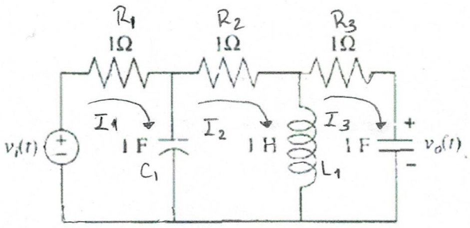
1. Represente la red eléctrica ilustrada en la figura P3.1 en el espacio de estados, donde $v_o(t)$ es la salida.



$$V_o(t) = V_{C_2}(t)$$

$$I_1 = \frac{dq_1(t)}{dt} \; ; \; I_2 = \frac{dq_2(t)}{dt} \; ; \; I_3 = \frac{dq_3(t)}{dt}$$

$$\Rightarrow \quad V_{in}(t) = V_{R_1}(t) + V_{C_1}(t) \quad \Rightarrow V_{in}(t) = R_1 \frac{dq_1(t)}{dt} + \frac{1}{C_1}[q_1(t) - q_2(t)] \;\ldots (1)$$

$$\emptyset = V_{R_2}(t) + V_{L_1}(t) + V_{C_1}(t)$$

$$\emptyset = R_2 \frac{dq_2(t)}{dt} + L_1\left[\frac{d^2q_2(t)}{dt} - \frac{d^2q_3(t)}{dt}\right] + \frac{1}{C_1}\left[q_2(t) - q_1(t)\right] \;\ldots (2)$$

$$\emptyset = V_{R_3}(t) + V_{L_1}(t) + V_{C_2}(t)$$

$$\emptyset = R_3 \frac{dq_3(t)}{dt} + L_1\left[\frac{d^2q_3(t)}{dt} - \frac{d^2q_2(t)}{dt}\right] + \frac{1}{C_2} q_3(t) \;\ldots (3)$$

Variables de estado:

$$x_1(t) = q_1(t) \; ; \; x_2(t) = q_2(t) \; ; \; x_3(t) = \dot{q}_2(t) \; ; \; x_4(t) = q_3(t) \; ; \; x_5(t) = \dot{q}_3(t)$$

$$\dot{x}_1(t) = \dot{q}_1(t) \; ; \; \dot{x}_2(t) = \dot{q}_2(t) = x_3(t) \; ; \; \dot{x}_3(t) = \ddot{q}_2(t) ; \; \dot{x}_4(t) = \dot{q}_3(t) = x_5(t) ; \; \dot{x}_5(t) = \ddot{q}_3(t)$$

Despejando de ec. (1) derivada mayor:

$$\frac{dq_1(t)}{dt} = \frac{V_{in}}{R_1} - \frac{1}{C_1R_1} q_1(t) + \frac{1}{C_1R_1} q_2(t)$$

Sustituyendo valores

$$\boxed{\dot{x}_1 = \frac{V_{in}}{R_1} - \frac{1}{C_1R_1} x_1 + \frac{1}{C_1R_1} x_2} \;\ldots (4)$$

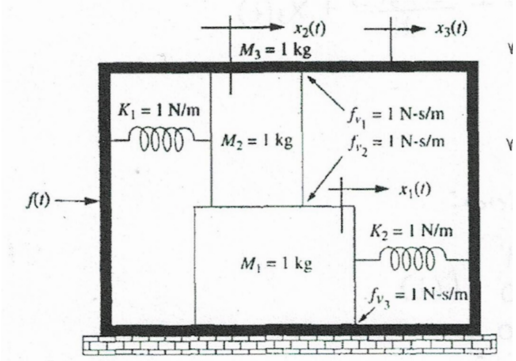
Despejando de ec (2) derivada mayor:

$$\frac{d^2q_2(t)}{dt} = \frac{-R_2}{L_1}\frac{dq_2(t)}{dt} + \frac{L_1}{L_1}\frac{d^2q_3(t)}{dt} - \frac{1}{C_1L_1} q_2(t) + \frac{1}{C_1L_1} q_1(t)$$

Sustituyendo

$$\boxed{\dot{x}_3 = \frac{-R_2}{L_1} x_3 + \dot{x}_5 - \frac{1}{C_1L_1} x_2 + \frac{1}{C_1L_1} x_1} \;\ldots (5)$$

5. Represente el sistema mecánico traslacional que se ilustra en la figura P3.5 en el espacio de estados, donde $x_1(t)$ es la salida.



