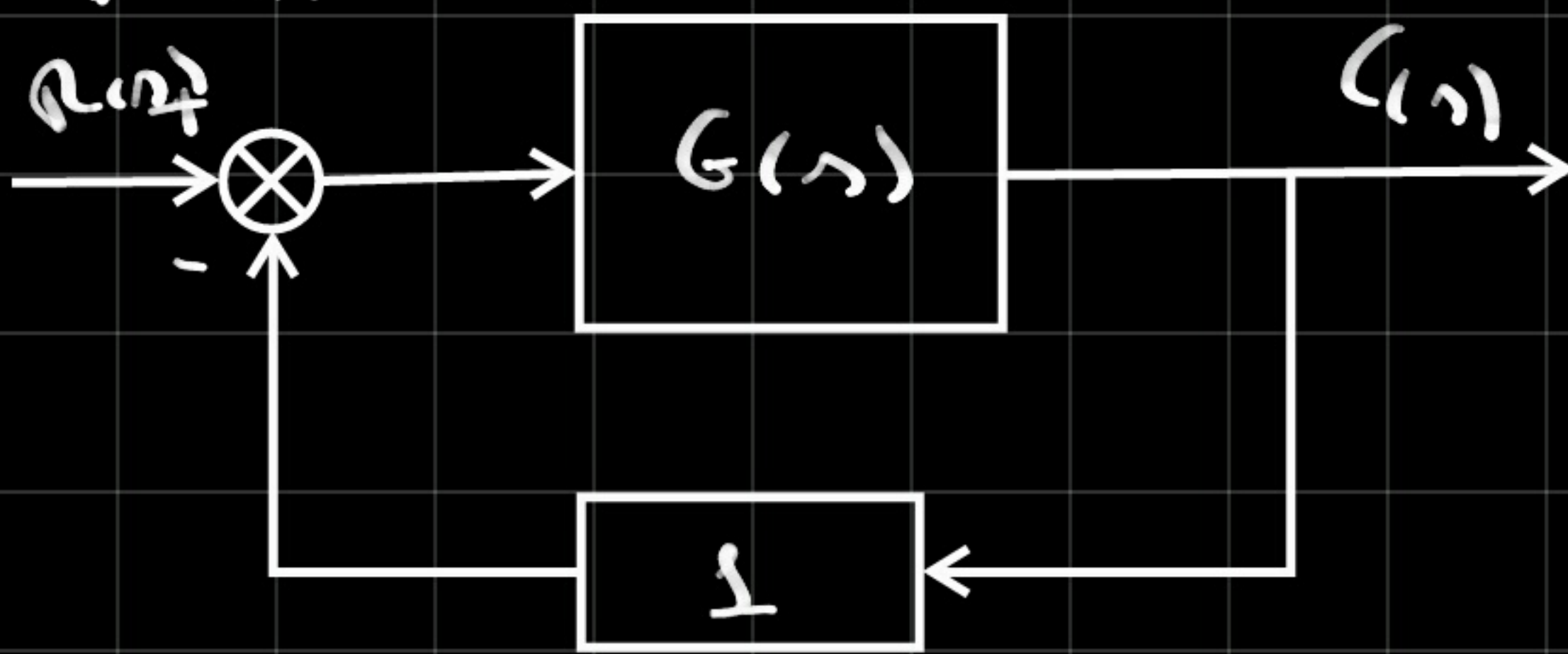


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B-7.1-



$$G_{cl} = \frac{GH}{1+GH} = \frac{10/s+1}{1+(10/s+1)} = \frac{10}{s+1+10} = \frac{10}{s+11}$$

