Part 4

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$\because \phi(t) \neq 0$ on any non-zero time interval,

$$u^*(t) = \underset{u}{\operatorname{argmin}} \; H(p_y, p_v, p_m, y, v, m)$$

$$= \underset{u}{\operatorname{argmin}} \left(p_y v + p_v\left(\frac{u}{m} - g\right) + p_m(-bu) \right)$$

$$= \underset{u}{\operatorname{argmin}} \left(-\underbrace{p_y(t)}\, v(t) + u(t)\left(\frac{p_v(t)}{m(t)} - b p_m(t)\right) - \underbrace{p_v(t)}\, g(t - t_f) \right)$$

($p_y(t)$, $p_v(t)$: indep of $u(t)$)

$$= \underset{u}{\operatorname{argmin}} \left(u(t)\, \phi(t) \right)$$

$0 \leq u(t) \leq u_{max}$

$\therefore$

$$u^*(t) = \begin{cases} 0 & \text{if } \phi(t) > 0 \\ u_{max} & \text{if } \phi(t) < 0 \end{cases}$$