$f(s) =$

$$m_3: (M_3 s^2 + f_{v_1} s + f_{v_3} s + K_1 + K_2) X_3(s) - (f_{v_1} s + K_1) X_2(s) - (f_{v_3} s + K_2) X_1(s)$$

$$m_2: (m_2 s^2 + f_{v_1} s + f_{v_2} s + k_1) X_2(s) - (f_{v_1} s + K_1) X_3(s) - (f_{v_2} s) X_1(s) = 0$$

$$m_1: (m_1 s^2 + f_{v_2} s + f_{v_3} s + K_2) X_1(s) - (f_{v_2} s) X_2(s) - (f_{v_3} s + K_2) X_3(s) = 0$$

$$f(t) = \frac{d^2 x_3(t)}{dt} + 2\frac{dx_3(t)}{dt} + 2x_3(t) - \frac{dx_2(t)}{dt} - x_2(t) - \frac{dx_1(t)}{dt} - x_1(t) \quad \dots ①$$

$$0 = \frac{d^2 x_2(t)}{dt} + 2\frac{dx_2(t)}{dt} + x_2(t) - \frac{dx_3(t)}{dt} - x_3(t) - \frac{dx_1(t)}{dt} \quad \dots ②$$

$$0 = \frac{d^2 x_1(t)}{dt} + 2\frac{dx_1(t)}{dt} + x_1(t) - \frac{dx_2(t)}{dt} - \frac{dx_3(t)}{dt} - x_3(t) \quad \dots ③$$

Variables de estado:

$a_1(t) = x_1(t)$; $a_2(t) = x_2(t)$; $a_3(t) = x_3(t)$; $a_4(t) = \dot{x}_1(t)$; $a_5(t) = \dot{x}_2(t)$; $a_6(t) = \dot{x}_3(t)$

$\dot{a}_1(t) = \dot{x}_1(t) = a_4$; $\dot{a}_2(t) = \dot{x}_2(t) = a_5(t)$; $\dot{a}_3(t) = \dot{x}_3(t) = a_6(t)$; $\dot{a}_4(t) = \ddot{x}_2(t)$; $\dot{a}_5(t) = \ddot{x}_2(t)$; $\dot{a}_6(t) = \ddot{x}_3(t)$

De ec. ① despejo derivada mayor:

$$\frac{d^2 x_3(t)}{dt} = -2\frac{dx_3(t)}{dt} - 2x_3(t) + \frac{dx_2(t)}{dt} + x_2(t) + \frac{dx_1(t)}{dt} + x_1(t) + f(t)$$

Sustituyendo:

$$\boxed{\dot{a}_6 = -2a_6 - 2a_3 + a_5 + a_2 + a_4 + a_1 + f(t)} \quad \dots ④$$

De ec. ② despejo derivada mayor:

$$\frac{d^2 x_2(t)}{dt} = -2\frac{dx_2(t)}{dt} - x_2(t) + \frac{dx_3(t)}{dt} + x_3(t) + \frac{dx_1(t)}{dt}$$

Sustituyendo

$$\boxed{\dot{a}_5 = -2a_5 - a_2 + a_6 + a_3 + a_4} \quad \dots ⑤$$

De ec. 3 despejo derivada mayor:

$$\frac{d^2 x_1(t)}{dt} = -2\frac{d x_1(t)}{dt} - x_1(t) + \frac{d x_2(t)}{dt} + \frac{d x_3(t)}{dt} + x_3(t)$$