$$2) \left| \frac{10}{s+11} \right| = \frac{10}{\sqrt{11^2+1}} = 0,9053$$

$$\angle \left( \frac{10}{s+11} \right) = -5,1944$$

$$C_{ss} = 0,9053 \sin(t + 24,8^\circ)$$

$$b) \left| \frac{10}{2s+11} \right| = 0,8944$$

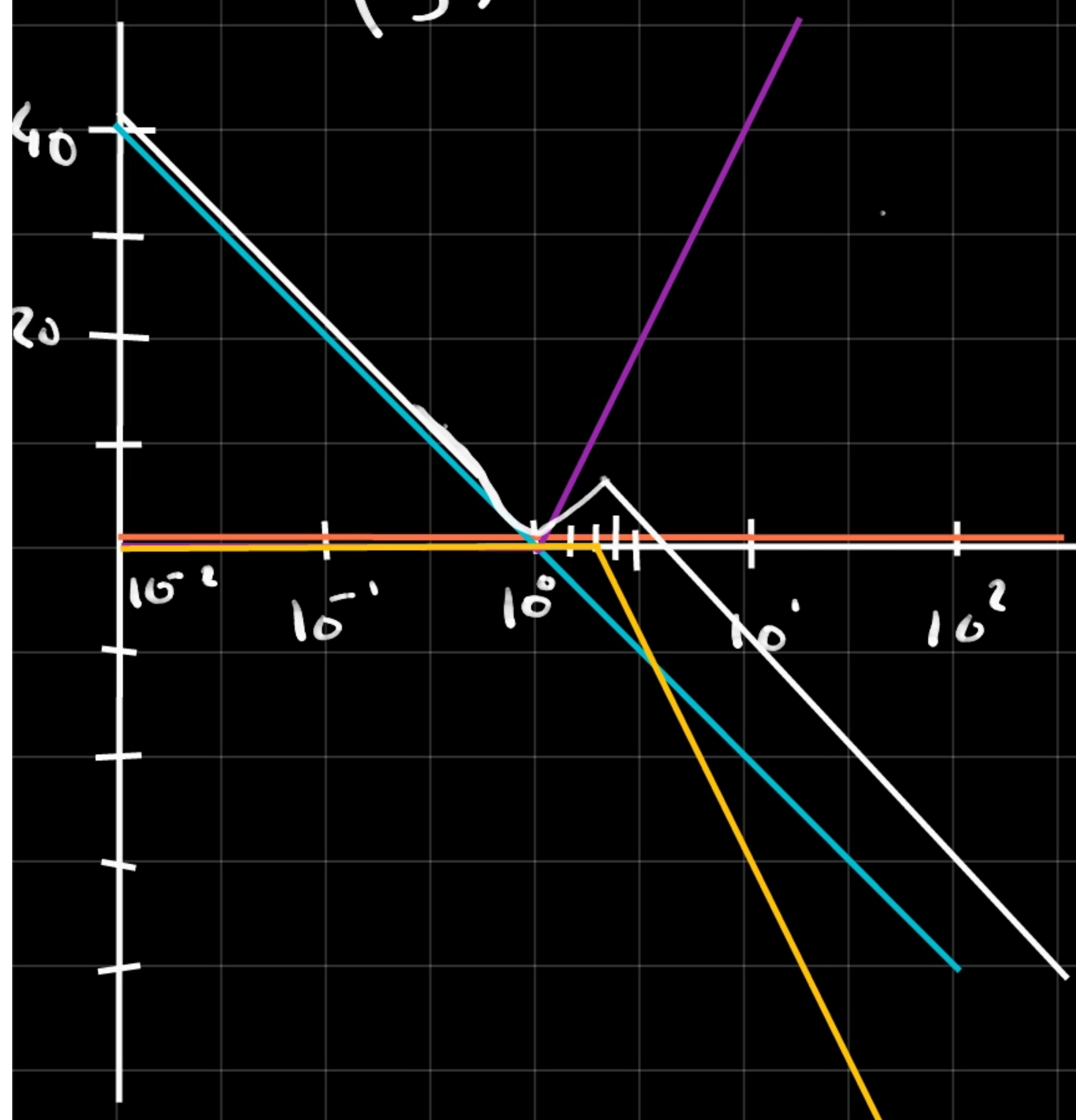
$$\angle \left( \frac{10}{2s+11} \right) = -10,3048$$

$$C_{ss} = 1,7888 \cos(2t - 55,3048)$$

$$c) C_{ss} = 0,9053 \sin(t + 24,8^\circ) - 1,7888 \cos(2t - 55,3048)$$

$$7.4 \quad G(s) = \frac{10(s^2 + 0.4s + 1)}{s(s^2 + 0.8s + 9)} = \frac{\sqrt{10} [1 + (2 \cdot 0.25\omega/1) + (\omega/1)^2]}{9s [1 + 2 \cdot 0.43\omega/3 + (3\omega/3)^2]}$$

$$G_0 = 20 \log\left(\frac{10}{9}\right) = 0.915$$



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B-7.5

$$G(j\omega) = \frac{1}{(j\omega)^2 + 2\zeta\omega_n(j\omega) + \omega_n^2} = \frac{1}{\left(j\frac{\omega}{\omega_n}\right)^2 + 2\zeta\left(j\frac{\omega}{\omega_n}\right) + 1}$$

