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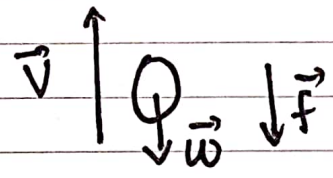
Gerak vertikal keatas dibawah pengaruh gaya gesekan kuadratik : $f = -bv^2$



$$\Sigma f = m \cdot \vec{a}$$
$$-\vec{w} - \vec{f} = m \cdot \vec{a}$$
$$-mg - bv^2 = m.a \qquad | \times \frac{1}{m}$$
$$-g - \frac{b}{m}v^2 = a$$
$$-g - \frac{b}{m}v^2 = \frac{dv}{dt}$$
$$\int_{v_0}^{v(t)} \frac{dv}{-g - \frac{b}{m}v^2} = \int_0^t dt$$

Misalkan : $-g - \frac{b}{m}v^2 = u$

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

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

$$\int_{V_0}^{V(t)} \frac{1}{-g-\frac{b}{m}v^2}\,dv = \int_0^t dt$$

$$\frac{-m}{bv}\ln|u|\Big|_{V_0}^{V(t)} = t$$

$$\frac{-m}{bv}\ln\left[-g-\frac{bv^2}{m}\right]_{V_0}^{V(t)} = t$$

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

$$\frac{-g-\frac{bV(t)}{m}}{-g-\frac{bV_0}{m}} = e^{-\frac{bv^2}{m}}$$

$$-g-\frac{b}{m}V(t) = \left(-g-\frac{b}{m}V_0\right)e^{-\frac{bv^2}{m}}$$

$$V(t) = \left(\frac{-mg}{bv}\right)-\left(\frac{-mg}{bv}-V_0\right)e^{-\frac{bV(t)}{m}}$$

Karena $f = -w$

$bv = mg$

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

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

•) $a(t) = \frac{dV(t)}{dt}$

$$= \frac{d}{dt}\left[V_T-(-V_0+V_T)\,e^{-\frac{bV(t)}{m}}\right]$$

$$= 0-(-V_0+V_T)\left(-\frac{bv}{m}\right)e^{-\frac{bvN}{m}}$$

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

$$= -\frac{bv}{m}\left(V_0+\frac{bv}{m}V_T\right)e^{-\frac{bV(t)}{m}}$$

• $v(t) = \frac{dy(t)}{dt}$

$$\int_0^{y(t)} dy(t) = \int_0^t v(t)\, dt$$

$$y(t) = \int_0^t \left(v_T - (-v_0 + v_T)e^{-\frac{bv(t)}{m}}\right) dt$$

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

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

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

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

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

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

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

Diaproksimasi :

$$e^u = 1 + \frac{u}{1!} + \frac{u^2}{2!} + \frac{u^3}{3!} + \dots$$

$$e^{-\frac{bv(t)}{m}} = 1 - \left(\frac{bv(t)}{m}\right) + \frac{1}{2}\left(\frac{bv(t)}{m}\right)^2 + \dots$$

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

$$y(t) = v_T t - (-v_0 + v_T)\left(t - \frac{1}{2}\frac{bv}{m}t^2\right)$$

$$y(t) = v_0 t + \frac{1}{2}\frac{bv}{m}v_0 t^2 + \frac{1}{2}\frac{bv}{m}\left(-\frac{mg}{bv}\right)t^2$$

Untuk $b = 0$

maka, $y(t) = v_0 t - \frac{1}{2}gt^2$.

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•) $v(t) = V_T - (-V_0 + V_T)\, e^{-\frac{bv(t)}{m}}$

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

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

untuk $b = 0$

maka $v(t) = V_0 - gt$

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

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

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

untuk $b = 0$

maka, $v(t) = -g$.