Sustituyendo

$$\boxed{a_4 = -2a_4 - a_1 + a_5 + a_6 + a_3} \quad \ldots \text{ⓖ}$$

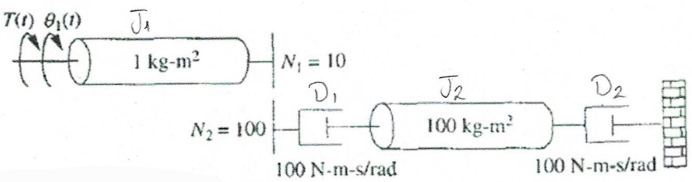
La matriz represendo 4, 5, 6

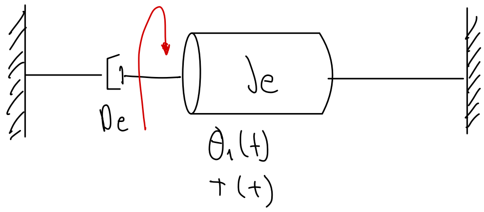
$$\begin{vmatrix} \dot{a}_6 \\ \dot{a}_5 \\ a_4 \end{vmatrix} = \begin{vmatrix} 1 & 1 & -2 & 1 & 1 & -2 \\ 0 & -1 & 1 & 1 & -2 & 1 \\ -1 & 0 & 1 & -2 & 1 & 1 \end{vmatrix} \begin{vmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \end{vmatrix} + \begin{vmatrix} 1 \\ 0 \\ 0 \end{vmatrix} f(t)$$

Salida: $X_1(t)$

$$X_1 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{vmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \end{vmatrix}$$

6. Represente el sistema mecánico traslacional que se ilustra en la figura P3.6 en el espacio de estados, donde $\theta_1(t)$ es la salida.





$$J_e = J_1 + J_2\left(\frac{N_1}{N_2}\right)^2 \qquad D_e = D_1\left(\frac{N_1}{N_2}\right)^2 + D_2\left(\frac{N_1}{N_2}\right)^2$$

$$J_e = 1 + 100\left(\frac{10}{100}\right)^2 \qquad D_e = 100\left(\frac{10}{100}\right)^2 + 100\left(\frac{10}{100}\right)^2$$

$$\boxed{J_e = 2} \qquad \boxed{D_e = 2}$$

$$\Rightarrow T(s) = (J_e s^2 + D_e s)\,\theta_1(s) \qquad \Rightarrow T(t) = J_e \frac{d^2\theta_1(t)}{dt} + D_e \frac{d\theta_1(t)}{dt} \quad \ldots ①$$

Variables de estado

$$x_1(t) = \theta_1(t)\ ;\ x_2(t) = \dot{\theta}_1(t)$$

$$\dot{x}_1(t) = \dot{\theta}_1(t) = x_2(t)\ ;\ \dot{x}_2(t) = \ddot{\theta}_1(t)$$

De ec ① despe. derivada mayor.

$$\frac{d^2\theta_1(t)}{dt} = \cancel{\frac{-D_e}{J_e}}^{\,1} \frac{d\theta_1(t)}{dt} + \frac{T(t)}{J_e}$$

Sustituyendo:

$$\boxed{\dot{x}_2 = -x_2 + \frac{T(t)}{J_e} = -x_2 + \frac{1}{2}T(t)}$$

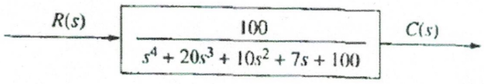
Realizando matriz

$$\boxed{\begin{vmatrix} \dot{x}_1 \\ \dot{x}_2 \end{vmatrix} = \begin{vmatrix} 0 & 1 \\ 0 & -1 \end{vmatrix} \begin{vmatrix} x_1 \\ x_2 \end{vmatrix} + \begin{vmatrix} 0 \\ 0.5 \end{vmatrix} T(t)}$$

