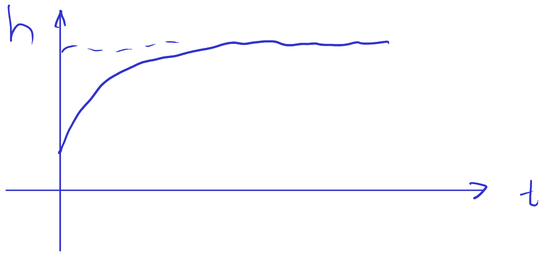
$$\dot{h}(t) = -\overset{1/\tau}{\frac{k}{C}}h(t) + \frac{1}{C}q_i(t) \to \text{ec. dif.} \to \text{simulac (2)}$$

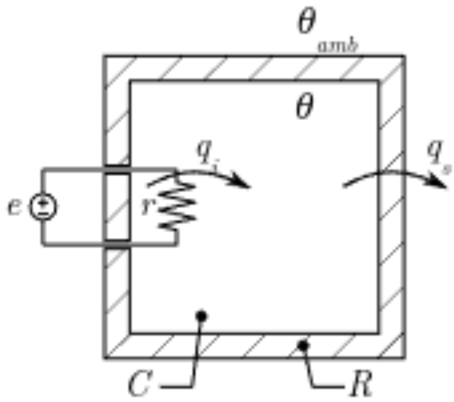
$$h(t) = \frac{U_0}{k} + \left(h_0 - \frac{U_0}{k}\right)e^{-(k/C)t} \to \text{graficar (1)} \checkmark$$



¿valor final? $h(t \to \infty) = \boxed{\frac{U_0}{k}}$

¿tiempo de simulación? $\frac{k}{C} = \frac{1}{\tau} \to \boxed{\tau = \frac{C}{k}}$

Clase 2



$[\theta]$: °C

(1) $q_i - q_s = C\frac{d\theta}{dt}$

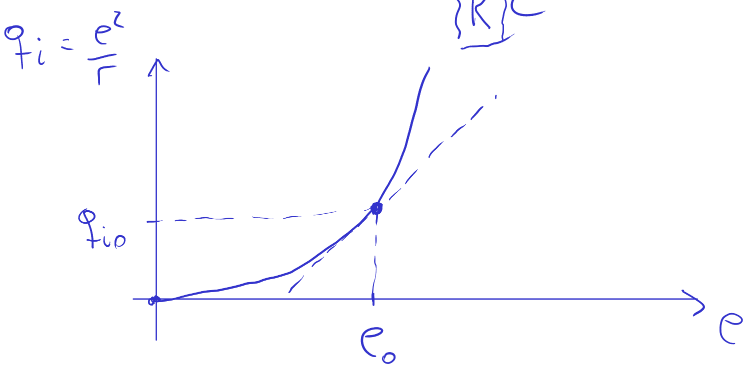
$[q_i]$ = W (watt) = $[q_s]$

(2) $q_i(t) = \frac{\{e(t)\}^2}{r}$

(3) $q_s = \frac{\theta - \theta_{amb}}{R}$

$$C\frac{d\theta}{dt} = -\frac{\theta - \theta_{amb}}{R} + \frac{e^2}{r}$$

$$\dot{\theta}(t) = -\frac{1}{RC}\theta(t) + \frac{1}{RC}\theta_{amb}(t) + \frac{1}{C}\left(\frac{e^2(t)}{r}\right)$$



$\frac{e_0^2}{r}$

$$q_{i\_lin} - q_{io} = \frac{2e_0}{r}(e - e_0)$$

$$q_{i\_lin} = \boxed{\frac{2e_0}{r}(e - e_0) + \frac{e_0^2}{r}}$$

Cerca del punto de op. $q_i \approx q_{i\_lin}$

$$\dot{\theta}(t) = -\frac{1}{RC}\theta(t) + \frac{1}{RC}\theta_{amb}(t) + \frac{1}{rC}e^2(t)$$

q_i

$$\dot{\theta}(t) \simeq -\frac{1}{RC}\theta(t) + \frac{1}{RC}\theta_{amb} + \frac{1}{C}\left[\frac{2e_0}{r}(e - e_0) + \frac{e_0^2}{r}\right]$$

