

Esercitazione Bode

$$H(s) = \underbrace{K}_{\text{costante}} \cdot \underbrace{s^{M_1}}_{\text{nullo}} \cdot \underbrace{(s+p)^{M_2}}_{\text{reale}} \cdot \underbrace{\left(s^2 + 2\zeta\omega_n s + \omega_n^2\right)^{M_3}}_{\text{complesso coniugato}}$$

Esercizio 1

$$H(s) = \frac{1+s}{s+0.1} = 10 \frac{1+s}{1+10s} = 10(1+s)^1 \cdot (1+10s)^{-1}$$

$$K_B = 10$$

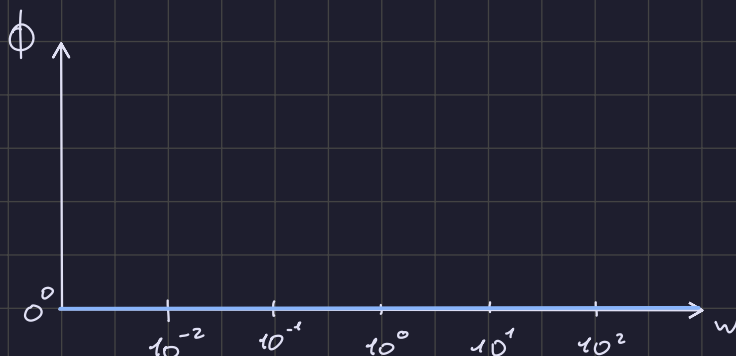
$$Z_1: \begin{cases} \tau_1 = 1 \\ \mu_1 = 1 \end{cases}$$

$$P_1: \begin{cases} \tau_2 = 10 \\ \mu_2 = -1 \end{cases}$$

Guadagno:

$$A = 20 \log_{10}(10) \text{ dB} = 20 \text{ dB}$$

$$\Phi = \begin{cases} 0^\circ & K_B > 0 \\ -180^\circ & K_B < 0 \end{cases} = 0^\circ$$



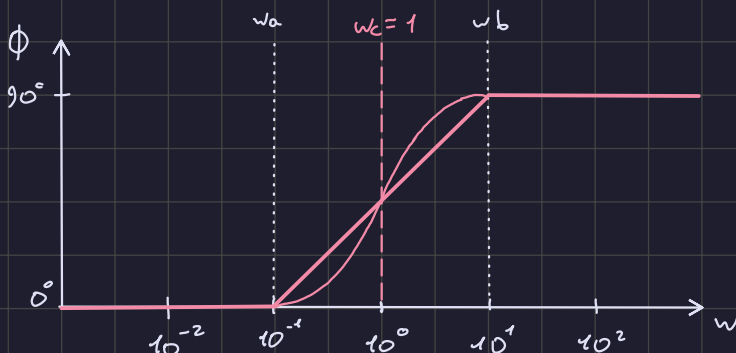
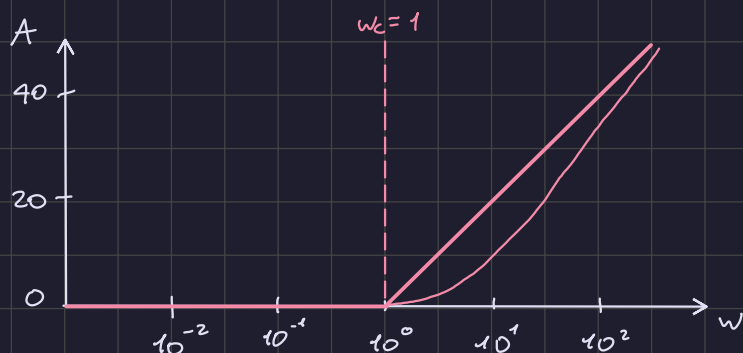
Zero ($\tau_1 = 1, \mu_1 = 1$)