Donde la salida : $\theta_1(t)$

$$\boxed{\theta_1 = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{vmatrix} x_1 \\ x_2 \end{vmatrix}}$$

9. Encuentre la representación en el espacio de estados en forma de las variables de fase para cada uno de los sistemas que se muestran en la figura P3.8.



a)

$$\frac{C(s)}{R(s)} = \frac{100}{s^4 + 20s^3 + 10s^2 + 7s + 100}$$

$$100\,R(s) = (s^4 + 20s^3 + 10s^2 + 7s + 100)\,C(s)$$

Suponiendo condiciones iniciales = 0:

$$100\,r = \ddddot{c} + 20\,\dddot{c} + 10\,\ddot{c} + 7\,\dot{c} + 100\,c \quad \ldots (1)$$

Variable de estado:

$$x_1 = c\ ;\ x_2 = \dot{c}\ ;\ x_3 = \ddot{c}\ ;\ x_4 = \dddot{c}$$

$$\dot{x}_1 = \dot{c} = x_2\ ;\quad \dot{x}_2 = \ddot{c} = x_3\ ;\quad \dot{x}_3 = \dddot{c} = x_4\ ;\quad \dot{x}_4 = \ddddot{c}$$

De (1) desp derivada mayor:

$$\ddddot{c} = 100\,r - 20\,\dddot{c} - 10\,\ddot{c} - 7\,\dot{c} - 100\,c$$

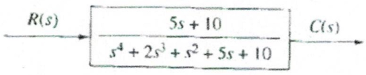
Sustituyendo:

$$\dot{x}_4 = 100\,r - 20\,x_4 - 10\,x_3 - 7\,x_2 - 100\,x_1 \quad \ldots (1)$$

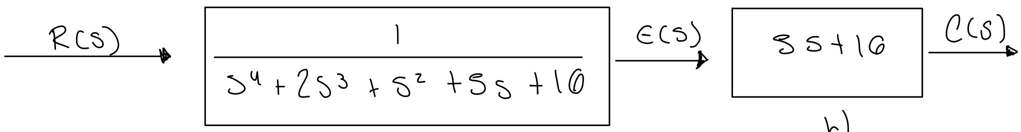
Armando matriz con

$$\boxed{\begin{vmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \end{vmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -100 & -7 & -10 & -20 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} + \begin{vmatrix} 0 \\ 0 \\ 0 \\ 100 \end{vmatrix} r}$$

11. Para cada sistema que se ilustra en la figura P3.9, escriba las ecuaciones de estado y la ecuación de salida para la representación de las variables de fase.



a)



a) b)

Resolviendo a):

$$\frac{E(S)}{R(S)} = \frac{1}{S^4 + 2S^3 + S^2 + 5S + 10} \Rightarrow R(S) = E(S)(S^4 + 2S^3 + S^2 + 5S + 10)$$

$$r = \ddddot{e} + 2\dddot{e} + \ddot{e} + 5\dot{e} + 10e \quad \ldots (1)$$

Variables de estado:

$$X_1 = e \;;\; X_2 = \dot{e} \;;\; X_3 = \ddot{e} \;;\; X_4 = \dddot{e}$$

$$\dot{X}_1 = \dot{e} = X_2 \;;\; \dot{X}_2 = \ddot{e} = X_3 \;;\; \dot{X}_3 = \dddot{e} = X_4 \;;\; \dot{X}_4 = \ddddot{e}$$

