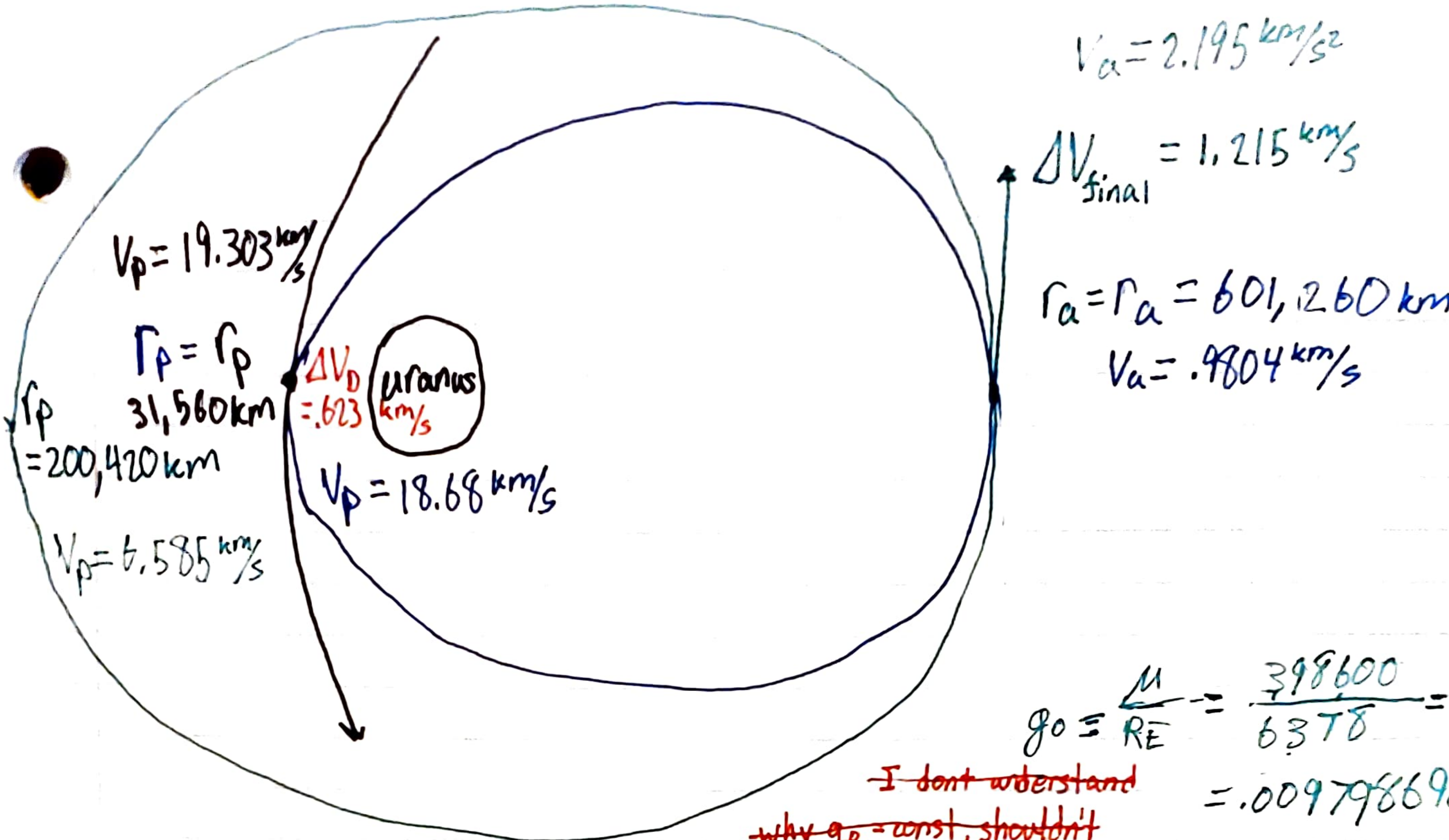


$$g_0 = \frac{\mu}{R_E} = \frac{398600}{6378} = .009798696 \frac{km}{s^2}$$

~~I dont understand why g_0 = const, shouldn't we use g_0 @ distance from planet?~~

At target orbit: $m_{s/c}$ = dry mass (centaur + scientific payload)

$= 2247 kg + 502.9 kg = 2749.9 kg$

$$m_0 = m_{s/c}\, e^{\frac{\Delta V_{final}}{I_{sp}\, g_0}} = 2749.9\, e^{\frac{1.215}{450.5(.00978)}}$$