$$\omega_c = \frac{1}{|\tau|} = 1$$

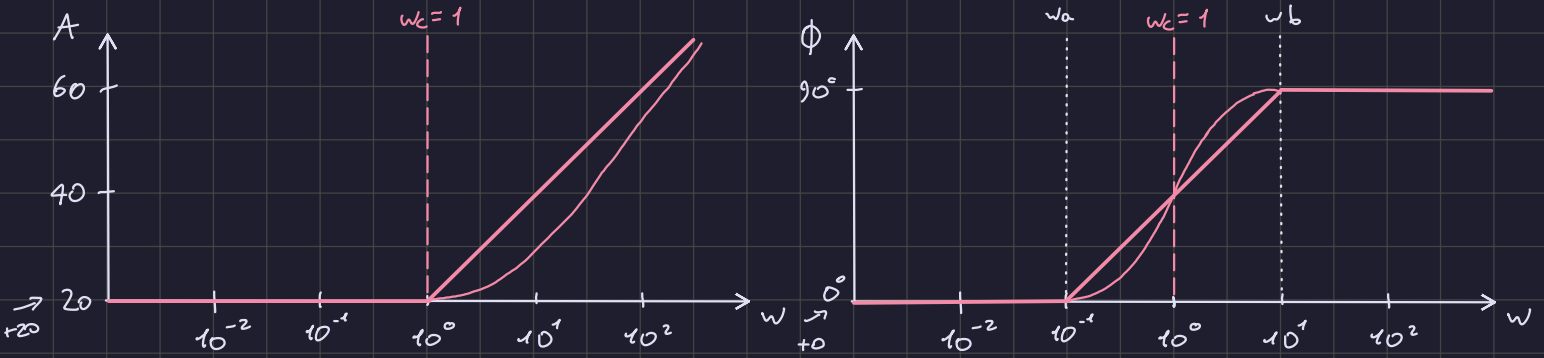
$$\omega_0 = 0.1 \\ \omega_b = 10$$

$$A = \begin{cases} 0 \text{ dB} & \omega < 1 \\ 20 \frac{\text{dB}}{\text{dec}} & \omega > 1 \end{cases}$$

$$\Phi = \begin{cases} 0^\circ & \omega < 0.1 \\ 90^\circ & \omega > 10 \end{cases}$$



Guadagno + Zero



Polo ($\tau_2 = 10, \mu_2 = 1$)