$$G(j\omega_n) = \frac{1}{-1 + 2\zeta j + 1}$$

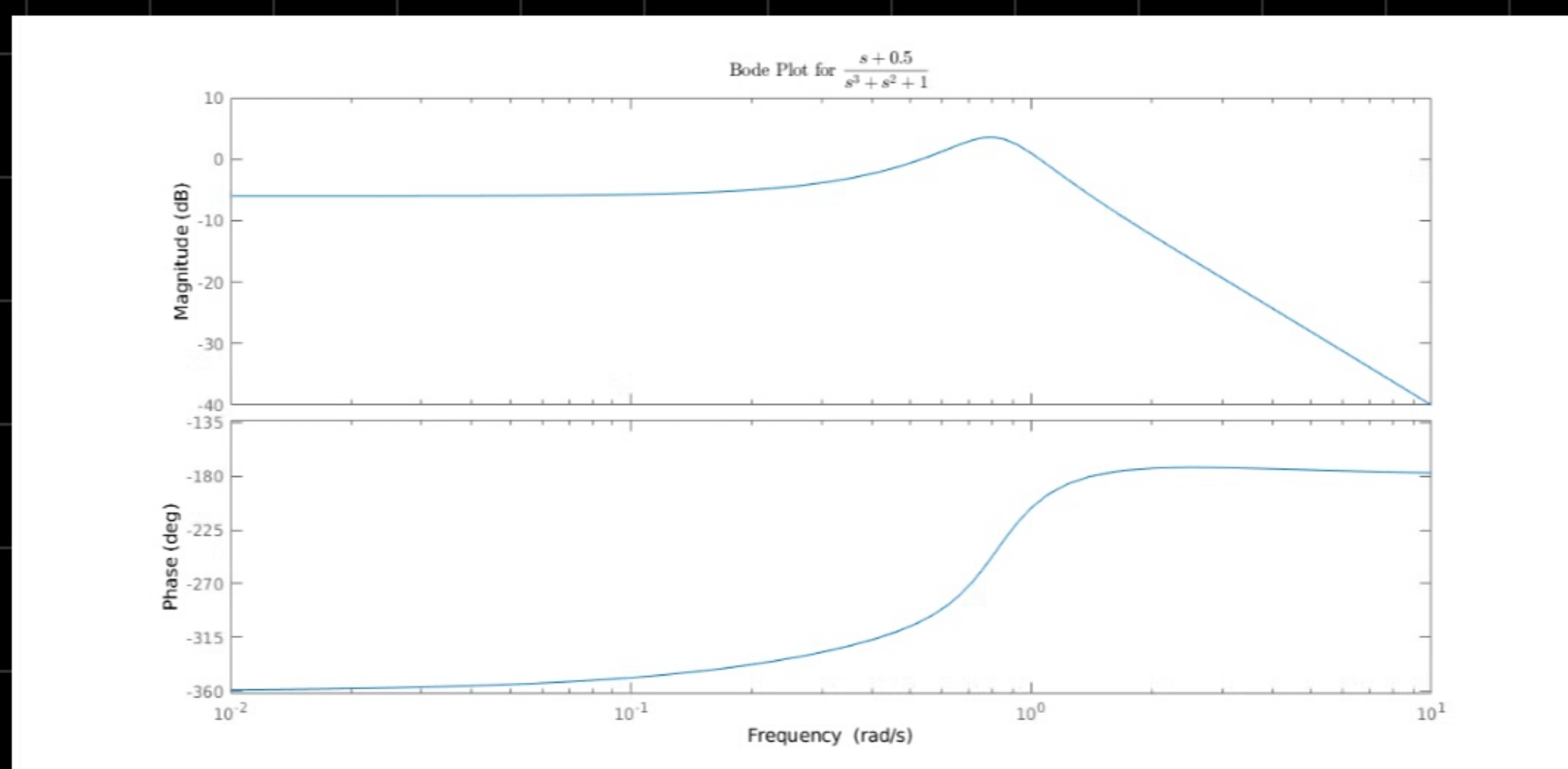
$$|G(j\omega_n)| = \left| \frac{1}{-1 + 2\zeta j + 1} \right| = \frac{1}{2\zeta}$$

B-7.6

Gs1=tf([1 0.5], [1 1 0 1])

figure

bode(Gs1)



O ângulo de fase do sistema acima vai de 0 a 180° pois o sistema é de fase não mínima. Assim, calculando a fase do sistema para  $\omega \rightarrow 0$  e  $\omega \rightarrow \infty$ , temos:

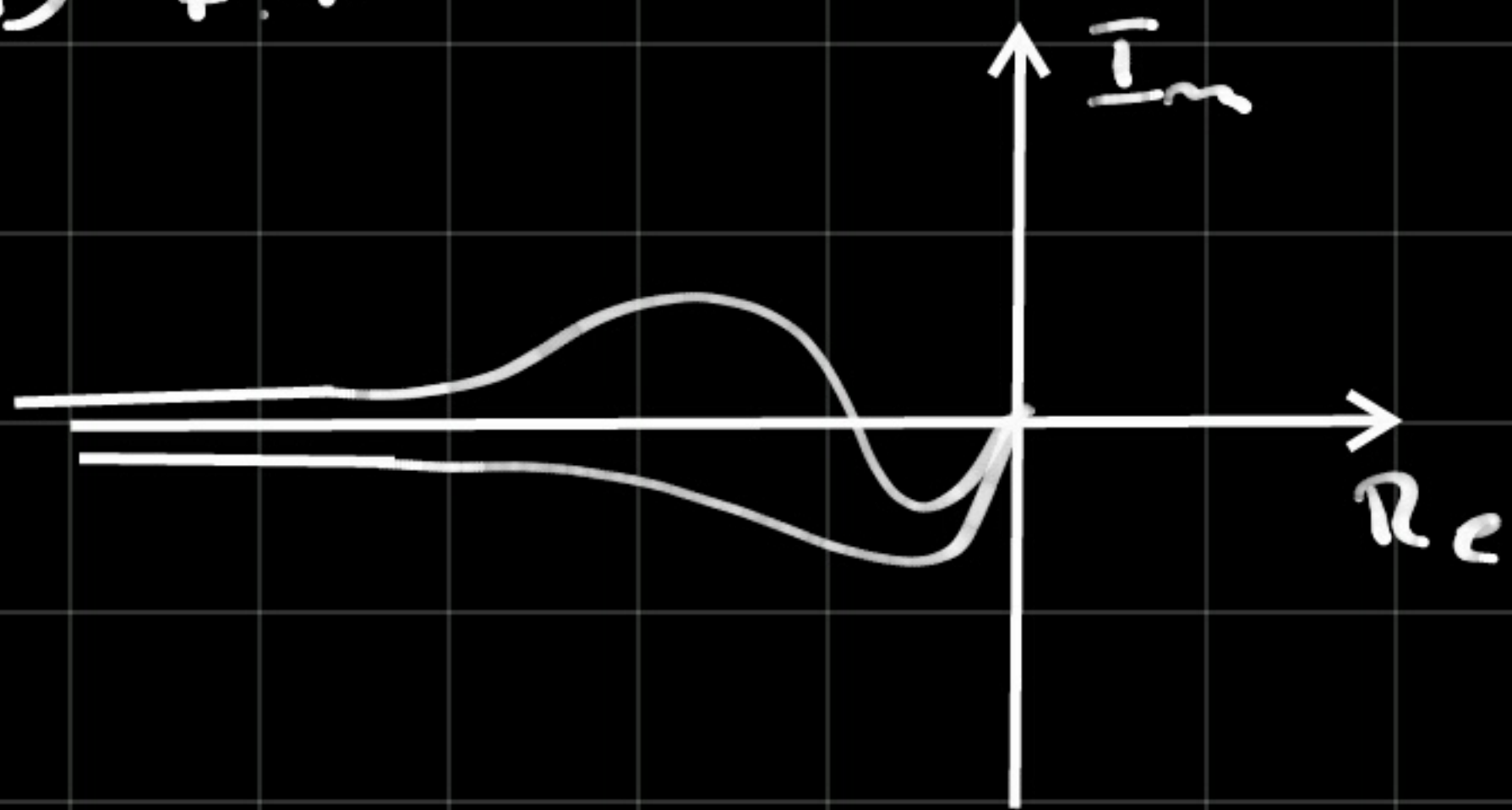
$$\angle G(j0) = \angle 0,5 - \angle 1,4636 - \tan^{-1}\left(\frac{0,7976}{0,2328}\right) + \tan^{-1}\left(\frac{0,7976}{0,2328}\right) = 0$$

$$\angle G(j\infty) = 90 - 90 - \tan^{-1}\left(\frac{\infty}{-0,2328}\right) - \tan^{-1}\left(\frac{\infty}{-0,2328}\right) = 180^\circ$$

