Part 2

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PART 2

Final Be: $\left[\left(p_y(t_f), p_v(t_f), p_m(t_f)\right) - \nabla h\left(y(t_f), v(t_f), m(t_f)\right)\right]$

$$\cdot \ker \nabla F\left(y(t_f), v(t_f), m(t_f)\right) = 0$$

$F(y, v, m) := m - m_f$

$$\Rightarrow \nabla F = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

Let $w \in \ker \nabla F \Rightarrow \begin{pmatrix} w_1 & w_2 & w_3 \end{pmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = 0$

$$\Rightarrow w_3 = 0$$

$$\Rightarrow \ker \nabla F = \left\{ w \in \mathbb{R}^3 : w_3 = 0 \right\}$$

$h = -y(t_f)$

$$\Rightarrow \nabla h = \begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix}$$

$\begin{matrix} p_y \\ p_v \\ p_m \end{matrix} - \nabla h$ $\qquad$ $\ker \nabla F$

$$\Rightarrow \begin{bmatrix} p_y(t_f) + 1 \\ p_v(t_f) \\ p_m(t_f) \end{bmatrix} \cdot \begin{bmatrix} w_1 \\ w_2 \\ 0 \end{bmatrix} = 0$$

$$\Rightarrow w_1\left(p_y(t_f) + 1\right) + w_2\left(p_v(t_f)\right) = 0 \quad \forall\ w_1\ w_2$$

$$\Rightarrow \boxed{p_y(t_f) = -1 \quad \text{and} \quad p_v(t_f) = 0}$$