De ec (1) despe. derivada mayor

$$\ddddot{e} = r - 2\dddot{e} - \ddot{e} - 5\dot{e} - 10e$$

Sustituyendo

$$\boxed{\dot{X}_4 = r - 2X_4 - X_3 - 5X_2 - 10X_1}$$

Matriz:

$$\boxed{\begin{vmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \\ \dot{X}_4 \end{vmatrix} = \begin{vmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -10 & -5 & -1 & -2 \end{vmatrix} \begin{vmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{vmatrix} = \begin{vmatrix} 0 \\ 0 \\ 0 \\ 1 \end{vmatrix} r}$$

b)

$$\frac{C(S)}{E(S)} = 5S + 10 \Rightarrow C(S) = E(S)(5S + 10)$$

$$\Rightarrow c = 5\dot{e} + 10e$$

$X_1 = e$
$X_2 = \dot{e}$

Sustituyendo

$$y = c = 5X_2 + 10X_1 \Rightarrow y = [10 \;\; 5 \;\; 0 \;\; 0] \begin{vmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{vmatrix}$$

14. Encuentre la función de transferencia, $G(s) = Y(s)/R(s)$, para cada uno de los siguientes sistemas representados en el espacio de estados.

a)
$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -5 \end{bmatrix}\mathbf{x} + \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix} r$$

$$y = [1 \quad 0 \quad 0]\mathbf{x}$$

$$(SI - A)^{-1} = \frac{adj(SI - A)}{det(SI - A)}$$

$$T(s) = \frac{Y(s)}{U(s)} = C(SI - A)^{-1} B + D$$

$$(SI - A) = \begin{vmatrix} s & 0 & 0 \\ 0 & s & 0 \\ 0 & 0 & s \end{vmatrix} - \begin{vmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & 2 & -5 \end{vmatrix} = \begin{vmatrix} s & -1 & 0 \\ 0 & s & -1 \\ 3 & -2 & s+5 \end{vmatrix}$$

$$Adj(SI - A) \longrightarrow \begin{bmatrix} s(s+5)-2 & s+5 & 1 \\ -3 & s(s+5) & s \\ -3s & 2s-3 & s^2 \end{bmatrix} \qquad Det(SI - A) \rightarrow s[s(s+5)-2]+3$$

Sustituyendo

$$T(s) = C(SI - A)^{-1} B + D$$

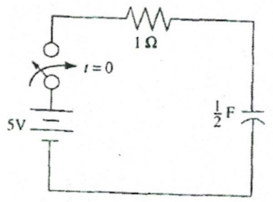
$$T(s) = [1 0 0]\,(SI - A)^{-1} \begin{vmatrix} 0 \\ 0 \\ 10 \end{vmatrix} + 0 = \frac{10}{s[s(s+5)-2]} = \frac{10}{s[s^2+5s)-2]+3}$$

$$\frac{10}{s^3 + 5s^2 - 2s + 3}$$

$\Rightarrow$

$$\boxed{T(s) = \frac{10}{s3 + 5s^2 - 2s + 3}}$$

4. Encuentre el voltaje del capacitor de la red que se ilustra en la figura P1.2, si el interruptor se cierra en $t = 0$. Suponga condiciones iniciales cero. También encuentre la constante de tiempo, tiempo de levantamiento, y tiempo de asentamiento para el voltaje del capacitor.



$$0 = V_c(t) + V_R(t) \Rightarrow 0 = V_c(t) + RC\frac{dV_c(t)}{dt}$$

$$\frac{1}{RC}V_c(t) + \frac{dV_c(t)}{dt} = 0 \Rightarrow \frac{dV_c(t)}{dt} = -\frac{1}{RC}V_c(t)$$

$$\int_{V_e}^{V_c} \frac{dV_c(t)}{dt} = \int_0^t -\frac{1}{Rc}\,dt \Rightarrow \ln(V_c(t))\Big|_{V_e}^{V_c} = -\frac{1}{RC}t\Big|_0^t$$

$$\ln(V_c(t) - V_e(t)) = -\frac{1}{RC}t \Rightarrow \ln\left(\frac{V_c(t)}{V_e(t)}\right) = -\frac{1}{RC}t$$

$$\frac{V_c(t)}{V_e(t)} = e^{-1/RCt} \Rightarrow V_c(t) = V_e(t)\,e^{-1/RCt} \Rightarrow V_c = 5e^{-1/as\,t}$$

