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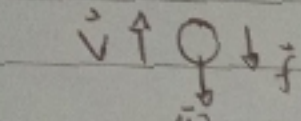
Meninjau benda yang akan bergerak vertikal ke atas dengan pengaruh gaya gesekan kuadratik $f = -bv^2$



$\Sigma F = m \cdot a$

$-\vec{w} - \vec{f} = m \cdot a$

$-mg - bv^2 = m \cdot a$

$$\int_{v_0}^{v_t} \frac{dv}{-g - \frac{bv^2}{m}} = \int_0^t dt$$

$$\int_{v_0}^{v_t} \frac{f}{v} \frac{dv}{-g - \frac{bv}{m}} = \int_0^t dt$$

Misal : $-g - \frac{bv}{m} = u$

$$-\frac{b}{m} dv = du$$

$$dv = \frac{m}{b} \cdot du$$

$$\int \frac{1}{u}\left(-\frac{m}{b} - du\right) = -\frac{m}{b}\int \frac{1}{u} du = \frac{m}{b} \ln(u)$$

$$\int_{b_0}^{v_t} \frac{1}{-g - \frac{bv^2}{m}} dv = \int_0^t dt$$

$$-\frac{m}{b} \ln(u) = t$$

$$-\frac{m}{bv} \ln\left[-g - \frac{bv^2}{m}\right]_{v_0}^{v_t} = t$$

$$-\frac{m}{bv}\left(\ln\left|\frac{-g\frac{bv^2}{m}}{-g\frac{bv_0^2}{m}}\right|\right)^v = t$$

$$\frac{-g - \frac{bv_t}{m}}{-g - \frac{bv_0}{m}} = e^{-\frac{bv^2}{m}}$$

$$-g - \frac{b}{m} v_t = \left(-g - \frac{b}{m} v_0\right) e^{-\frac{bvt}{m}}$$

$$v_t = -\frac{mg}{bv} - \left(-\frac{mg}{bv} - v_0\right) e^{-\frac{bvt}{m}}$$

$f = -w$

$bv = mg$

$$v_T = \frac{mg}{bv}$$

$$v(t) = v_T - (v_T - v_0) e^{-\frac{bvt}{m}}$$

$$a(t) = \frac{dv(t)}{dt}$$

$$= \frac{d}{dt}\left(v_T - (-v_0 + v_T) e^{-\frac{bvt}{m}}\right)$$

$$= 0 - (-v_0 + v_T)\left(-\frac{bv}{m}\right) e^{\frac{bvt}{m}}$$

$$= \frac{bv}{m}(-v_0 + v_T) e^{-\frac{bvt}{m}}$$

$$= -\frac{bv}{m}\left(v_0 + \frac{bv}{m} v_T\right) e^{-\frac{bvt}{m}}$$

$$= \left(\frac{bv}{bv} - \frac{mg}{bv} - \frac{bv}{m} v_0\right) e^{-\frac{bvt}{m}}$$

$$a(t) = \left(-g - \frac{b}{m} v_0\right) e^{-\frac{bvt}{m}}$$

$$v(t) = \frac{dy(t)}{dt}$$

$$\int_{y_0}^{y_t} dy(t) = \int_0^t v(t)\, dt$$

$$y(t) = \int_0^t v_T - (-v_0 + v_T) e^{-\frac{bvt}{m}}$$

$$y(t) = \left[v_T t - (-v_0 + v_T)\left(-\frac{m}{bv}\right) e^{-\frac{bvt}{m}}\right]_0^t$$

$$y(t) = \left[v_T t - (-v_0 + v_T)\left(-\frac{m}{bv}\right) e^{-\frac{bvt}{m}}\right] - \left[(-v_0 - v_T)\left(-\frac{m}{bv}\right)\right]$$

$$y(t) = v_T t - \left(-\frac{m}{bv}\right)(-v_0 + v_T)\left(e^{-\frac{bvt}{m}}\right)$$

$$y(t) = v_T t - \frac{m}{bv}(-v_0 + v_T)\left(1 - e^{-\frac{bvt}{m}}\right)$$

$$y(t) = V_T t - \frac{M}{bm}(-V_0 - V_T)\left(1 - e^{-\frac{bvt}{m}}\right)$$

$$V(t) = V_T - (-V_0 + V_t)\, e^{\frac{bvt}{m}}$$

$$a(t) = \left(-g - \frac{bv}{m} V_0\right) e^{-\frac{bvt}{m}}$$

Diaproksimasi

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots$$

$$e^{-\frac{bvt}{m}} \sim 1 - \frac{bvt}{m} + \frac{1}{2}\left(\frac{bvt}{m}\right)^2 + \cdots$$

$$y(t) = V_T t - \frac{m}{bv}(-V_0 - V_T)\left(1 - e^{-\frac{bvt}{m}}\right)$$

$$y(t) = V_T t - (-V_0 + V_T)\left(t - \tfrac{1}{2}\frac{bv}{m} t^2\right)$$

$$y(t) = V_0 t + \frac{1}{2}\frac{bv}{m} V_0 t^2 + \frac{1}{2}\frac{bv}{m}\left(\frac{-mg}{bv}\right) t^2$$

$b = 0$

$$y(t) = V_0 t - \frac{1}{2} g t^2$$

$$V(t) = V_T - (-V_0 + V_T)\, e^{-\frac{bvt}{m}}$$

$$V(t) = V_T - (-V_0 + V_T)\left(1 - \left(-\frac{bvt}{m}\right)\right)$$

$$V(t) = V_0 + \frac{bv}{m} V_0 t - gt$$

$b = 0$

$$V(t) = V_0 - gt$$

$$a(t) = \left(-g - \frac{bv}{m} V_0\right) e^{-\frac{bvt}{m}}$$

$$a(t) = \left(-g - \frac{bv}{m} V_0\right)\left(1 - \frac{bvt}{m}\right)$$

$$a(t) = -g + g\frac{bvt}{m} - \frac{bv}{m} V_0 + \frac{b^2 v^2}{m^2} V_0 t$$

$b = 0$

$$V(t) = -g$$