

Curso

SISTEMAS Y CONTROL

Clase 17

Fotogramas de los pizarrones de clases filmadas

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Año 2020

Este material fue elaborado como material de apoyo para ser utilizado por los estudiantes de este curso de Ingeniería Eléctrica de la Facultad de Ingeniería, Universidad de la República (UdelaR).

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Clase 17 –

- Respuesta Temporal 4 (Respuesta temporal del Sistema de Parámetros Concentrados a entradas específicas)

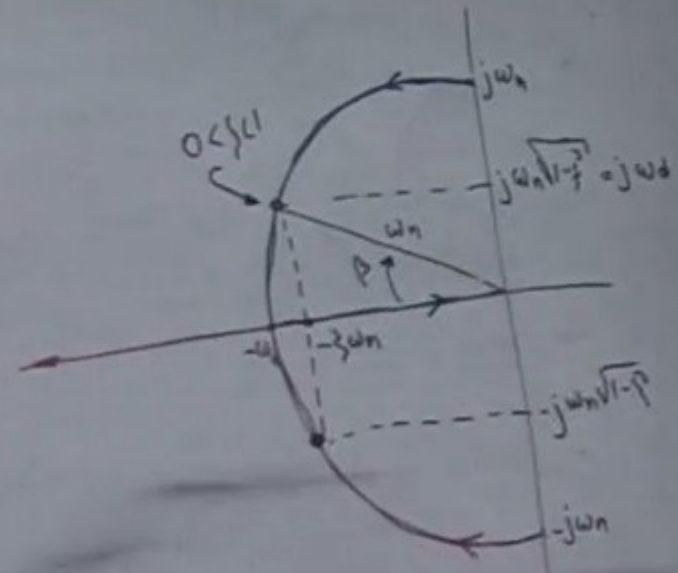
- Sistema de orden 2, respuesta a escalón (cálculo de t_s , t_l , t_d)

Esta clase hace uso de las transparencias, “resp_orden2_mp.pdf”, respuesta_orden2_tl_ts.pdf”

SISTEMA ORDEN 2 - Resp a escalón

$$H(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

$$H(s) = \frac{\omega_n^2 (\alpha s + 1)}{s^2 + 2\zeta\omega_n s + \omega_n^2} \quad \alpha = \frac{1}{\zeta}$$



$$\beta = \arctan \left[\frac{\sqrt{1-\zeta^2}}{\zeta} \right] \quad 0 < \zeta < 1$$

$$\sin \beta = \sqrt{1-\zeta^2}$$

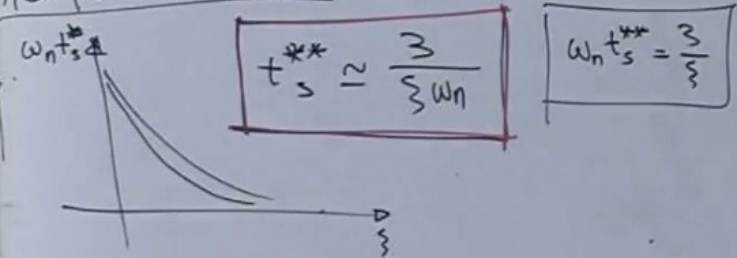
$$y(t) = 1 - \frac{e^{-\zeta \omega_n t}}{\sqrt{1-\zeta^2}} \sin\left(\underbrace{\omega_n \sqrt{1-\zeta^2}}_{\omega_d} t + \arctan\left[\frac{\sqrt{1-\zeta^2}}{\zeta}\right]\right)$$

$$M_p = e^{-\frac{\zeta \pi}{\sqrt{1-\zeta^2}}}$$

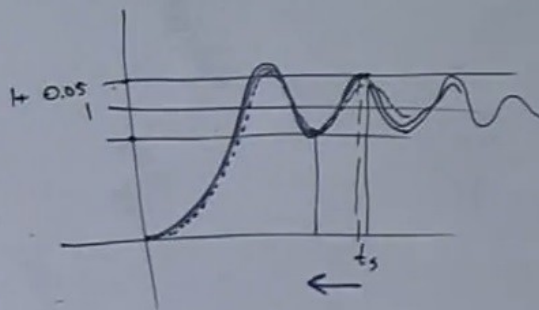
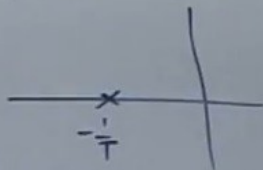
$$t_p = \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n \sqrt{1-\zeta^2}}$$

$$y(t) = 1 - \left(\frac{e^{-\zeta \omega_n t}}{\sqrt{1-\zeta^2}} \right) \underbrace{\sin\left(\underbrace{\omega_n \sqrt{1-\zeta^2}}_{\omega_d} t + \arctan\left[\frac{\sqrt{1-\zeta^2}}{\zeta}\right]\right)}_{\beta}$$