$$\omega_c = 0.1$$

$$\omega_a = 0.01$$

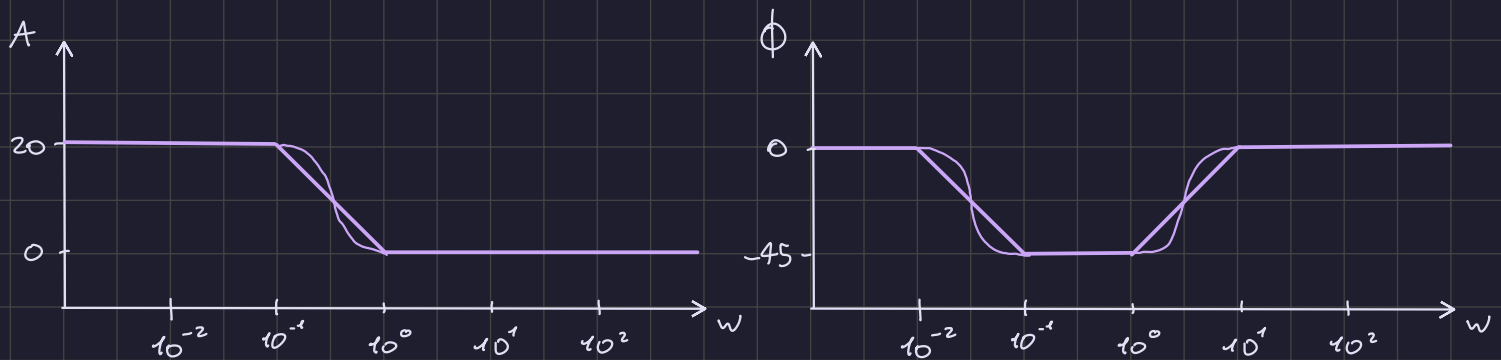
$$\omega_b = 1$$

$$A = \begin{cases} 0 \text{ dB} & \omega < 0.1 \\ -20 \frac{\text{dB}}{\text{dec}} & \omega > 0.1 \end{cases}$$

$$\phi = \begin{cases} 0^\circ & \omega < 0.01 \\ -90^\circ & \omega > 1 \end{cases}$$



Grafico totale



Esercizio 2

$$H(s) = \frac{(s+500)}{s(s-0.1)} = \frac{500 \left(\frac{1}{500} s + 1 \right)}{0.1 s (10s - 1)} = 5000 \cdot \frac{1}{s} \cdot \frac{(0.002s + 1)}{(10s - 1)}$$

$$= -5000 \cdot \frac{1}{s} \cdot \frac{(0.002s + 1)}{(-10s + 1)} = -5000 \cdot s^{-1} \cdot (1 + 0.002s)^1 \cdot (1 - 10s)^{-1}$$

$$K_b = -5000$$

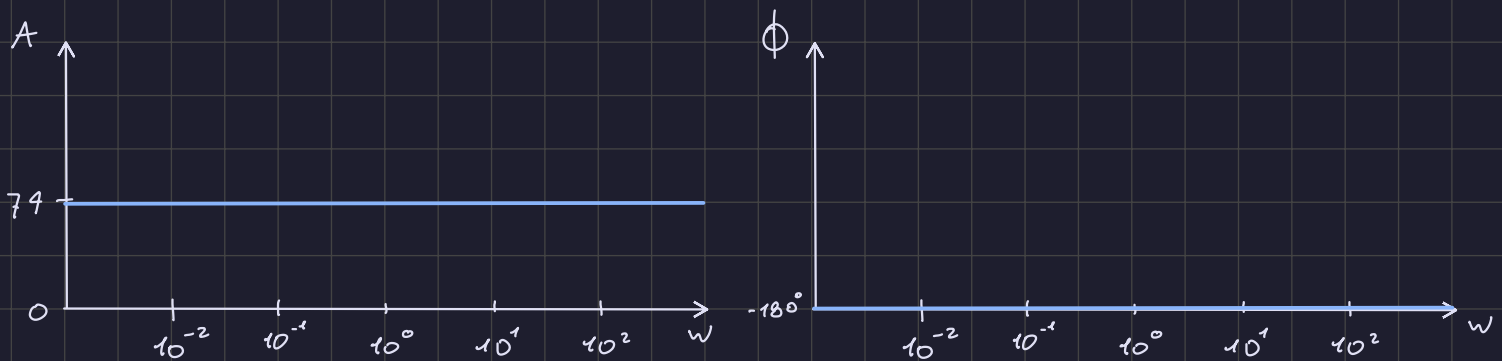
$$p_1: \mu_0 = -1$$

$$z_1: \begin{cases} \tau_1 = 0.002 \\ \mu_1 = 1 \end{cases}$$

$$p_2: \begin{cases} \tau_2 = -10 \\ \mu_2 = -1 \end{cases}$$

Guadagno

$$A = 74 \text{ dB} \quad \phi = -180^\circ$$



Radice all'origine ($\mu_0 = -1$)

$$A = -20 \frac{\text{dB}}{\text{dec}} \quad \phi = -90^\circ$$



Gradegno + Radice all'origine



Zero ($\tau_1 = 0,002$ $\mu_1 = 1$)