$$\boxed{V_c = 5e^{-2t}} \Rightarrow \mathcal{L}[V_c] = \frac{5}{s+2}$$

Donde la cte. de tiempo.
$T = RC = (1)(0.5) = \boxed{0.5(s)}$

Pendiente inicial (a) $= \frac{1}{T} = \frac{1}{0.5} = \boxed{2}$

Tiempo de asentamiento (Ts) $= \frac{4}{a} = \frac{4}{2} = \boxed{2[s]}$

Tiempo de levantamiento (Tr) $= \frac{2.2}{a} = \frac{2.2}{2} = \boxed{1.1[s]}$

23. Para cada par de especificaciones de sistema de segundo orden que siguen, encuentre la posición del par de polos de segundo orden.

b) $\%OS = 17\%$; $T_p = 0.5$ segundos

$$\rho = \frac{-\ln\left(\frac{\%OS}{100}\right)}{\sqrt{\pi^2 + \ln^2\left(\frac{\%OS}{100}\right)}} = \frac{-\ln\left(\frac{17}{100}\right)}{\sqrt{\pi^2 + \ln^2\left(\frac{17}{100}\right)}} = 0.4913$$

$$T_p = \frac{\pi}{W_n\sqrt{1-\rho^2}} \Rightarrow W_n = \frac{\pi}{T_p\sqrt{1-\rho^2}} = \frac{\pi}{0.5\,(1-0.4913^2)}$$

$W_n = 7.213718$

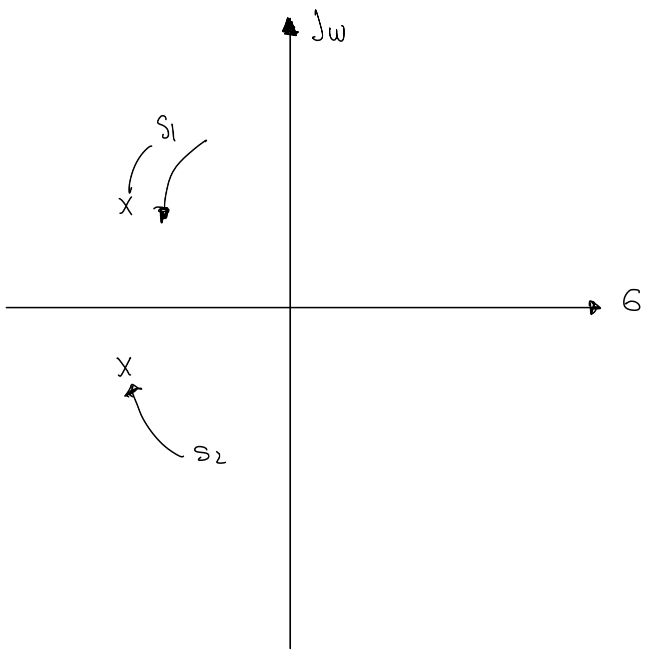
$W_d = W_n\sqrt{1-\rho^2} = 6.283185$

$\rho W_n = (0.4913)(7.213718) = 3.5439$

$j W_d = (6.283185)$

$\Rightarrow$

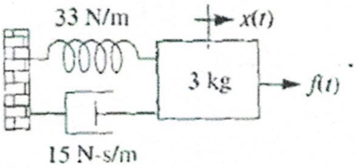
$$\boxed{\begin{array}{l} P_1 = -3.5439 + 6.283185 \\ P_2 = -3.5439 - 6.283185 \end{array}}$$



25. Para el sistema que se ilustra en la figura P4.7, haga lo siguiente:

a) Encuentre la función de transferencia $G(s) = X(s)/F(s)$.

b) Encuentre ζ, ω_n, $\%OS$, T_s, T_p, T_r.