Tempo de assentamento t_s



$$t_s \approx 3T$$

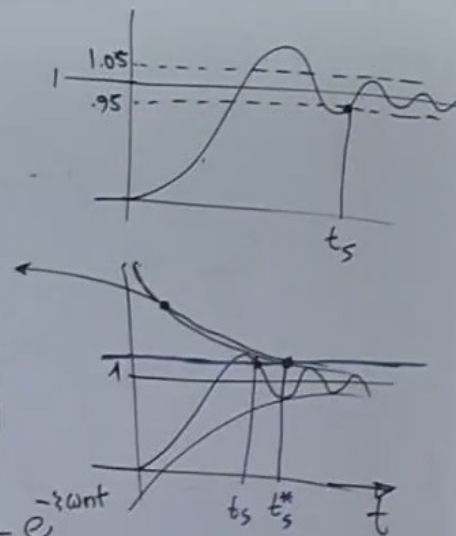


$$t_s^*$$

$$\omega_n t_s^*$$

$$1 + \frac{e^{-\zeta \omega_n t}}{\sqrt{1-\zeta^2}} \leq 0.05$$

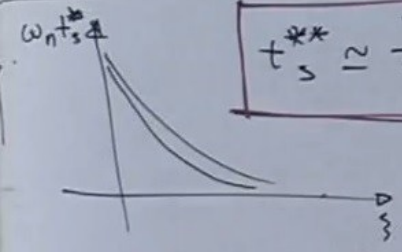
$$e^{-\zeta \omega_n t} \leq 0.05 \sqrt{1-\zeta^2}$$



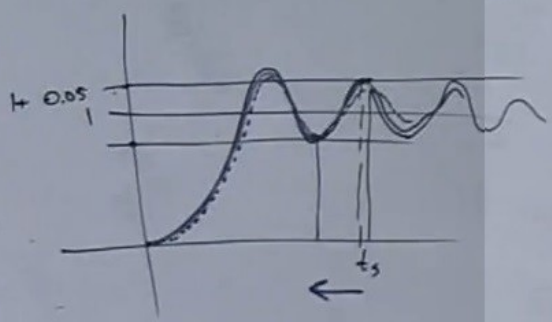
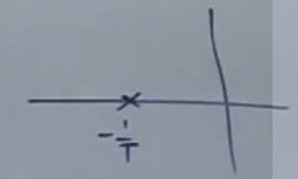
$$y(t) = 1 - \left(\frac{e^{-\zeta \omega_n t}}{\sqrt{1-\zeta^2}} \right) \sin \left(\underbrace{\omega_n \sqrt{1-\zeta^2}}_{\omega_d} t + \arctan \left[\frac{\sqrt{1-\zeta^2}}{\zeta} \right] \right)$$

Tempo de assentamento t_s

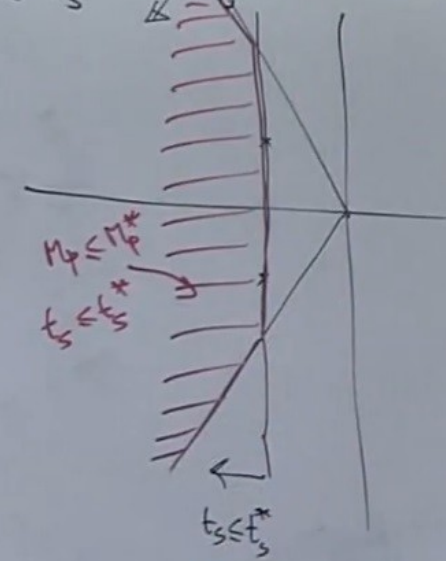
$$t_s^{**} \approx \frac{3}{\zeta \omega_n} \quad \omega_n t_s^{**} = \frac{3}{\zeta}$$