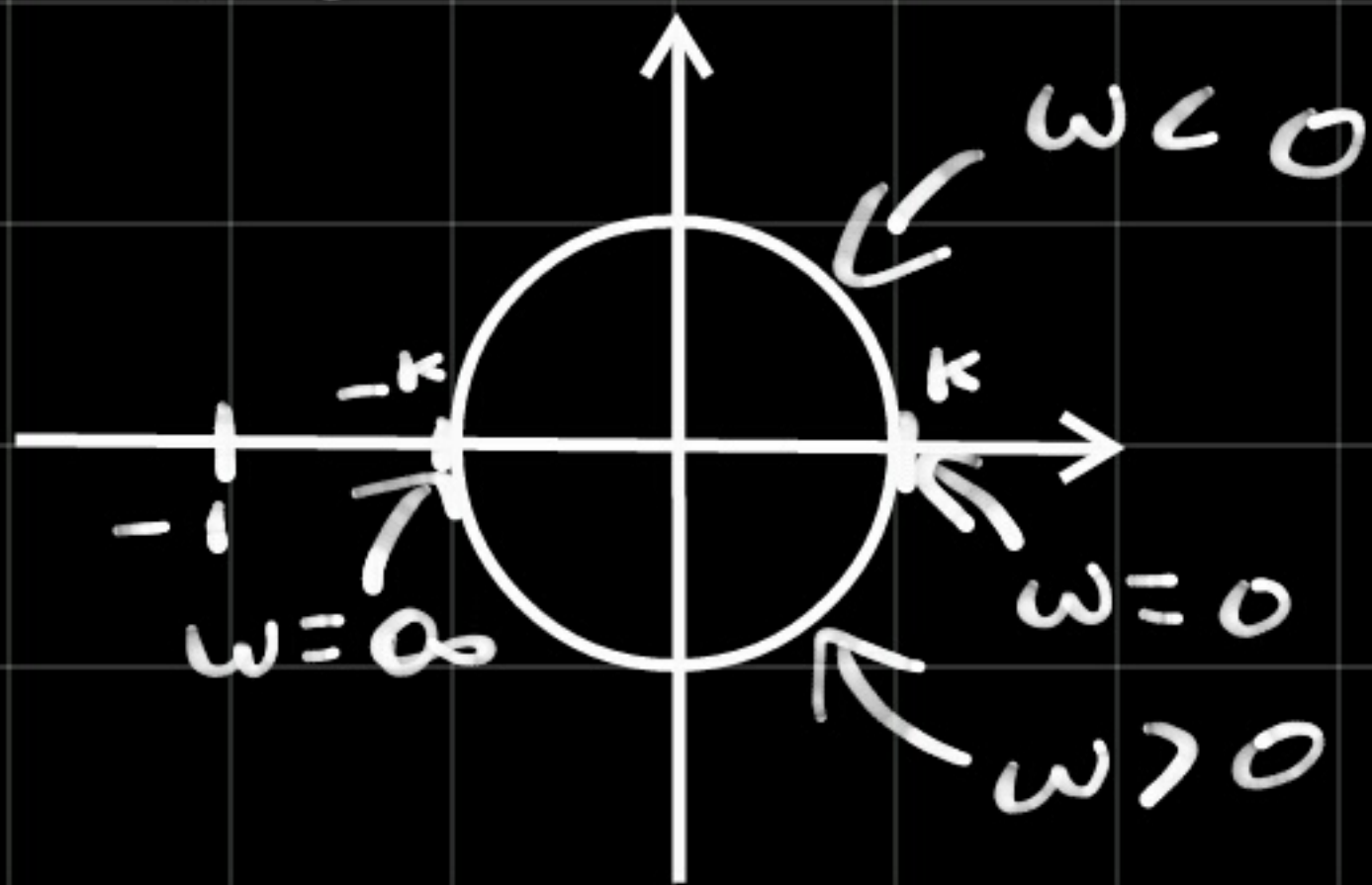


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B-7.7



B-7.8



B-7.10

$$G(s)H(s) = \frac{10k(s+0.5)}{s^2(s+2)(s+10)}$$

Para  $\omega = 0$

$$\lim_{\omega \rightarrow 0^+} G(j\omega)H(j\omega) = -\infty - j0 \quad \left\{ \begin{array}{l} \lim_{\omega \rightarrow 0^+} G(j\omega)H(j\omega) = -\infty - j0 \\ \lim_{\omega \rightarrow 0^-} G(j\omega)H(j\omega) = -\infty + j0 \end{array} \right.$$

Para  $\omega = \infty$

$$\lim_{\omega \rightarrow \infty^+} G(j\omega)H(j\omega) = -0 + j0 \quad \left\{ \begin{array}{l} \lim_{\omega \rightarrow \infty^+} G(j\omega)H(j\omega) = -0 + j0 \\ \lim_{\omega \rightarrow \infty^-} G(j\omega)H(j\omega) = -0 - j0 \end{array} \right.$$

Separando Parte real e imaginária, temos:

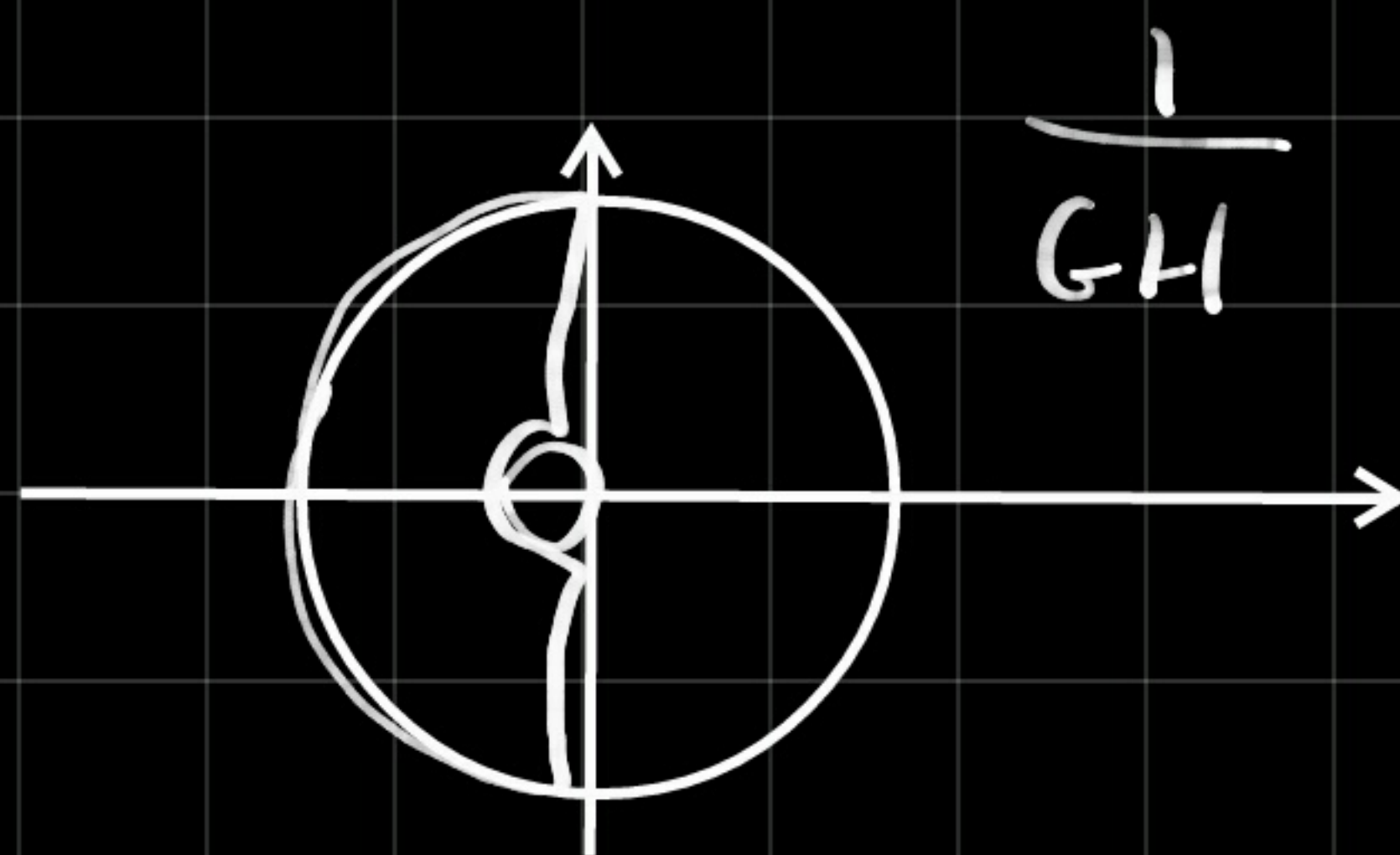
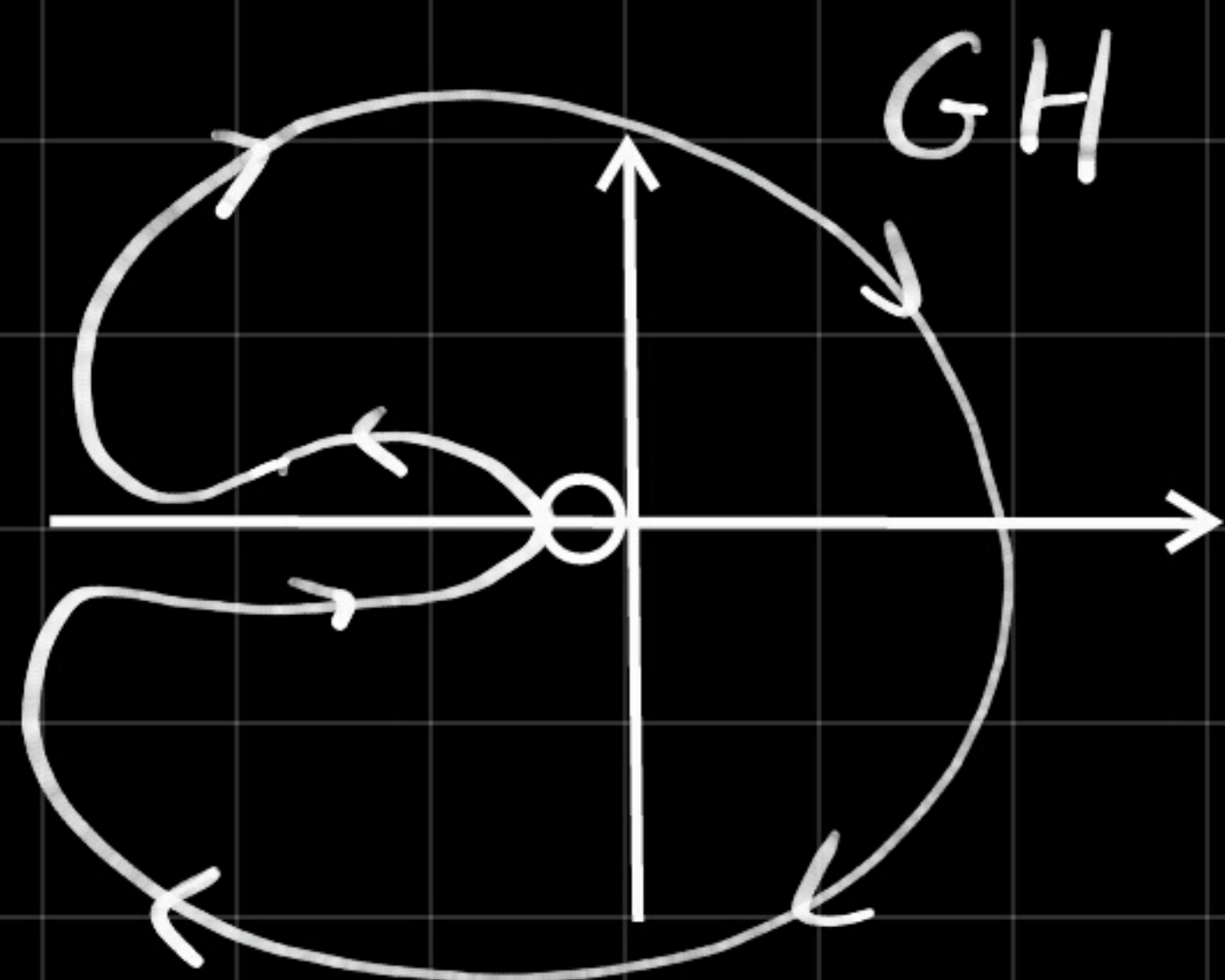
$$\begin{aligned} G(j\omega)H(j\omega) &= \frac{10k(j\omega+0.5)}{(j\omega)^2(j\omega+2)(j\omega+10)} = \frac{10k(j\omega+0.5)}{-\omega^2(j\omega+2)(j\omega+10)} = \frac{10k(j\omega+0.5)}{\omega^4 - 12i\omega^3 - 20\omega^2} \\ &= \frac{10k(j\omega+0.5)}{(\omega^4 - 20\omega^2) - i(12\omega^3)} \cdot \frac{(\omega^4 - 20\omega^2) + i(12\omega^3)}{(\omega^4 - 20\omega^2) + i(12\omega^3)} = \\ &= \frac{-(15\omega^4 + 10\omega^2) + i(10\omega^5 - 140\omega^3)}{(\omega^4 - 20\omega^2)^2 + (12\omega^3)^2} \end{aligned}$$



