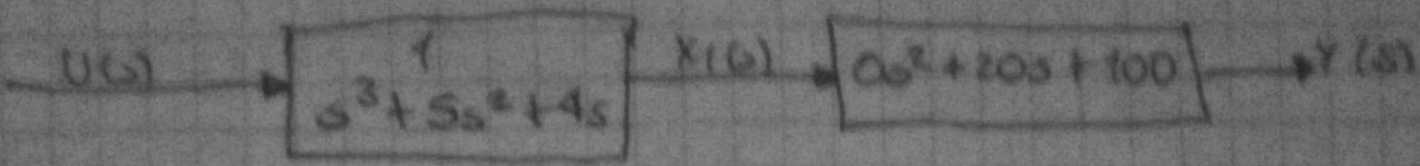
$$G(s) = \frac{20(s+2)}{s(s+1)(s+4}$$

$0,5\% = 9,5\%$.

$t_s = 0,74s$



$$\frac{X_1(s)}{U(s)} = \frac{1}{s^3+5s^2+4s}$$

$(s^3+5s^2+4s)X_1(s) = U(s) \quad ; \quad \dddot{x}_1 + 5\ddot{x}_1 + 4\dot{x}_1 = u$

$X_1(s) = x_1 \quad ; \quad x_2 = \dot{x}_1 \quad ; \quad \dot{x}_2 = \ddot{x}_1 \qquad \dot{x}_3 = \dddot{x}_1$

$\dot{x}_3 = -5x_3 - 4x_2 + u$

$Y(s) = (b_2s^2 + b_1s + b_0)X_1(s)$

$= (0s^2 + 20s + 100)X_1(s)$

$= (20s + 100)X_1(s)$

$20\dot{x}_1 + 100x_1 \Rightarrow 20x_2 + 100x_1$.

$y = 20x_2 + 100x_1$

$$\begin{matrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{matrix} = \begin{vmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -4 & -5 \end{vmatrix} \begin{matrix} x_1 \\ x_2 \\ x_3 \end{matrix} + \begin{vmatrix} 0 \\ 0 \\ 1 \end{vmatrix} u$$

$$y = |100 \quad 20 \quad 0| \begin{vmatrix} x_1 \\ x_2 \\ x_3 \end{vmatrix}$$

$$0{,}095 = e^{-\left(\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right)}$$

$$\ln(0{,}095) = \ln e^{-\left(\zeta\pi / \sqrt{1-\zeta^2}\right)}$$

$$-2{,}3539 = \frac{\zeta\pi}{\sqrt{1-\zeta^2}}$$

$$5{,}54 - 5{,}54\zeta^2 = \zeta^2\pi^2$$

$$5{,}54 = \zeta^2(\pi^2 + 5{,}54)$$

$$\zeta = \sqrt{\frac{5{,}54}{\pi^2 + 5{,}54}}$$

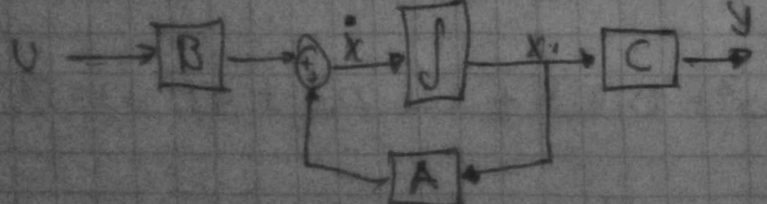
$$\zeta = 0{,}5996$$

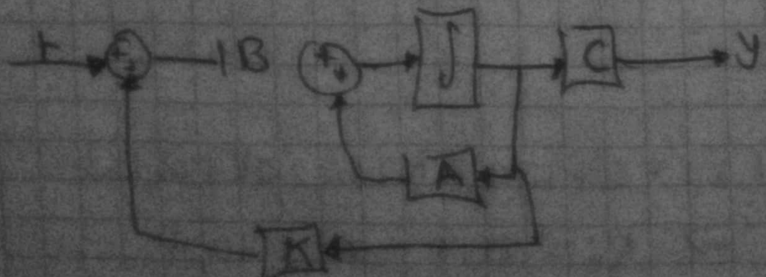
$\theta = 53{,}16°$ $\quad t_s = 0{,}74$; $\quad t_s = \frac{4}{\sigma}$

$\sigma = \frac{4}{0{,}74} = 5{,}405$ $\quad \sigma = \zeta\omega_n$ $\quad \omega_n = 9{,}02 \ rad/s$

$\tan\theta = \frac{\omega_d}{\sigma} \Longleftrightarrow \omega_d = \tan(53{,}16)(5{,}4) = 7{,}21$

$\dot{x} = Ax + Bu$ $\quad y = Cx$





$\dot{x} = Ax + Bu \rightarrow \dot{x} = Ax + B(-Kx + r)$

$\dot{x} = -BKx + Br + Ax \longrightarrow \dot{x} = (A - BK)x + Br$

$$\begin{vmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{vmatrix} = \begin{vmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -4 & -5 \end{vmatrix} \begin{vmatrix} x_1 \\ x_2 \\ x_3 \end{vmatrix} + \begin{vmatrix} 0 \\ 0 \\ 1 \end{vmatrix} u$$

$$y = \begin{vmatrix} 100 & 20 & 0 \end{vmatrix} \begin{vmatrix} x_1 \\ x_2 \\ x_3 \end{vmatrix}$$

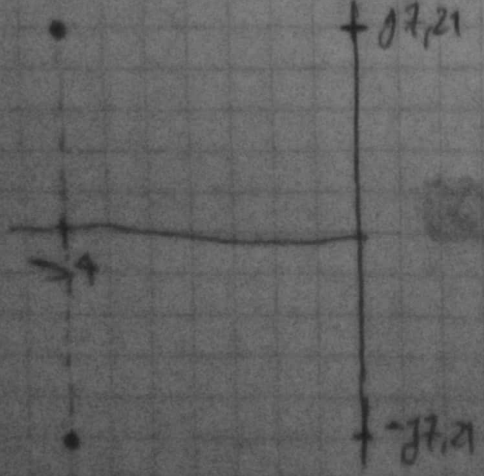
$\dot{x}_3 = -4x_2 - 5x_3 + u$

$= -4x_2 - 5x_3 - K_3x_3 - K_2x_2 - K_1x_1 + r$

$= -K_1x_1 - (4 + K_2)x_2 - (5 + K_3)x_3 + r$

$$\begin{vmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{vmatrix} = \begin{vmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -K_1 & -(4+K_2) & -(5+K_3) \end{vmatrix} \begin{vmatrix} x_1 \\ x_2 \\ x_3 \end{vmatrix} + \begin{vmatrix} 0 \\ 0 \\ 1 \end{vmatrix} r$$

$\det((sI - (A - BK)) = s^3 + (5 + K_3)s^2 + (4 + K_2)s + K_1 = 0$



$(s + 5,4 + j7,2)(s + 5,4 + j7,2)$
$(s + 5,1)$

$s^3 + 15,9s^2 + 136,22s + 413,83 = 0$

$s^3 + (5 + K_3)s^2 + (4 + K_2)s + K_1 = s^3 + 15,9s^2 + 136,22s + 413,83$

$(5 + K_3)s^2 = 15,9s^2 \Rightarrow K_3 = 15,9 - 5 = 10,9$

$(4 + K_2)s = 136,22s \Rightarrow K_2 = 136,22 - 4 = 132,22$

$K_1 = 413,83$