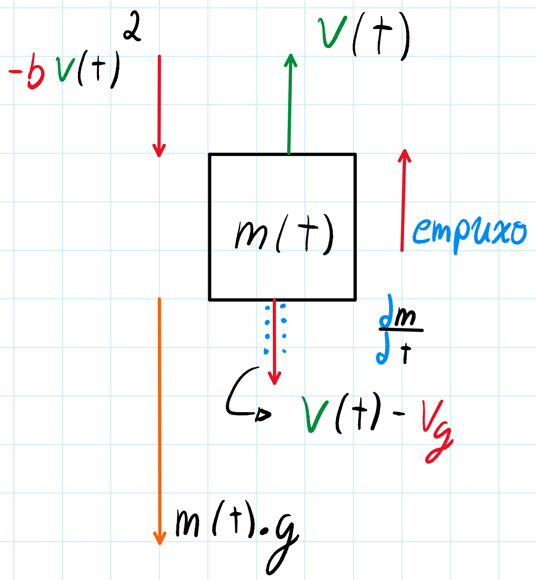

$$\frac{dP}{dT} = \sum_i F_i$$

Foguete: $p(t) = m(t).v(t)$

$$\frac{dp}{dt} = m\frac{dv}{dt} + v\frac{dm}{dt}$$

combustível: $\frac{dp}{dt} = -\frac{dm}{dt}\left(v(t) - v_g\right)$

v_g = velocidade que o combustível sai

$$\frac{dp}{dt} = \left(m\frac{dv}{dt} + v\frac{dm}{dt}\right) + \left(-\frac{dm}{dt}\left(v(t) - v_g\right)\right)$$

$$m\frac{dv}{dt} + \cancel{v\frac{dm}{dt}} - \cancel{v\frac{dm}{dt}} + v_g\frac{dm}{dt}$$

$$\boxed{\frac{dP}{dt} = m\frac{dv}{dt} + v_g\frac{dm}{dt}}$$

$$\sum F = -m(t)g - bv(t)^2 + F_e$$

↳ Empuxo

$$\frac{dP}{dT} = \sum_i F_i$$

$$-m(t)g - bv(t)^2 + F_e = m\frac{dv}{dt} + v_g\frac{dm}{dt}$$

$$m(t)\frac{dv}{dt} = -v_g\frac{dm}{dt} - bv(t)^2 - m(t)g + F_e$$

$$\frac{dv}{dt} = \frac{-V_g}{m(t)}\frac{dm}{dt} - \frac{b}{m(t)} v(t)^2 - g + \frac{Fe}{m(t)}$$

MASSA De combustível

$$m_c(t) = m_c(0) - z(t)$$

$$z(t) = 0{,}9\, t^n$$

ou

MASSA De combustível

$$m_c(t) = m_c(0)\, e^{-\frac{t}{n}}$$

MASSA total: $m(t) = M_{Foguete} + M_c(t)$

$$\lim_{t\to\infty} m(t) = M_{Foguete} \qquad m(t) = M_F + M_c(0)\, e^{-\frac{t}{n}}$$

$$\frac{dv}{dt} = \frac{-V_g}{m(t)}\frac{d}{dt} m(t) - \frac{b}{m(t)} v(t)^2 - g + \frac{Fe}{m(t)}$$

Fe constante ou Fe(t)?

$$Fe(t) = \alpha \frac{d}{dt} m_c(t) \qquad \alpha = 1{,}2$$

PADronização entre 0 & 1

$$m(t) = m_0 z(t) \qquad \frac{d}{dt} v(t) = -\frac{b}{m_0 z(t)} v(t)^2 \frac{-V_g}{m_0 z(t)} \frac{d}{dt} m_0 z(t) - g$$

$$z(t) = 1 - 0{,}9\, t^n$$

tempo de Lançamento: t_0

$$v'(t) = \underline{V(t)}$$

$$v'(t) = \frac{V(t)}{V_g}$$

$$t' = T \cdot T_0$$

$$z(t' = 0) = 1$$

$$z(t' = 1) = 0,1$$

$$m' = \frac{m_0}{-b\, V_g\, T_0}$$

MULTIPLICANDO POR T_0 & DIVIDINDO POR V_g :

$$\frac{d}{dt'} v'(t) = -\frac{b\, V_g\, t_0}{m_0\, z(t')} v'(t)^2 - \frac{1}{\cancel{m_0} z(t)} \frac{d}{dt'} \cancel{m_0} z(t) - \frac{g\, T_0}{V_g}$$

$$\frac{d}{dt'} v'(t) = -\frac{b\, V_g\, t_0}{m_0\, z(t')} v'(t)^2 - \frac{1}{z(t')} \frac{d}{dt'} z(t') - \frac{g\, T_0}{V_g}$$

$$\frac{d}{dt'} v'(t) = -\frac{1}{m_0'\, z(t')} v'(t)^2 - \frac{1}{z(t')} \frac{d}{dt'} z(t') - \frac{g\, T_0}{V_g}$$