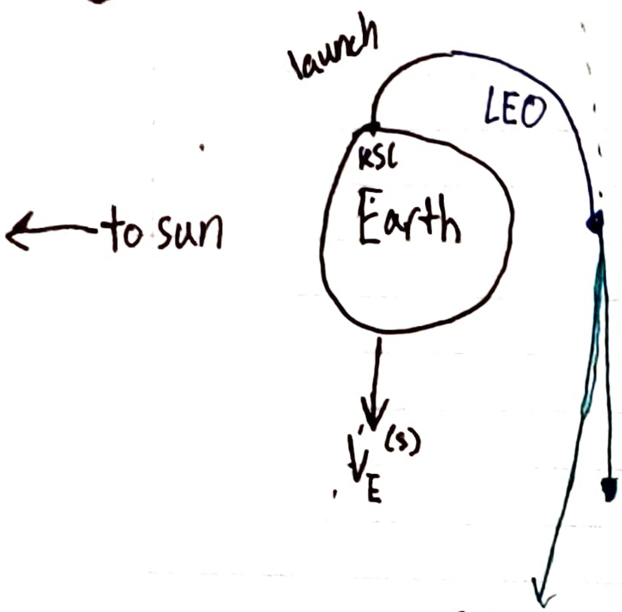
$= 3621.2 kg$

From grav assist: $dV_{dep} = 5.2423$ km/s

$V_{cir,earth} = \sqrt{\frac{\mu_{sun}}{r}} = \sqrt{\frac{132,712,000,000}{149.6E6}} = 29.784$ km/s

$V_{cir} = \sqrt{\frac{\mu_e}{r}} = \sqrt{\frac{398,600}{6378+380}}$

$= 7.67997$ km/s



$r_p = r_a = 380$ km

$r_{p,Hyp} = 380$ km

$V_{p,Hyp} = 12.92197$ km/s $= V_{cir} + \Delta V_{dep}$

$V_\infty = \frac{\mu}{h}\sqrt{e^2-1}$, $\mu = 398,600$, $h = r_p v_{p,Hyp}$, $e = \frac{v_{p,Hyp}^2 r_p}{\mu} = \frac{12.922^2(380)}{398,600} - 1$

$= 59.4889$

$\mathcal{E}_{Hyp} = \frac{V_{p,Hyp}^2}{2} - \frac{\mu_E}{r_p} = \frac{V_\infty^2}{2} = 24.50447$

$V_\infty = \sqrt{2(24.5045)} = 7.0006$ km/s wrt earth

$m_0 = m_{s/c}\, e^{\frac{\Delta V_{dep}}{I_{sp} g_0}}$, $m_{s/c}$ here is SEC III + payload + fuel for insertion into target orbit at Uranus.

.27563

$\boxed{= 11,874.28 \text{ kg}}$ Atlas V must deliver this much mass to 380km LEO

$L = 17\,m$, $D = 1.6\,m$ ISP 279.3 s Thrust = [illegible] kN

0-5 x AJ-60A Boosters $m_0 = 46{,}697\,kg$ $m_f = 4{,}057\,kg$, $M_{fuel} = $ [illegible]

$L = 32.46\,m$ $D = 3.81\,m$ $t_{bo} = 94\,s$

Common Core Booster ISP = 311.3 s sea-level $T = 3827\,kN$ L

$m_f = 21{,}054\,kg$ $m_0 = 303{,}143\,kg$ 337.8 s vacuum $4{,}152\,kN$ V

$t_{bo} = 253\,s$

Atlas V LS→LEO = 8,250 kg − 20,520 kg (16,[illegible] lb − 45,[illegible] lb)

payload lift capability

RIOC-1 Centaur III Single Engine ← up to 12 restarts (12 dV maneuvers)

$m_s = 2247\,kg$ (4,954 lb)

→ $ISP = 450.5\,s$ → $t_{bo} = 842$ seconds

$T = 99.2\,kN$

→ can carry up to 18,273 kg (payload + fuel) → $m_{fuel,max} = 17{,}770.1\,kg$

→ $m_{pay} = 502.9\,kg$

constrained by Atlas V lift capacity (m_{tot} cannot exceed 20,520 kg)

max mass at LEO: 20,520 kg ($m_{0,\,SEC\,III} + m_{payload}$)

so we can take up to 17,770.1 kg LEO→Uranus target of fuel with us,

$$\Delta V = I_{sp}\, g_0 \ln\left(\frac{m_0}{m_f}\right)$$

April 30th, 2021 @ 7:21 am

Uranus Target

$r_p = 200,420\,km$ $\quad \alpha = \frac{h^2}{\mu_{uranus}}$

$r_a = 601,260\,km$ $\quad e = \frac{r_a - r_p}{r_a + r_p} = \frac{601,260 - 200,420}{601,260 + 200,420} = .5$