$$t_s \approx 3T$$

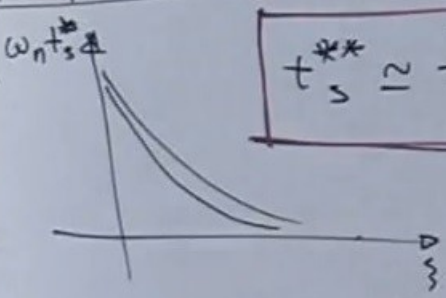


$$M_p \leq M_p^* \quad t_s \leq t_s^*$$



$$y(t) = 1 - \frac{e^{-\zeta \omega_n t}}{\sqrt{1-\zeta^2}} \sin\left(\underbrace{\omega_n \sqrt{1-\zeta^2}}_{\omega_d} t + \arctan\left[\frac{\sqrt{1-\zeta^2}}{\zeta}\right]\right)$$

tiempo de asentamiento t_s



$$t_s^{**} \approx \frac{3}{\zeta \omega_n}$$

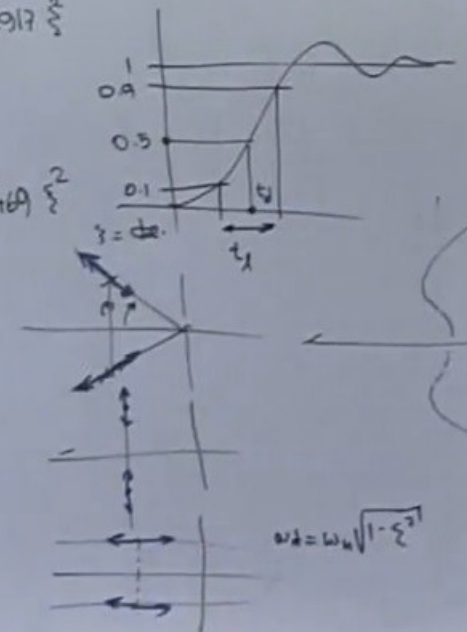
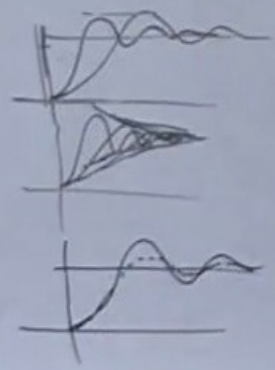
$$\omega_n t_s^{**} = \frac{3}{\zeta}$$

t. de levantamiento

$$t_{r, 10-90\%} \text{ (aprox)} \rightarrow \begin{cases} \omega_n t_{r1} \approx 0.8 + 2.5 \zeta \\ \omega_n t_{r2} \approx 1 - 0.4167 \zeta + 2.917 \zeta^2 \end{cases}$$

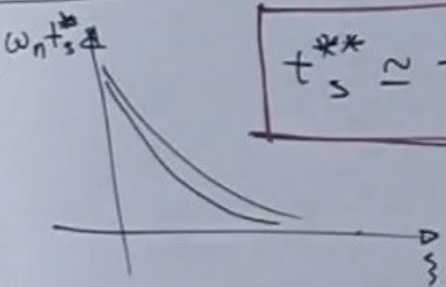
t. de retardo

$$t_d \text{ (aprox)} \rightarrow \begin{cases} \omega_n t_d \approx 1 + 0.7 \zeta \\ \omega_n t_d \approx 1.1 + 0.125 \zeta + 0.469 \zeta^2 \end{cases}$$



$$y(t) = 1 - \frac{e^{-\zeta \omega_n t}}{\sqrt{1-\zeta^2}} \sin\left(\underbrace{\omega_n \sqrt{1-\zeta^2}}_{\omega_d} t + \arctan\left[\frac{\sqrt{1-\zeta^2}}{\zeta}\right]\right)$$

tiempo de asentamiento t_s



$$t_s^{**} \approx \frac{3}{\zeta \omega_n}$$

$$\omega_n t_s^{**} = \frac{3}{\zeta}$$

t. de levantamiento

$t_{r 10-90\%}$

$$\text{(aprox)} \rightarrow \begin{cases} \omega_n t_r \approx 0.8 + 2.5 \zeta \\ \omega_n t_r \approx 1 - 0.4167 \zeta + 2.917 \zeta^2 \end{cases}$$

t. de retardo

t_d (aprox)

$$\rightarrow \begin{cases} \omega_n t_d \approx 1 + 0.7 \zeta \\ \omega_n t_d \approx 1.1 + 0.125 \zeta + 0.469 \zeta^2 \end{cases}$$