3 Actividades de simulación

3.1 Actividad 2.1

Graficar la evolución de la temperatura $\theta(t)$ en base a la ecuación linealizada, considerando

- temperatura inicial 10°
- temperatura ambiente nula
- tensión de entrada constante $e(t) = e_0$

$$\dot{\theta}(t) = \underbrace{\frac{-1}{RC}}_{a}\theta(t) + \underbrace{\frac{e_0^2}{rC}}_{b}$$

$R = 1 \quad r = 1 \quad C = 1$

$e_0 = 1 \quad \theta_0 = 10$

$$\tau = \frac{1}{1/RC} = RC = 1$$

$t_s = 5\tau$

settling ← 98% Vf.

Modelo de Estados

Sist. de ecs. dif → Ec matricial

$$\dot{\Theta}(t) \simeq -\frac{1}{RC}\Theta(t) + \frac{1}{RC}\Theta_{amb} + \frac{1}{C}\left[\frac{2e_0(e-e_0)}{r} + \frac{e_0^2}{r}\right] \rightarrow \frac{2e_0 e}{r} - \frac{2e_0^2}{r} + \frac{e_0^2}{r}$$

$$\begin{aligned} \dot{x}_1 &= f(x_1, x_2, x_3) + u_1 \\ \dot{x}_2 &= g(x_1, x_2, x_3) + u_2 \\ \dot{x}_3 &= h(x_1, x_2, x_3) + u_3 \end{aligned}$$

$$\underset{\text{vector}}{\dot{x}} = A\,\underset{\text{vector}}{x} + B\,\underset{\text{vector}}{u}$$

matrices

$$\dot{\Theta} \simeq -\frac{1}{RC}\Theta(t) + \frac{1}{RC}\Theta_{amb}(t) + \frac{2e_0}{rC}e(t) - \frac{e_0^2}{rC}$$

. variables de la ec. dif: 1 $\Theta(t)$ → x

. señales externas: 2 "y medio" → Θ_{amb}, $e(t)$, ½ e_0^2/rC (linealización) → u

$x = \Theta$

$$u = \begin{bmatrix} \Theta_{amb}(t) \\ e(t) \\ 1 \end{bmatrix}$$

2.1 No lineal

Ecuación diferencial no-lineal:

$$\dot{\theta}(t) = -\frac{1}{RC}\theta + \frac{1}{RC}\theta_{amb} + \frac{1}{rC}e^2(t)$$

Convirtiendo al modelo de estados:

$$\frac{d}{dt}\left[\theta(t)\right] = \left[-\frac{1}{RC}\right]\left[\theta(t)\right] + \begin{bmatrix}\frac{1}{RC} & \frac{1}{rC}\end{bmatrix}\begin{bmatrix}\theta_{amb}(t) \\ e^2(t)\end{bmatrix}$$

$$y(t) = \theta(t)$$

2.2 Lineal

Ecuación diferencial linealizada:

$$\dot{\theta}(t) = -\frac{1}{RC}\theta + \frac{1}{RC}\theta_{amb} + \frac{2e_0}{rC}(e(t) - e_0) + \frac{e_0^2}{rC}$$

Convirtiendo al modelo de estados:

$$\frac{d}{dt}\left[\theta(t)\right] = \left[-\frac{1}{RC}\right]\left[\theta(t)\right] + \begin{bmatrix}\frac{1}{RC} & \frac{2e_0}{rC} & -\frac{e_0^2}{rC}\end{bmatrix}\begin{bmatrix}\theta_{amb}(t) \\ e(t) \\ 1\end{bmatrix}$$

$$y(t) = \theta(t)$$