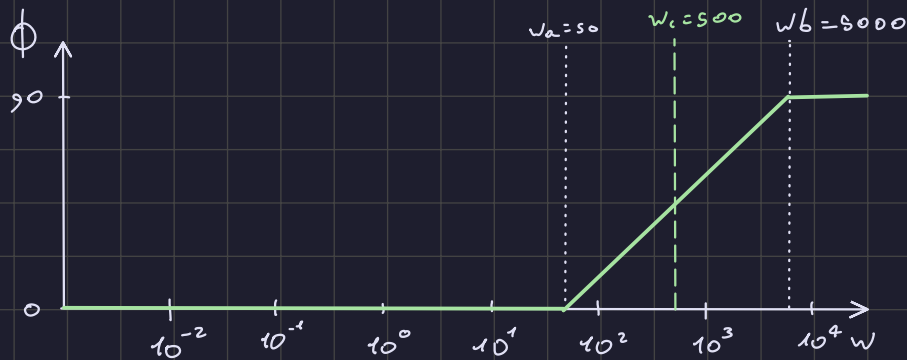
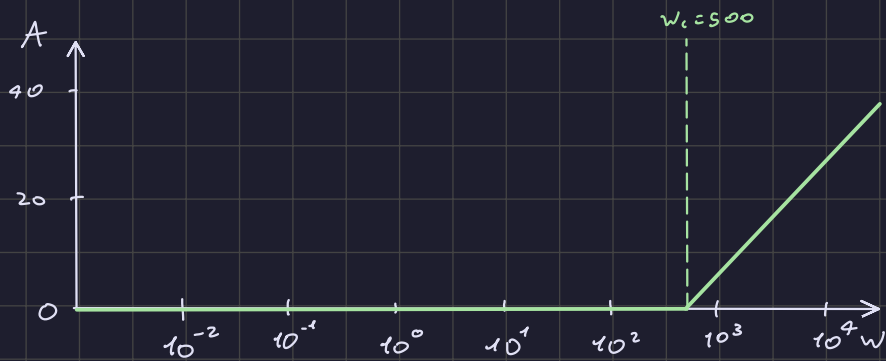
$$\omega_c = \frac{1}{0,002} = 500$$

$$\omega_a = 50$$

$$\omega_b = 5000$$

$$A = \begin{cases} 0 \text{ dB} & \omega < 500 \\ 20 \frac{\text{dB}}{\text{dec}} & \omega > 500 \end{cases}$$

$$\phi = \begin{cases} 0^\circ & \omega < 50 \\ 90^\circ & \omega > 5000 \end{cases}$$



Polo ($\tau_2 = -10$ $\mu_2 = -1$)

$$\omega_c = 0.1$$

$$\omega_a = 0.01$$

$$\omega_b = 1$$

$$A = \begin{cases} 0 & \omega < 0.1 \\ -20 \frac{\text{dB}}{\text{dec}} & \omega > 0.1 \end{cases}$$

$$\phi = \begin{cases} 0^\circ & \omega < 0.01 \\ 90^\circ & \omega > 1 \end{cases}$$

