$$q(t) = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \alpha_3 t^3 \longrightarrow \dot{q}(t) = \alpha_1 + 2\alpha_2 t + 3\alpha_3 t^2$$

$$q(0) = q_0 = \alpha_0 \qquad \dot{q}(0) = \alpha_1$$

$$q(t_f) = q_0 + \alpha_1 t_f + \alpha_2 t_f^2 + \alpha_3 t_f^3 = q_f \qquad \dot{q}(t_f) = \dot{q}_f = \dot{q}(0) + 2\alpha_2 t_f + 3\alpha_3 t_f^2$$

$$\begin{bmatrix} q_0 \\ q_f \\ \dot{q}_0 \\ \dot{q}_f \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & t_f & t_f^2 & t_f^3 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 2t_f & 3t_f^2 \end{bmatrix}}_{A} \begin{bmatrix} \alpha_0 \\ \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix}$$

Si $\dot{q}_0 = \dot{q}_B = 0 \Rightarrow$ $\boxed{a_2 = \frac{3}{h^2} \cdot \Delta q}$

$\Delta q = (q_B - q_0)$

$\boxed{a_3 = -\frac{2}{h^3} \cdot \Delta q}$

5. $\dot{q}_0 = \dot{q}_\beta = 0 \Rightarrow$

$$a_2 = \frac{3}{t_\beta^2} \cdot \Delta q$$

$$\Delta q = (q_\beta - q_0)$$

$$a_0 = q_0$$

$$a_1 = 0$$

$$a_3 = -\frac{2}{t_\beta^3} \cdot \Delta q$$

$\dot{q}_0 = 0 = \dot{q}_f \longrightarrow$ $q(t) = q_i + \frac{3}{t_f^2} \Delta q \cdot t^2 - \frac{2}{t_f^3} \Delta q \, t^3$

$t_g = \text{Sonchronicle}(K_v, K_a)$

$\forall t,\ \dot{q}(t) \leq K_v$

$\dot{q}_{max} \Rightarrow \ddot{q}(t) = 0$

$$\dot{q}(t) = \frac{6}{t_g^2}\Delta q \cdot t - \frac{6}{t_g^3} \cdot t^2 \Delta q$$

$$\ddot{q}(t) = \frac{6}{t_g^2}\Delta q - \frac{12}{t_g^3} t \Delta q$$

Pour $t = \frac{t_g}{2} \Rightarrow \dot{q}\left(\frac{t_g}{2}\right) = \frac{3}{t_g}\Delta q - \frac{3}{2}\frac{\Delta q}{t_g} \leq K_v$

$\frac{\Delta q}{t_g^2} = \frac{2 t \Delta q}{t_g^3} \Rightarrow t = \frac{t_g}{2}$

$$\frac{3}{t_g} \Delta q \left(1 - \frac{1}{2}\right) = K_w$$

$$\frac{3}{2} \frac{\Delta q}{K_w} = t_g$$

$$\forall k,\ \ddot{q}(k) \leq K_a$$

$$\frac{6}{t_s^2}\Delta q = K_a \Rightarrow t_s = \sqrt{\frac{6\Delta q}{K_a}}$$

$$\int_0^{\tau_2} \ddot{q}(t)\,dt = \dot{q}(\tau_2) - \dot{q}(0) = k_v$$

$$k_a \int_0^{\tau_1} dt = \tau_1 k_a$$

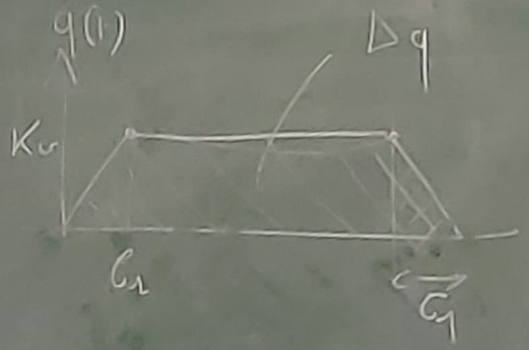
$$\Rightarrow \boxed{\tau_1 = \frac{k_v}{k_a}}$$

$$\int_{\tau_2}^{t_f} \ddot{q}(t)\,dt = \dot{q}(t_f) - \dot{q}(\tau_2) = -k_v$$

$$\dot{q}(t_f) = 0 \qquad \dot{q}(\tau_2) = k_v$$

$$-k_a \int_{\tau_2}^{t_f} dt = -k_a (t_f - \tau_2)$$

$$\Rightarrow \boxed{(t_f - \tau_2) = \frac{k_v}{k_a} = \tau_1}$$



$$\int_0^{t_y} q(t)\,dt = q(t_y) - q(0) = \Delta q$$

$$\Delta q = t_2 \cdot K_v + K_v(t_y - 2t_1)$$

$$\Delta q = K_v t_y - t_1 K_v \Rightarrow$$

$$\boxed{t_y = \frac{\Delta q}{K_v} + \frac{K_v}{K_q}}$$

$0 \le t \le t_1$:

$$\ddot{q}(t) = K_a$$

$$\int_0^t \ddot{q}(s)\,ds = \int_0^t K_a \cdot ds = K_a \cdot t$$

$$= \dot{q}(t) - \dot{q}(0)$$

$$\dot{q}(t) = K_a \cdot t$$

$$\int_0^t \dot{q}(s)\,ds = q(t) - q(0) = \int_0^t K_a \cdot s\,ds = K_a \cdot \frac{t^2}{2}$$

$$q(t) = q(0) + K_a \cdot \frac{t^2}{2}$$

$$t_1 \le t \le t_2$$

$$\dot{q}(t) = 0$$

$$\dot{q}(t) = K_0$$

$$\int_{t_1}^{t} \dot{q}(\tau)\, d\tau = q(t) - q(t_1) = \int_{t_1}^{t} K_0\, d\tau = K_0 (t - t_1)$$

$$\boxed{q(t) = q(t_1) + K_0 (t - t_1)}$$

$$q(t_2) - q(t_1) = (t_2 - t_1)\dot{q}(\tau_2) = -k_a \int_{t_1}^{t_2} q(\tau)\, d\tau$$

$$= -\frac{k_a}{2}(t_2 - t_1)(\tau_3)\dot{q} =$$

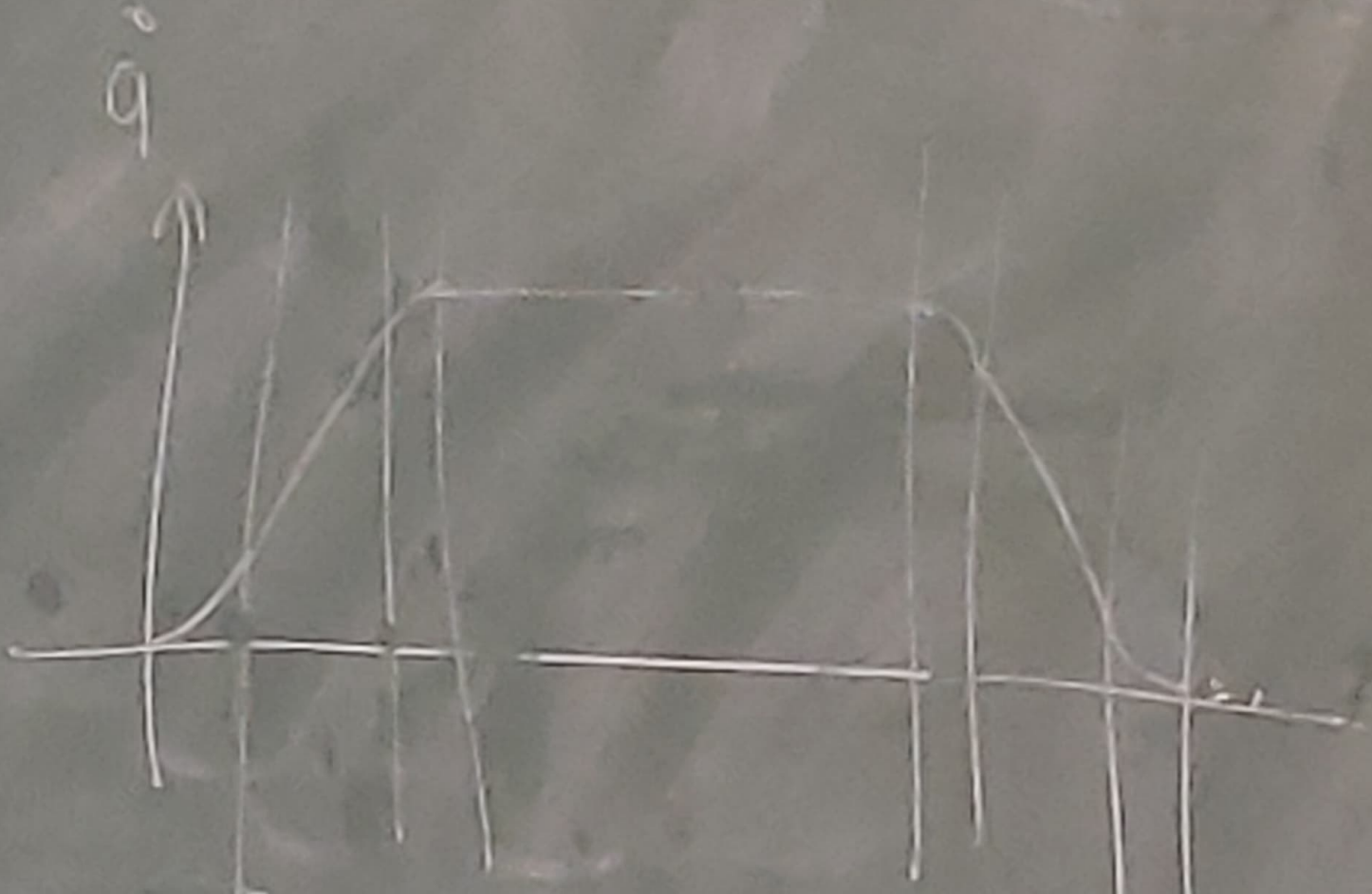
$$\int_{t_1}^{t_2} \dot{q}(\tau)\, d\tau = q(t_2) - q(t_1)$$