a) $F(s) = (ms^2 + f_v s + K)\,X(s)$

$$\frac{X(s)}{F(s)} = \frac{1}{ms^2 + f_v s + k}$$

$$\boxed{\frac{X(s)}{F(s)} = \frac{1/m}{s^2 + \frac{f_v}{m}s + \frac{k}{m}}}$$

b) $\omega_n^2 = k/m \Rightarrow \omega_n = \sqrt{k/m} = \sqrt{33/3} \Rightarrow \omega_n = 3.317$

$2\zeta\omega_n = \frac{f_v}{m} = \frac{15}{3} \Rightarrow \zeta = \frac{5}{3.317(2)} = 0.754$

$\%OS = e^{-(\zeta\pi/\sqrt{1-\zeta^2})} \times 100 = e^{-(0.754\pi)/\sqrt{1-0.754^2}} \times 100 = 2.716\%$

$T_s = \frac{4}{\zeta\omega_n} = \frac{4}{(0.754)(3.317)} \Rightarrow \boxed{T_s = 1.6}$

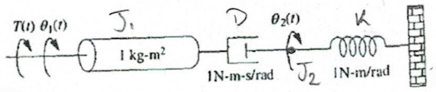
$T_p = \frac{\pi}{(3.317)\sqrt{1-(0.754^2}} \Rightarrow \boxed{T_p = 1.442}$

$$\boxed{G(s) = \frac{K}{s^2 + 2\zeta\omega_n s + \omega_n^2}}$$

26. Para el sistema que se ilustra en la figura P4.8, se aplica un par tipo escalón en $\theta_1(t)$. Encuentre

a) La función de transferencia, $G(s) = \theta_2(s)/T(s)$.

b) El sobrepaso en porcentaje, tiempo de asentamiento y tiempo pico para $\theta_2(t)$.



$$T(s) = (J_1 s^2 + Ds)\,\theta_1(s) - Ds\,\theta_2(s)$$

$$0 = (\cancel{J_2}^{0} s^2 + Ds\, k)\,\theta_2(s) - Ds\,\theta_1(s)$$

De ② despejo $\theta_1(s)$

$$\theta_1(s) = \frac{(Ds + k)\,\theta_2(s)}{Ds} \quad \ldots ③$$

Sust ec. ③ en ①

$$T(s) = (J_1 s^2 + Ds)\,\frac{(Ds + k)\,\theta_2(s)}{Ds} - Ds\,\theta_2(s)$$

Sustituyendo:

$$T(s) = (s^2 + s)\,\frac{(s+1)\,\theta_2(s)}{s} - s\,\theta_2(s) \longrightarrow T(s) = (s^2 + s)\left(\theta_2(s) + \frac{\theta_2(s)}{s}\right) - s\,\theta_2(s)$$

$$T(s) = (s^2 + s + 1)\,\theta_2(s)$$

$$\Rightarrow \boxed{G(s) = \frac{\theta_2(s)}{T(s)} = \frac{1}{s^2 + s + 1}}$$

b) $W_n^2 = 1 \Rightarrow W_n = 1$

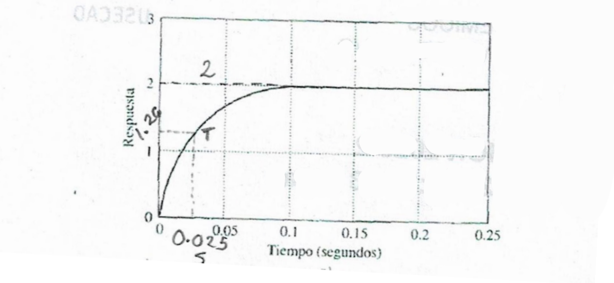
$$2\zeta W_n = 1 \longrightarrow \zeta = \frac{1}{2(1)} \Rightarrow \zeta = \frac{1}{2}$$

$$\%OS = e^{-(0.5\pi)/\sqrt{1-0.5^2}} \times 100 = 16.303\%$$

$$T_s = \frac{4}{\zeta W_n} = \frac{4}{(0.5)(1)} \Rightarrow T_s = 8$$

$$T_p = \frac{\pi}{W_n\sqrt{1-\zeta^2}} = \frac{\pi}{(1)\sqrt{1-0.5^2}} \Rightarrow T_p = 3.628$$

29. Para cada una de las respuestas escalón unitario que se muestran en la figura P4.9, encuentre la función de transferencia del sistema.



