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- Exercícios 12/11 -

1- $G_1(s) = \dfrac{s^2+5s+25}{s(s^3+7,4s^2+76s+320)} = ①$

$\Rightarrow G_1(\omega j) = \dfrac{25\left(1-\left(\frac{\omega}{5}\right)^2+\frac{\omega}{5}j\right)}{s\cdot 320\left(\frac{\omega j}{5}+1\right)\left(1-\left(\frac{\omega}{8}\right)^2+0,0375\cdot\omega j\right)}$

Constante de Bode:

$k_b = \dfrac{25}{320} = \dfrac{5}{64} \Rightarrow 20\log\left|\dfrac{5}{64}\right| \equiv -22,14\ dB$

Fase: $0°$ $(k_B > 0)$

Par de zeros qdo: $\omega_{n_2} = 5\ rad/s$ | $\zeta_2 = \dfrac{\omega_n}{10} = 0,5$

Pico: $\omega_{r_2} = \omega_n\sqrt{1-2\zeta^2} = 3,5\ rad/s$

$M_{r_2} = (2\zeta\sqrt{1-\zeta^2})^{-1} \equiv 1,15 \Rightarrow 1,25\ dB$

Se $\omega >> \omega_{n_2}$:

Por década: aumento de 40 dB | Na fase: $+180°$

Se o termo integrador $\frac{1}{s}$:

Por década: decai 20 dB | Na fase: $-90°$

Se o polo real é em -5: (para $\omega_{p_1} > 5\ rad/s$)

Por década: decai 20 dB | Na fase: $-90°$

Par de polos complexos:

$\omega_{n_{pr}} = 5\ rad/s$ | $\zeta = 0,15$

$\omega_{r_p} = \omega_n \sqrt{1-2\zeta^2} = 7,8\ rad/s$ | $M_r = \left(2\zeta\sqrt{1-\zeta^2}\right)^{-1} \cong 3,37$

$\Rightarrow 10,55\ dB$

Se $\omega >> \omega_{n_p}$:

Por década: decai 40 dB | Na fase: $-180°$

Diagrama de ganho:

