GSLV Mk III D2 Flight

Combining the two S200 motors:

$$\dot{m} = 2.95\ tons/s, \text{ and } \mathcal{T} = 7931.0\ kN \tag{1}$$

H1

For the L110 engine

$$\dot{m} = 564\ kg/s, \text{ and } \mathcal{T} = 1,621.45\ kN \tag{2}$$

For the C25 engine

$$\dot{m} = 42.86\ kg/s, \text{ and } \mathcal{T} = 182.42kN \tag{3}$$

Use the "K" notation from Projectile Motion lecture to find the altitudes and speeds

$$\begin{aligned} K &= \frac{M_p}{M_{ini}} \text{ and } MR = \frac{M_{ini}}{M_{fin}} = \frac{1}{1-K} \\ \Delta V_n &= g_o I_{sp_n} \ln MR \equiv -g_o I_{sp_n} \ln (1-K) \\ V_{b_n} &= V_{b_{n-1}} + \Delta V_n - g_o t_{b_n} \\ h_{b_n} &= h_{b_{n-1}} + V_{b_{n-1}} t_{b_n} + g_o t_{b_n} \left\{ I_{sp_n} \left(1 - \left[\frac{1-K}{K} \right] \ln MR \right) - \frac{1}{2} t_{b_n} \right\} \end{aligned}$$

As for accelerations,

$$\eta = \frac{\mathcal{T}}{M g_o} - 1 \tag{4}$$

Launch mass is $M_o = 634.3\ tons$

Phase 1

Only S 200 strap-on motors are firing

Begins at 0 min 0 sec, and Ends at 1 min 50.16 sec

H3

Burn time is 110.16 sec

Propellant consumption rate is 2946.2 kg/s, Thrust is 7931 kN

Delta V in Phase 1 is 1.93 km/s

Burnout velocity at the end of 110.16 sec is 0.85 km/s, altitude is 34.2 km

At the end of 110.16 sec:

Velocity is 0.85 km/s

Altitude is 34.2 km

Acceleration changes from 0.28 to 1.61

Phase 2

Both the S 200 strap-on motors and the L 110 engine are firing

Begins at 1 min 50.16 sec, and Ends at 2 min 19.16 sec

H3

Burn time is 29.0 sec

Here, we have three engines firing:

$$
\begin{aligned}
\mathcal{T} &= 2\mathcal{T}_{S200} + \mathcal{T}_{L110} \\
\dot{m} &= 2\dot{m}_{S200} + \dot{m}_{L110} \\
I_{sp} &= \mathcal{T} / \dot{m} \\
M_p &= M_{p_{S200-2}} + M_{p_{L110-2}}
\end{aligned}
$$

Propellant consumption rate is 3510.6 kg/s, Thrust is 9552 kN

Delta V in Phase 2 is 1.08 km/s

At the end of 139.16 sec:

Velocity is 1.65 km/s

Altitude is 69.4 km

Acceleration changes from 2.14 to 3.68

Phase 3

Only the L 110 Engine is firing. The S 200 strap-on motors are ejected

Begins at 2 min 19.16 sec, and Ends at 5 min 15.72 sec

H3

Burn time is 176.56000000000003 sec

Propellant consumption rate is 564.3 kg/s, Thrust is 1621 kN

Delta V in Phase 3 is 3.3 km/s

At the end of 315.72 sec:

Velocity is 3.22 km/s

Altitude is 444.4 km

Acceleration changes from 0.13 to 2.57

Phase 3a

No engine is firing. The L 110 engine is ejected

Begins at 5 min 15.72 sec, and Ends at 5 min 21.24 sec

H3

Coast time is 5.519999999999982 sec

Nothing happens here in terms of change in total energy (mgh + mv^2/2)

At the end of 321.24 sec:

Velocity is 3.16 km/s

Altitude is 462.0 km

Phase 4

Only the C 25 engine is firing

Begins at 5 min 21.24 sec, and Ends at 16 min 28.5 sec

H3

Burn time is 667.26 sec

Propellant consumption rate is 42.9 kg/s, Thrust is 182 kN

Delta V in Phase 4 is 6.51 km/s

At the end of 988.5 sec:

Velocity is 3.13 km/s

Altitude is 2028.2 km

Acceleration changes from -0.49 to 1.35

In total

Vehicle $\Delta V = 12.83\ km/s$

g-t loss is 9.69 km/s

H3