$$= -k_a \int_{t_1}^{t_2} q(\tau)\, d\tau = -k_a (t_2 - t_1)$$

$$\boxed{q(t_2) = q(t_1) - k_a (t_2 - t_1)}$$

$$t_1 \le t_2 \le t_3$$

$$\dot{q}(t) = -k_a$$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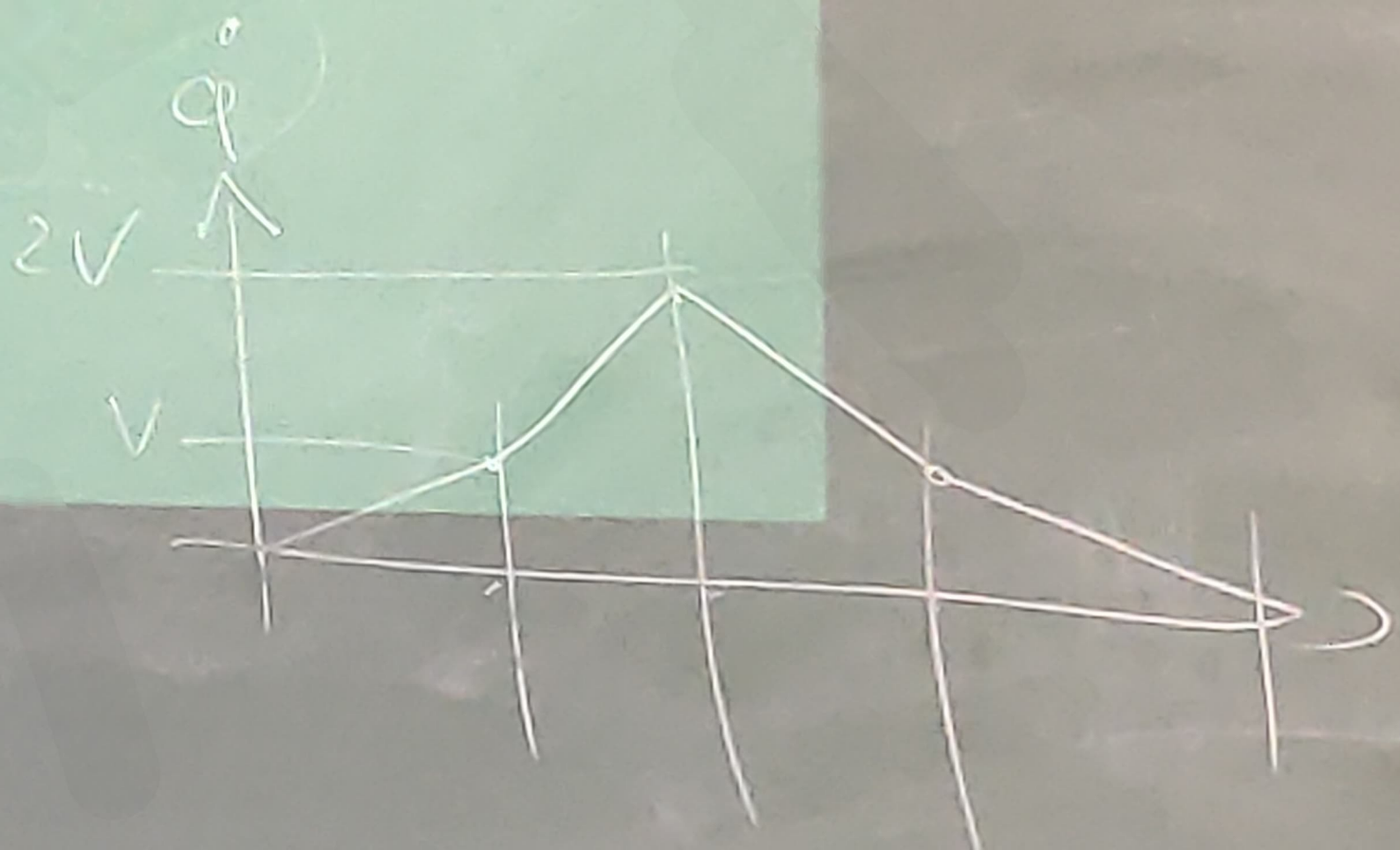
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