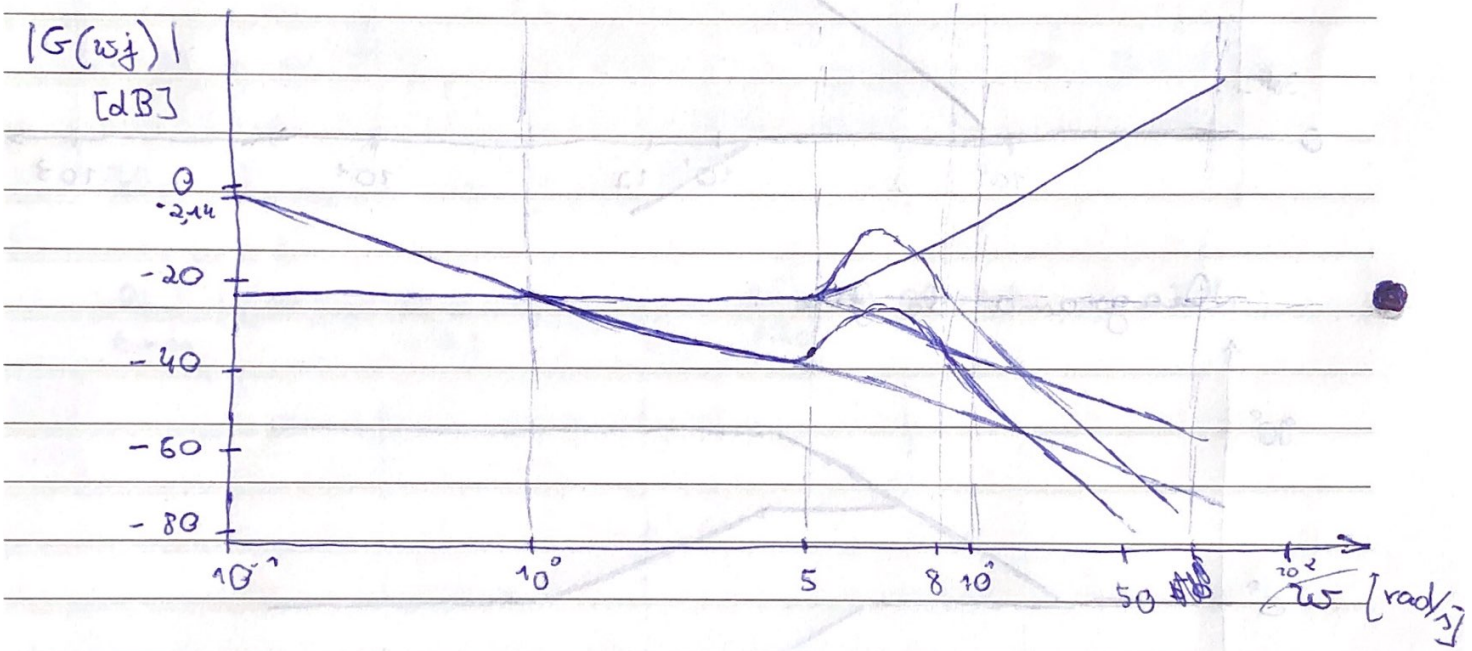
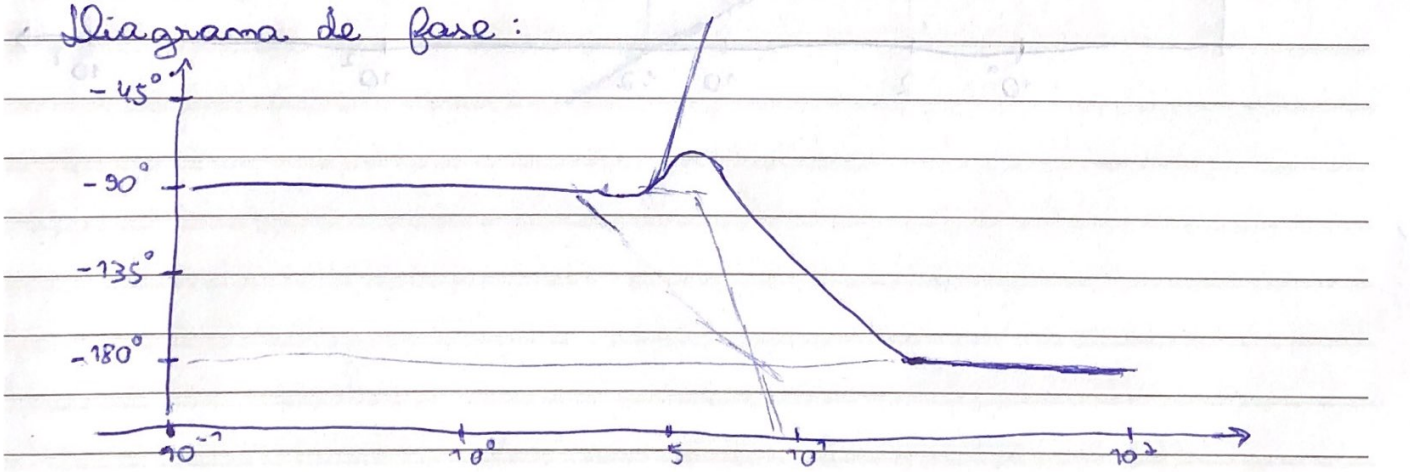


Diagrama de fase:



2- $G_2(s) = 6\left(\frac{s+2}{s+12}\right) \Rightarrow G_2(\omega j) = 1\left(\frac{\frac{\omega}{2}j+1}{\frac{\omega}{12}j+1}\right)$

Zero do: $\omega_{n_2} = 2$ rad/s | Por década: decai 20dB

Na fase: $+90°$ (se $\omega = 12$ rad/s)

Diagrama de ganho:

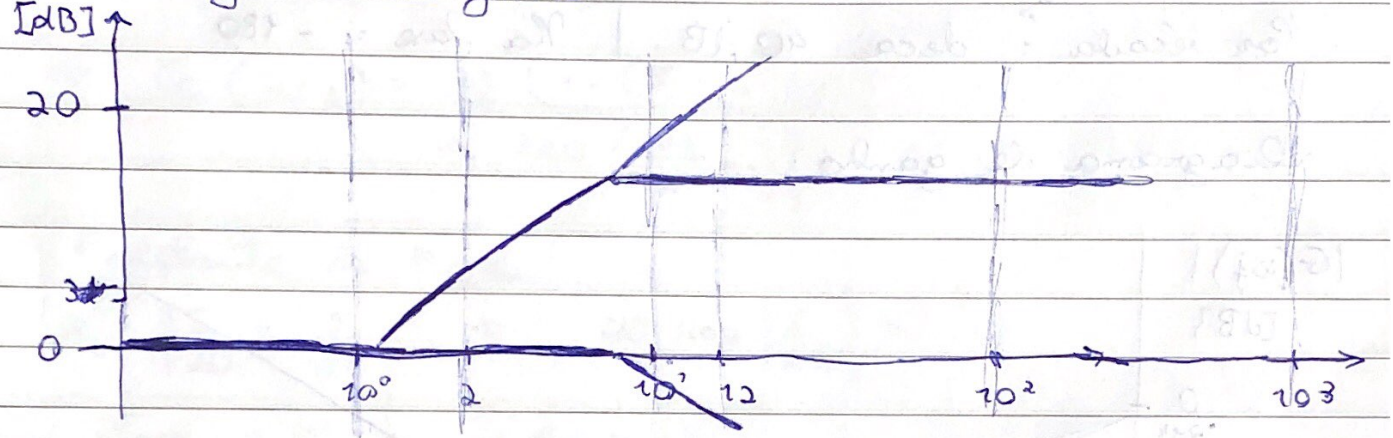
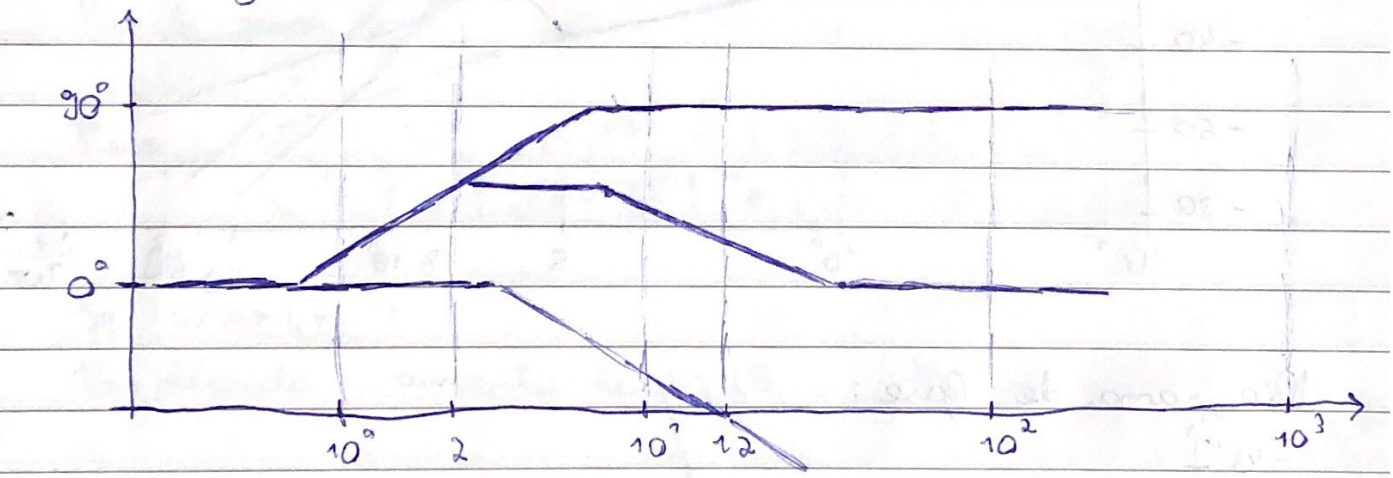


Diagrama de fase:



3- Se são 5 rad/s, na fase: 45,5°

4- Polos: $p_1 = -5$ | $p_2 = 0$ | $p_3 = -1,2 + 7,9i$ | $p_4 = -1,2 - 7,9i$

$$\omega_n = \sqrt{(-1,2)^2 + (-7,9i)^2} = \sqrt{1,44 + 62,41} \cong 7,99 \text{ rad/s}$$

$$\zeta = \frac{1,2}{7,99} = 0,25$$

$$\omega_r = \omega_n \sqrt{1 - 2\zeta^2} = 7,8 \text{ rad/s}$$

5- $M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}} = e^{\frac{-0,75\pi}{0,9682}} \cong 0,621 \Rightarrow 62,1\%$

Pelo Teorema do Valor Final:

$$\lim_{t \to \infty} f(\infty) = \lim_{s \to 0} s \cdot F(s) = \frac{25}{320} \cong 0,0781$$