1^{er} orden

$$G(s) = \frac{k}{s+a}$$

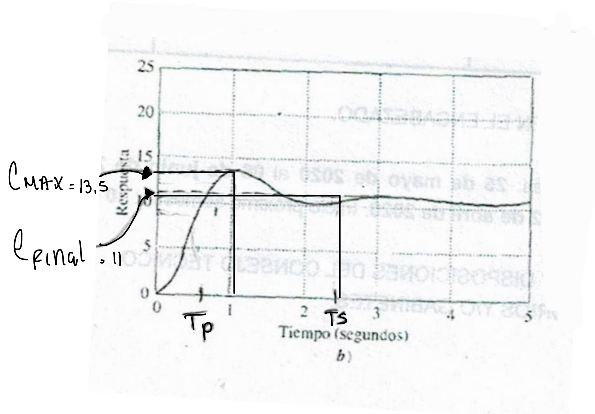
T = cte. t = 63% del valor final

$T = (0.63)(2) = 1.26 \approx 0.025 s$ Partiendo de gráfica

$$a = \frac{1}{T} = \frac{1}{0.025 s} = 40$$

k/a = Valor más alto. $\frac{k}{a} = 2 \Rightarrow k = 2a = 2(40) = 80$

$$\therefore G(s) = \frac{80}{s+40}$$



Tp - 0.90 final

$Tp = 0.90(11) = 9.9$

Ts = 0.98 C_{final}

$Ts = 0.98(11) = 10.78$

$\%OS = (C_{MAX} - C_{FINAL})/C_{FINAL}$

$\%OS = (13.5 - 11)/11$

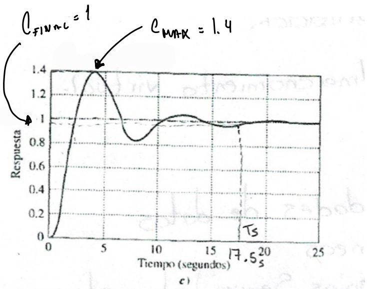
$\%OS = 22.727\%$

$$\zeta = \frac{-\ln(22.727/100)}{\sqrt{\pi^2 + \ln^2(22.727/100)}} = 0.427$$

$$T_s = \frac{4}{\zeta W_n} \Rightarrow W_n = \frac{4}{T_s \zeta} = \frac{4}{(0.427)(2.5 s)} = 3.747$$

$$\frac{K}{W_n^2} = C_{FINAL} \Rightarrow k = 11(3.747)^2 = 154.44$$

$$\therefore G(s) = \frac{K}{s^2 + 2\zeta W_n s + W_n^2} = \frac{154.44}{s^2 + 3.2 s + 14.04}$$



$$T_s = 0.98\,C_{FINAL} = \underline{0.98}$$

$$T_s = 17.5\,[s]$$

$$\%\,OS = (1.4-1)/1 = \underline{40\%}$$

$$\zeta = \frac{-\ln(40/100)}{\sqrt{\pi^2 + \ln^2(40/100)}} = \underline{0.276}$$

$$W_n = \frac{4}{(0.270)(17.5\,[s])} = \underline{0.847}$$

$$K = (1)(0.847)^2 = \underline{0.717}$$

$$\therefore\ G(s) = \frac{K}{s^2 + 2\zeta W_n s + W_n^2} = \frac{0.717}{s^2 + 0.457\,s + 0.717}$$