$$= \frac{-(115\omega^4 + 10\omega^2) + i(10\omega^5 - 140\omega^3)}{(\omega^4 - 20\omega^2)^2 + (2\omega^3)^2} i$$

$$\text{Re}[(G(j\omega)H(j\omega))] = \frac{-(115\omega^4 + 10\omega^2)}{(\omega^4 - 20\omega^2)^2 + (2\omega^3)^2} =$$

$$= \frac{-(115\omega^4 + 10\omega^2) + i(10\omega^5 - 140\omega^3)}{\omega^8 - 104\omega^6 + 400\omega^4} = \frac{-(115\omega^2 + 10)}{\omega^6 - 104\omega^4 + 400\omega^2}$$



3-7.11

$$G(j\omega)H(j\omega) = \frac{k e^{-2j\omega}}{j\omega}$$

$$\angle G(j\omega)H(j\omega) = \angle [\cos(2\omega) - j\sin(2\omega)] - 90^\circ =$$

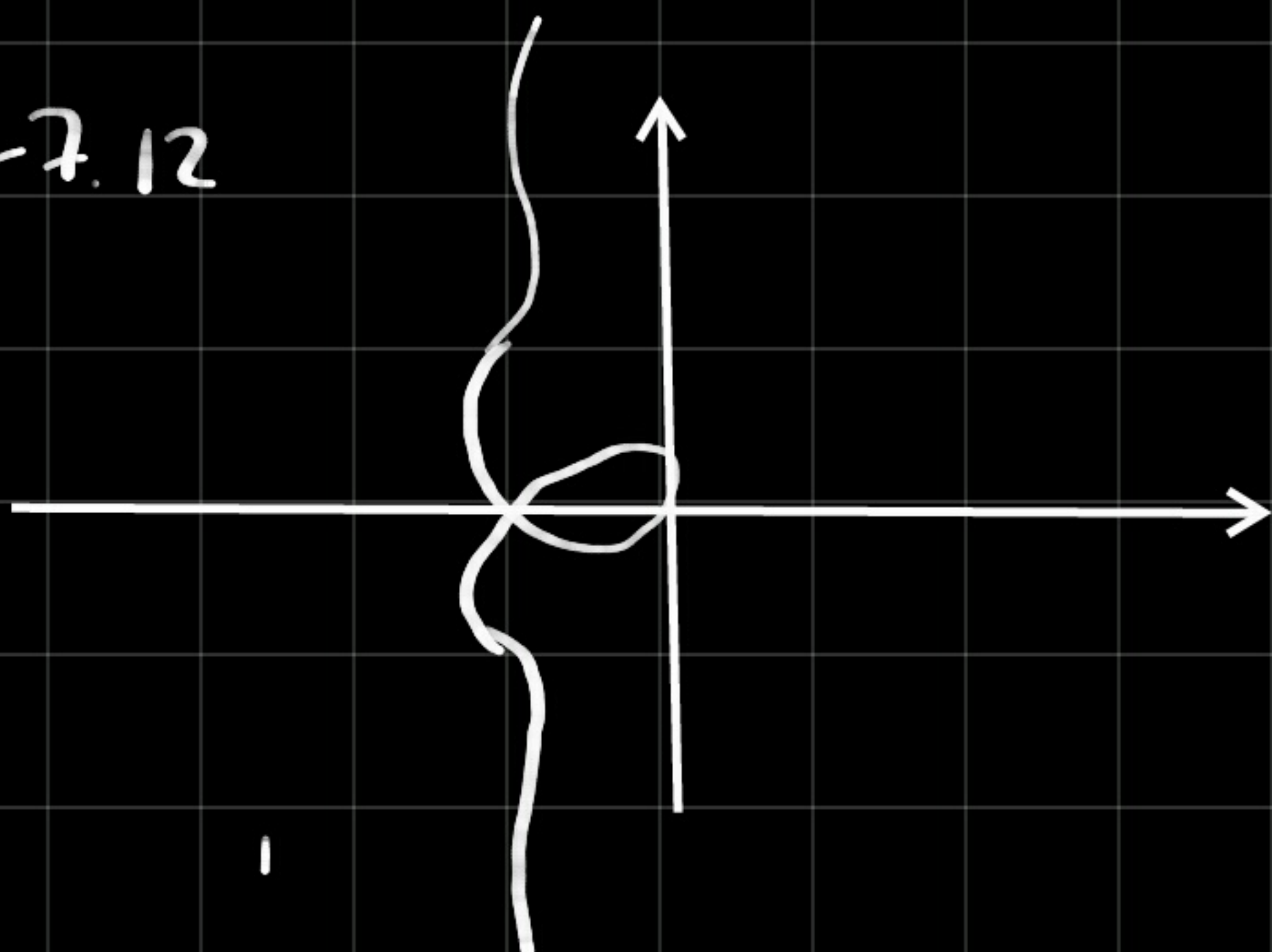
$$= -2\omega - 90^\circ$$

Para  $2\omega = 90^\circ$ ,  $\omega = 45^\circ$ , o ângulo alcança  $180^\circ$ .

Com isso, precisamos que para  $\theta = 45^\circ$ ,  $|G(j\omega)H(j\omega)| < 1$

$$|G(j\omega)H(j\omega)| = \frac{k}{\omega}$$

B-7.12



B-7-14