$a = \frac{r_p + r_a}{2} = 400,840$

$h = \sqrt{a\mu(1-e^2)} = \sqrt{400,840(5,794,000)(1-.5^2)}$

$= 1,319,791.734$

$V_p = \frac{h}{r_p} = 6.585\ km/s$ wrt. uranus

$V_a = \frac{h}{r_a} = 2.195\ km/s$

$V_{cir,uranus} = \sqrt{\frac{\mu_{sun}}{r_{,uranus}}} = 6.798\ km/s$

$DV_{arrival} = 2.257\ km/s = V_\infty \rightarrow r_p = 200420$

$= 2.333\ km/s \rightarrow r_p = 31,560$

$V_{SOI,Uranus} = 4.541\ km/s \leftarrow V_{s/c}$ wrt uranus

$r_p : r_U + r_{s/c} = 31560\,km$ $\quad a = \frac{r_p + r_a}{2} = \frac{31,560 + 601260\,km}{2} = 316,410\,km$

$r_a = 601,260\,km$ $\quad e = \frac{r_a - r_p}{r_a + r_p} = .90002$, $\quad h = \sqrt{(316,410)(5,794,000)(1-.9^2)}$

$= 589472.8$

$\Rightarrow V_p = 18.68\ km/s \leftarrow$ elliptical

$V_a = .9804\ km/s$

$V_{p,Hyp} = \sqrt{V_\infty^2 + \frac{2\mu_p}{r_p}} = 19.303\ km/s$, need $\Delta V_{Drag} = .623\ km/s$ to close orbit.

$\Delta V_{sinal\ burn} = 1.215\ km/s$

4,000,000 km

Transfer time → Jupiter 517.84 days $\Delta V_{DEP} = 7.325$

θ @ Departure 99.775° $\Delta V_{arr} = 1.478$

θ @ Flyby : 142.775° $\Delta V_{tot} = 8.803$

$\Delta V = V_{pHyp} - V_{park}$ $V_{park} = \sqrt{\frac{398600}{6758}} = 7.68$

$V_{pHyp} = 12.922 \text{ km/s}$ $V_\infty = \frac{\mu_E}{h}\sqrt{e^2-1}$, $h = V_p r_p = 12.922(6758) = 87,326.9$

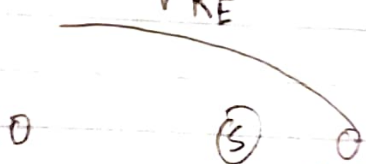
$= 7.001 \text{ km/s}$

$e = \frac{V_{pH}^2 r_p}{\mu_E} - 1 = \frac{(12.922)^2(6758)}{398600} - 1 = 1.831 \Rightarrow \beta = \cos\frac{1}{1.831}$

$= 56.897°$

$\Delta = r_p \frac{\sqrt{e^2-1}}{e-1} = 6758\left(\frac{\sqrt{1.831^2-1}}{1.831-1}\right) = 12,473.53 \text{km}$

$\sqrt{\frac{\mu_{sun}}{R_E}} =$



$V(\theta) = \frac{\mu_{sun}}{h}\sqrt{1+e^2+2e\cos\theta}$

$r_p = 149.6E6$ $V(142.775°) = \frac{132,712,000}{5.5031E9}\sqrt{1+(.678)^2+2(.678)\cos(\theta)}$

$V_p = 29.78 + 7.001 \text{ km/s}$ $= 14.867 \text{ km/s}$

$= 36.785$

$h = v_p r_p = 149.6E6(36.785)$

$=$

$e = \frac{r_a - r_p}{r_a + r_p} = \frac{778.6E6 - 149.6E6}{778.6E6 + 149.6E6} = .6777$

$\sqrt{\frac{\mu_{sun}}{R_J}} = 13.056 \text{ km/s}$ $V_\infty = 1.811 \text{ km/s}$

$V_{p,Hyp} = \sqrt{V_\infty^2 + \frac{\mu_{JUP}}{R_p}} = 11.915 \text{ km/s}$

$$V_{s/c}^{(s)} = \sqrt{{V_p^{(s)}}^2 + V_\infty^2 - 2V_p^{(s)} V_\infty \cos(\delta + \phi)}$$

$$= 15.693 \text{ km/s}$$