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Q1)

Transferring from orbit to intermediate orbit.

$$-\frac{GM_e m}{2r_1} + \frac{1}{2}mv^2 = -\frac{GM_e m}{r_1+r_2}$$

$$2\left(\frac{GM_e}{2r_1} - \frac{GM_e}{r_1+r_2}\right) = v^2$$

$$\sqrt{\frac{GM_e}{r_1}}\sqrt{\frac{r}{r_1+r_2}} = V_1$$

$$\Rightarrow \Delta V_1 = \sqrt{\frac{GM_e}{r_1}}\left(\sqrt{\frac{r}{r_1+r_2}} - 1\right)$$

for transforming from intermediate orbit.

$$\frac{-GM_e m}{r+r_2} + \frac{1}{2}mv_2^2 = \frac{-GM_e m}{2r_2}$$

$$\Delta V_2 = \sqrt{\frac{GM}{r}}\left(1 - \sqrt{\frac{2r_2}{r_1+r_2}}\right)$$

$$\Delta V_{total} = \Delta V_1 + \Delta V_2$$

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

On putting value of geostationary orbit

$$r_1 = 35800 R_e = 42200 \text{ km}$$

$$r_2 = 36050 R = 42450 \text{ km}$$

$$(\Delta V_{red})_{M} = \Delta V_1 + \Delta V_2 = 9.07 \text{ m/s}$$

Similarly on putting values for transfering b/w geostationary & ~~graveyard orbit~~ low earth orbit

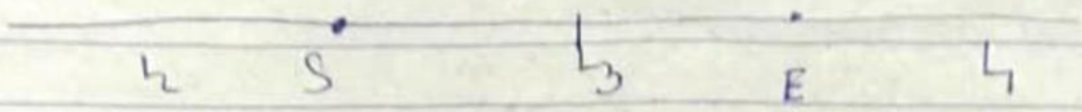
$$r_1 = 3800 + R_e = 42200$$

$$r_2 = 84000 + R_e = 68000$$

$$(\Delta V_{total})_{LEO} = -3856\ m/s$$

$$\Delta V_{total\ gv} > (\Delta V)_{geo}$$

We would transfer to graveyard ~~geo~~ orbit



$\therefore$ for an ~~equipo~~ equipotential region
$V =$ constant

$\Rightarrow \frac{dV}{dr} = 0 \Rightarrow F = 0$

$\Rightarrow (F_G)_S + (F_G)_E = F_{\text{centripetal force}} = F_c$

For L1 region

$$\frac{GM_S}{(x+r_1)^2} + \frac{GM_e}{(x-r_2)^2} = \frac{G(M_1+M_2)}{(R_{SE}^3)} \times x$$

$r_1 =$ Distance of sun from COM $= \frac{M_e}{M_e+M_s} R$

$r_2 =$ Distance of earth from COM $= \frac{M_s R}{M_s+M_e}$

~~Putting the value of M_e, M_s and R.~~

$$GM_S(x-r_2)^2 R^3 + GM_e(x+r_1)^2 R^3 = G(M_1+M_2)x(x$$

$$\Rightarrow M_S(x-r_2)^2 + M_e(x+r_1)^2 R^3 = (M_S+M_e)x$$

(1)

Putting
giving $L_1 = R\left(1+\left(\frac{M_E/M_S}{3}\right)^{1/3}\right)$

Putting G, M_E, M_S, R in eq^n L_1 and checking whether L_1 satisfies eq^n 1 or not

$L_2 = ~~1.5~~ \; 1.515 \times 10^{11}$ km

putting it in eq^n 1

eq^n 1 $= 0$
$\Rightarrow L_1$ satisfies eq^n 1

similarly for L_2

eq^n 2

$$\frac{GM_S}{(x-r_1)^2} + \frac{GM_E}{(x+r_2)^2} - \frac{G(M_S+M_E)}{R^3}x = 0$$

$$\Rightarrow M_S(x+r_1)^2 R^3 + GM_E(x-r_2)^2 R^3 = (M_S+M_E)x(\ldots$$

for $L_2 = 1.48 \times 10^{11}$ km $L_2 = \left(1-\left(\frac{M_E}{3M_S}\right)^{1/3}\right)R$

putting L_2 in eq^n 2

~~L_2~~ eq^n 2 $= 0$
$\Rightarrow L_2$ satisfies eq^n 2

for L_3

$$\frac{G M_s}{(x+r)^2} - \frac{G M_e}{(x-r_1)^2} = \frac{G(M_s+M_e)}{(r_1+x)^3} x \quad -(3)$$

$L_3 = -1.5000187 \times 10^{11}$ $L_3 = -R\left(1 + \frac{5}{12}\right.$

putting L_3 in eq (3)

eq (5) $= 0$

$\Rightarrow$ L_3 satisfies eq 5 $\quad = -R\left(1 + \frac{5}{12}\frac{M_2}{}\right.$

3) The fig. illustrate how a spacecraft can achieve an extraordinary ΔV using a gravity orbit. It changes the direction of probe motion in such a way that the velocity components (due to the relative motion wrt the sun & jupiter) add up at an obtuse ∠ as probe reaches from the plan. This manouvre would require an enormous amount of propellant if the planet's absent