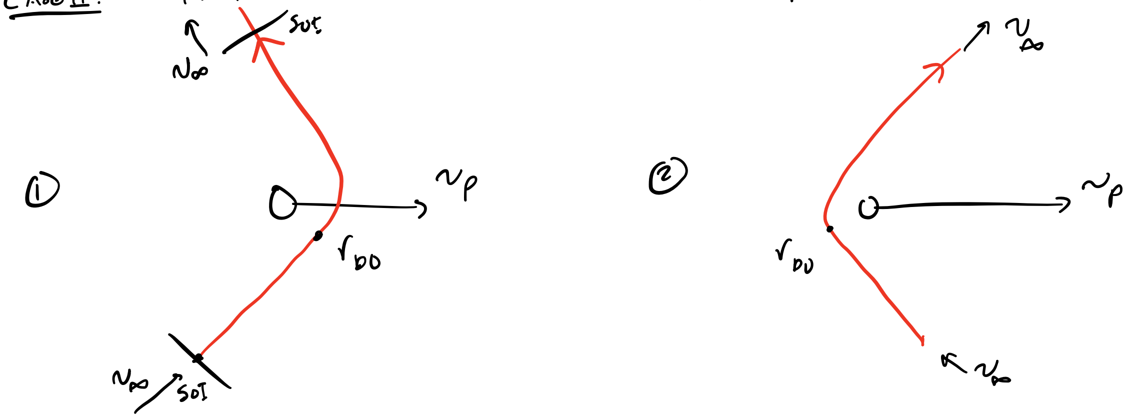
PLANETARY FLYBY & GRAVITATIONAL ASSIST

– NEED MOTION IN S.C./SUN & S.C./PLANET

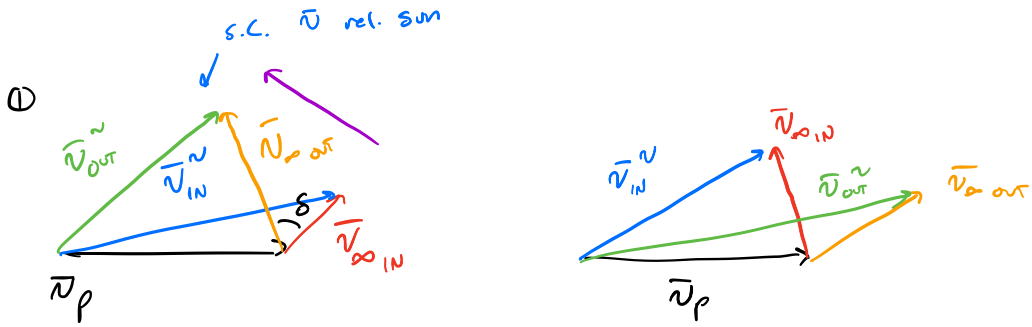
CASE I: LEADING SIDE – BURN OUT FACING PLANET MOTION

CASE II: TRAILING SIDE – BURN OUT AWAY FROM PLANET MOTION



JUST NEED VECTOR DIAGRAMS

RECALL: δ = TURN ANGLE



$$|\bar{v}_{OUT}^{\sim}| < |\bar{v}_{IN}^{\sim}|$$

$$|\bar{v}_{OUT}^{\sim}| > |\bar{v}_{IN}^{\sim}|$$

GRAVITY ASSIST

$$\Delta\bar{v}^{\sim} = \bar{v}_{OUT}^{\sim} - \bar{v}_{IN}^{\sim} = \bar{v}_{\infty\,OUT} - \bar{v}_{\infty\,IN}$$

$$\Delta v^{\sim} = 2 v_\infty \sin\left(\frac{\delta}{2}\right) = 2 v_\infty \left(\frac{1}{1 + \frac{r_{bo} v_\infty^2}{\mu_p}} \right)$$

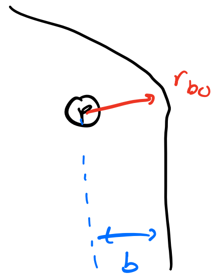
SEE SLIDE 37

WE CAN USE $\tilde{v}_{out}$ & ITS DIRECTION FOR NEXT MANEUVER

EXCESS VELOCITY: $v_\infty = |\bar{v}_{in} - \bar{v}_p|$

$\bar{v}_{in}$ COMES FROM

- $\bar{v}_{apogee}$ - from Hohmann, Bi-elliptic
- $\bar{v}_2$ - from Lambert
- Large $v_\infty \rightarrow$ large Δv^2



Burn out radius $\rightarrow$ $b \cong r_{bo}\sqrt{1 + \frac{2\mu_2}{r_{bo} v_\infty^2}}$

- Target $r_{bo} \cong 2 R_p$ often to start
  can iterate after

- "Designing" is an optimization problem

Example: Mars cont. "flyby"

set (first) $r_{bo} = 2 R_{Mars}$ $= (3379 \cdot 2)$ km

$$v_{bo} = \sqrt{v_\infty^2 + \frac{2\mu_{Mars}}{2r_{bo}} - \frac{2\mu_{Mars}}{r_{SOI\,Mars}}}$$

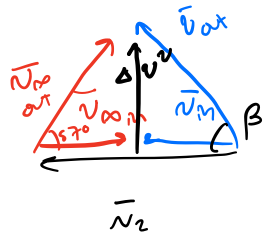
2.65 km/s   4.306 x 10^4 km^3/s^2 5.78 x 10^5 km

$$v_{bo} \approx 4.43 \text{ km/s}$$

Next: $b = \frac{r_{bo} v_{bo}}{v_\infty} = 11297$ km

Finally: $\delta = 2\sin^{-1}\left(\frac{1}{1 + \frac{r_{bo} v_\infty^2}{\mu_2}}\right) = 57^\circ$

will S.C. speed increase or decrease? slide 38



$v_2 = 24.13$

$v_\infty = 2.65$

$v_{in} = 21.48$

$\bar{v}_{out} = ?$ use law of cos

$$v_{out}^2 = v_2^2 + v_{\infty\,out}^2 - 2 v_2 v_{\infty\,out} \cos\delta$$

$v_{out} = 22.81$ km/s

$\beta = ?$ use law of sines

$$\frac{\sin\beta}{v_{\infty\,out}} = \frac{\sin\delta}{v_{out}} \rightarrow \beta = 6^\circ$$

$$\Delta v = 2 v_\infty \sin\left(\frac{\delta}{2}\right) = 2.53 \text{ km/s}$$