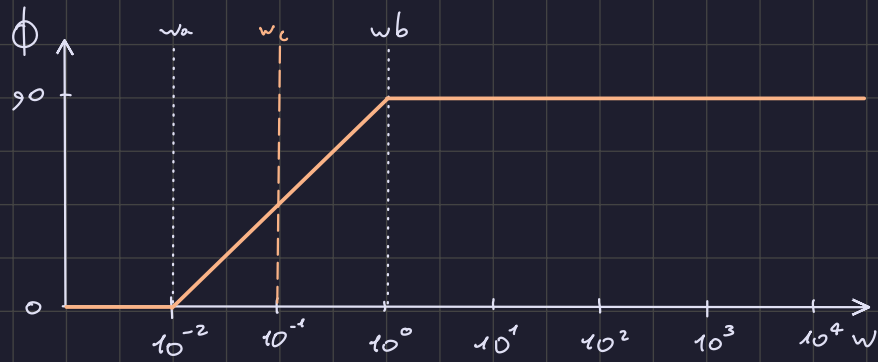
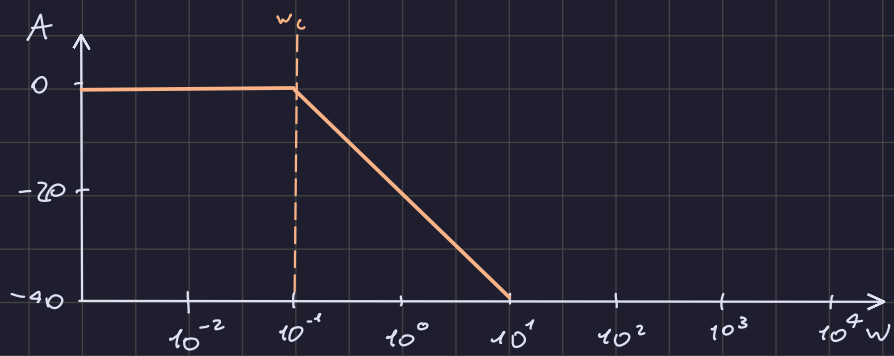
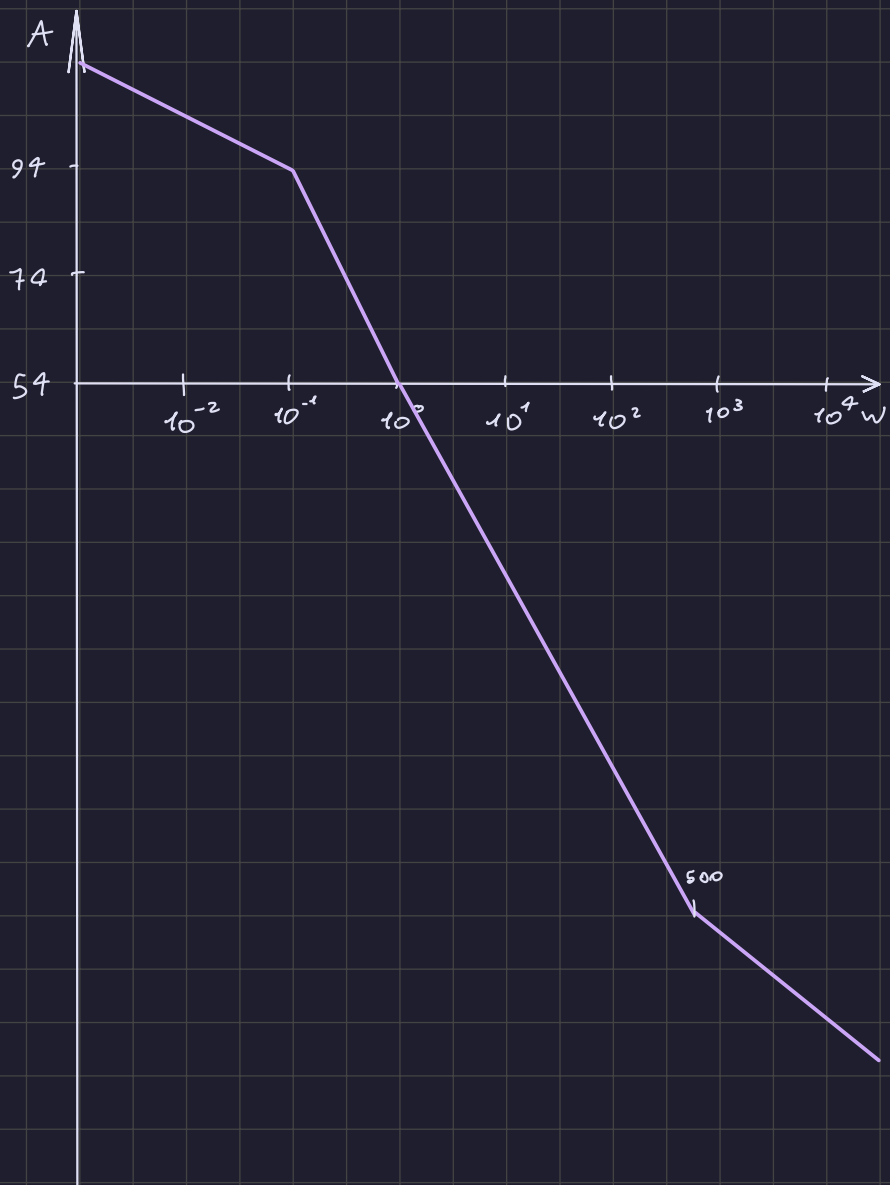


