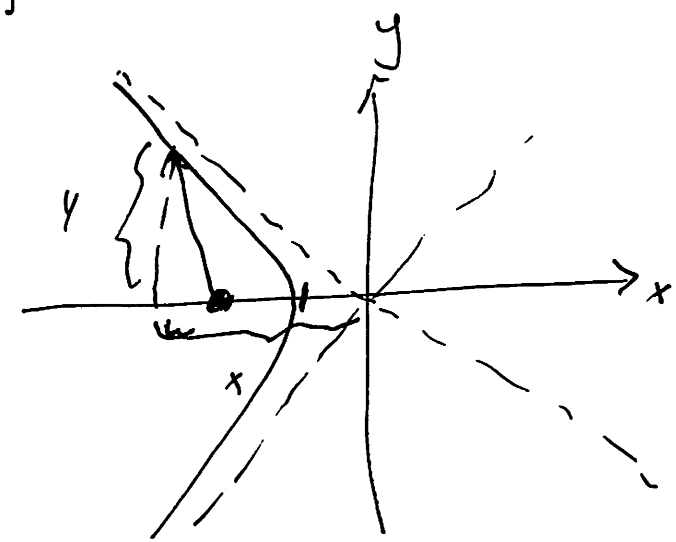
$$\underbrace{b = -a\sqrt{e^2 - 1}}_{\text{hyperbola}}$$

$$\frac{x^2}{a^2} \underset{\substack{(+)\\ \uparrow \\ \text{ellipse}}}{-} \frac{y^2}{b^2} = 1$$

$(E \to iE)$

$x = a(-e + \cosh H)$

$y = -a\sqrt{e^2-1}\,\sinh H$



$\Rightarrow r = \underbrace{\sqrt{x^2+y^2}}_{\text{hyperbola}} = a(1 - e\cosh H)$ orbit equation

analogy to ellipse:

$$r = a(1 - e\overset{\cos}{\cancel{\sin}} E)$$

$$r = \frac{p}{1 + e\cos f}$$ applies always!

$H \Longleftrightarrow f$

$$\cos f = \frac{-\cosh H + e}{e\cosh H - 1}$$

$$\sin f = \frac{\sqrt{e^2 - 1}\,\sinh H}{e\cosh H - 1}$$

$$\tan f = \frac{\sqrt{e^2-1}\,\sinh H}{-\cosh H + e}$$

Kepler Equation:

$$M = e \cdot \sinh H - H$$

1.) When is the spacecraft at a given location?

2.) Where is the spacecraft after a given time?

$$n = \sqrt{\frac{\mu}{-a^3}}$$

$$V_\pi = \sqrt{\underset{\substack{\uparrow \\ <0}}{\frac{\mu}{a}} \; \underbrace{\frac{1+e}{1-e}}_{<0}}$$

$$V = \sqrt{\frac{\mu}{p}} \sqrt{1+e^2+2e\cos f}$$

in general: all equations with f apply to hyp and para. without change

$$V_\infty = \sqrt{-\frac{\mu}{a}} \quad \Big| \quad \text{Velocity @ } f = f_{\pm\infty}$$

$\hookrightarrow V_\pi$?

$$V_\pi = V_\infty \sqrt{\frac{e+1}{e-1}}$$

$$\frac{\pi}{2} - \frac{\delta}{2} = \pi - f_\infty$$

$$\Rightarrow \quad f_\infty = \frac{\pi}{2} + \frac{\delta}{2}$$

$$\Rightarrow \underbrace{\cos f_\infty}_{-\frac{1}{e}} = -\sin\frac{\delta}{2}$$

$$\Rightarrow \boxed{\sin\frac{\delta}{2} = \frac{1}{e}}$$

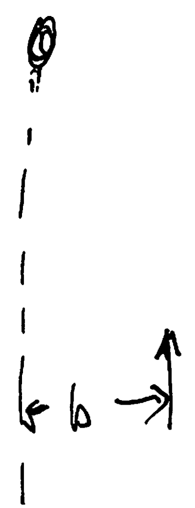
$$h = \sqrt{\mu p} = \underbrace{b V_\infty}$$

as $r \to \infty$

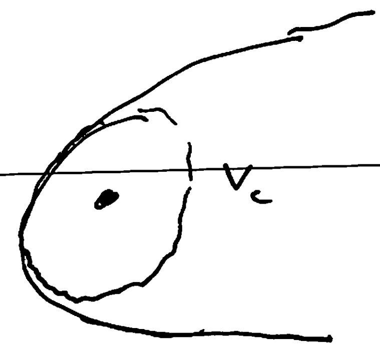
$$= \sqrt{\mu a(1-e^2)}$$

$$e = \sqrt{1 - \frac{b^2 v_\infty^4}{\mu^2}}$$

b : impact parameter



$$\sin\frac{\delta}{2} = \frac{1}{\sqrt{1 + \frac{b^2 v_\infty^4}{\mu^2}}}$$



$$v_\pi = \underbrace{\sqrt{\frac{2\mu}{r_\pi}}}_{\text{esc. velocity @ } r_\pi} = \sqrt{2}\, v_c$$

$\Rightarrow e = 1, \quad a \to \pm\infty$

$$\tan\frac{f}{2} = A - \frac{1}{A}$$

$$A = \sqrt[3]{B + \sqrt{B^2 + 1}}$$

$$B = 3\sqrt{\frac{\mu}{p^3}}\,(t - t_\pi)$$