Grafico totale





Esercizio 3

$$H(s) = \frac{1+s}{s^2 + 6s + 100} = \frac{1}{100} \cdot \frac{s+1}{1+0,06s+0,01s^2} = \frac{1}{100} \cdot \frac{s+1}{1+0,06s+\frac{1}{10^2}s^2}$$

$\omega_n = 10$

\downarrow
 $(s+a)(s+b)$
 se $\Delta > 0$

$$= 0,01 \frac{s+1}{1+2\frac{0,3}{10}s+\frac{1}{10^2}s^2}$$

$$P_1: \begin{cases} \omega_n = 10 \\ \zeta = 0,3 \\ M_2 = -1 \end{cases}$$

Polo complesso coniugato

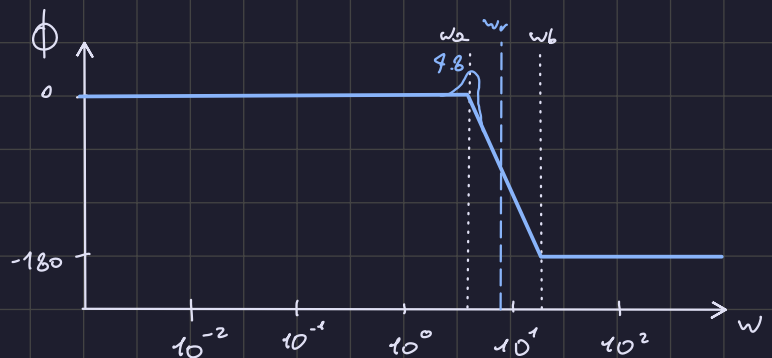
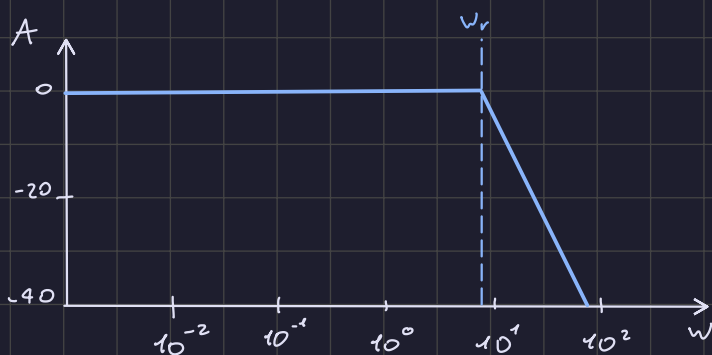
$$\omega_r = 9,05$$

$$\omega_a = 5,6$$

$$\omega_b = 49,5$$

$$A = \begin{cases} 0 \text{ dB} & \omega < 9,05 \\ -40 \frac{\text{dB}}{\text{dec}} & \omega > 9,05 \end{cases}$$

$$\Phi = \begin{cases} 0^\circ & \omega < 5,6 \\ -180^\circ & \omega > 49,5 \end{cases}$$



$\zeta < 0,5 \rightarrow$ calcoliamo il picco di risonanza

$$A_r = 4,8$$