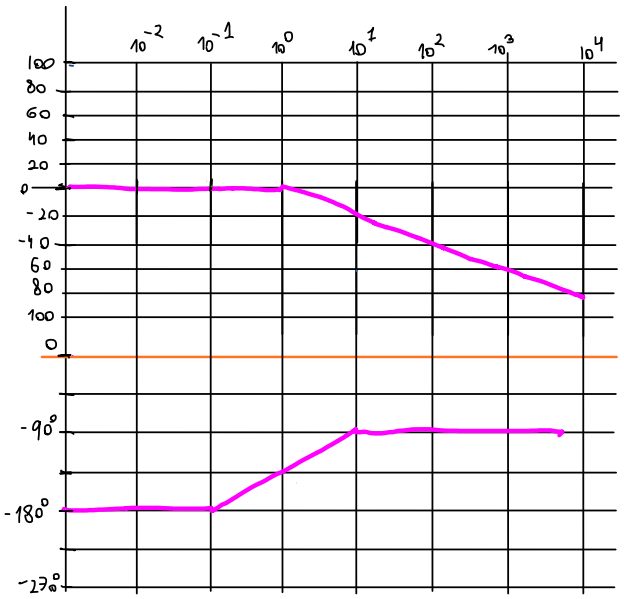
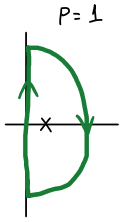
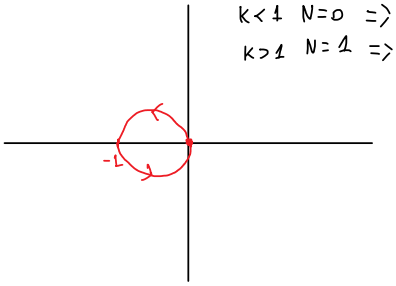
1.) $k(s) = k \in \mathbb{R}$

$G(s) = \frac{1}{s-1}$



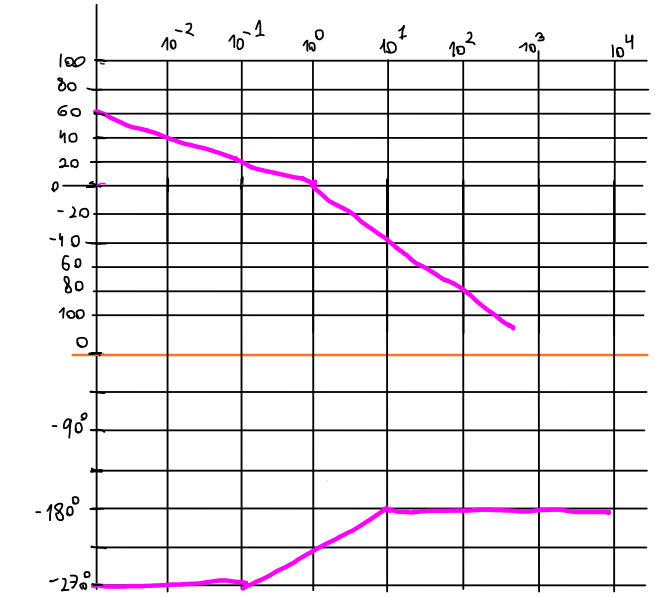


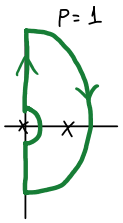


$k < 1 \quad N = 0 \Rightarrow Z = 1 \rightarrow$ instável

$k > 1 \quad N = 1 \Rightarrow Z = 0 \rightarrow$ estável

2) $k(s) = \frac{k}{s}$

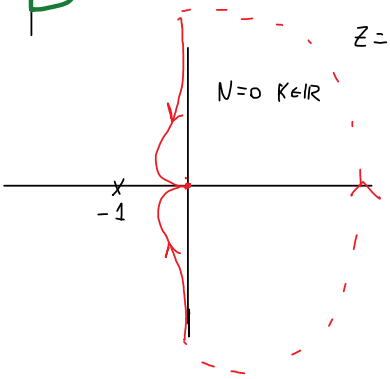




$s = \varepsilon e^{j\theta} \quad \frac{\pi}{4}$

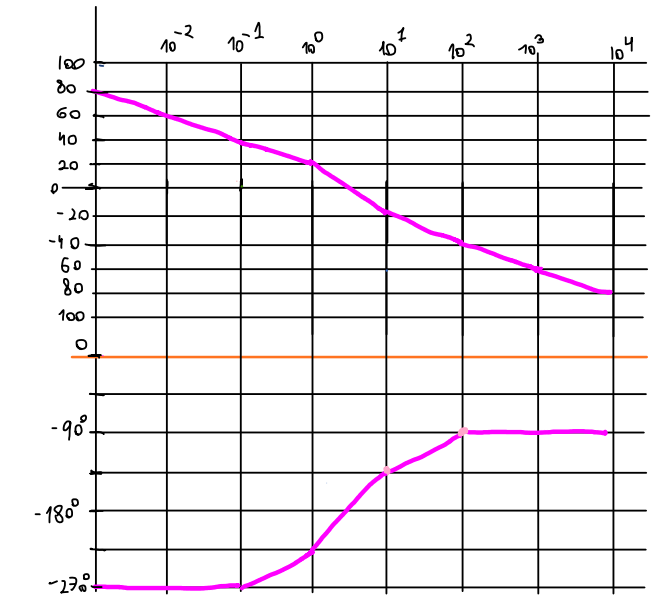
$\varepsilon \ll 1$

$\frac{k}{s} \cdot \frac{1}{(s-1)} = -\frac{k}{\varepsilon} e^{j\theta} = -\frac{k}{\varepsilon} e^{-j\theta}$

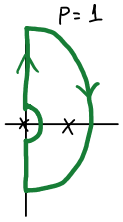


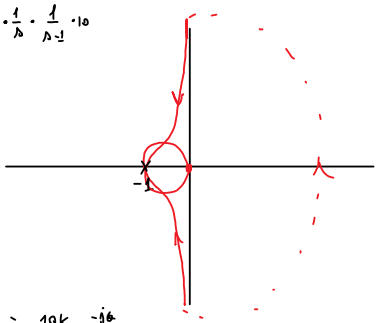
$Z = 1$ logo é sempre instável

$K(s) = K \frac{s+10}{s}$



$K \frac{s+10}{s} \cdot \frac{1}{s-1} = K \cdot \frac{s+10}{10} \cdot \frac{1}{s} \cdot \frac{1}{s-1} \cdot 10$





$s = \varepsilon e^{j\theta} \quad K \frac{s+10}{s} \cdot \frac{1}{s-1} = -\frac{10K}{\varepsilon} e^{-j\theta}$

$\arg\left(\frac{\omega}{10}\right) - 90 - \left(180 - \arg\left(\frac{\omega}{1}\right)\right) = 180 \Leftrightarrow$

$\arg\left(\frac{\omega}{10}\right) + \arg(\omega) = 450^{\circ}$

$\frac{\frac{\omega}{10} + \omega}{1 - \frac{\omega^2}{10}} = \infty \Rightarrow 1 - \frac{\omega^2}{10} = 0 \Leftrightarrow \omega = \sqrt{10} \quad \left| \frac{j\sqrt{10}+10}{j\sqrt{10}} \cdot \frac{1}{j\sqrt{10}-1} \right| = \frac{1}{K} \Leftrightarrow K = 1$

Logo para $K > 1$ o sistema é estável e para $K < 1$ não é

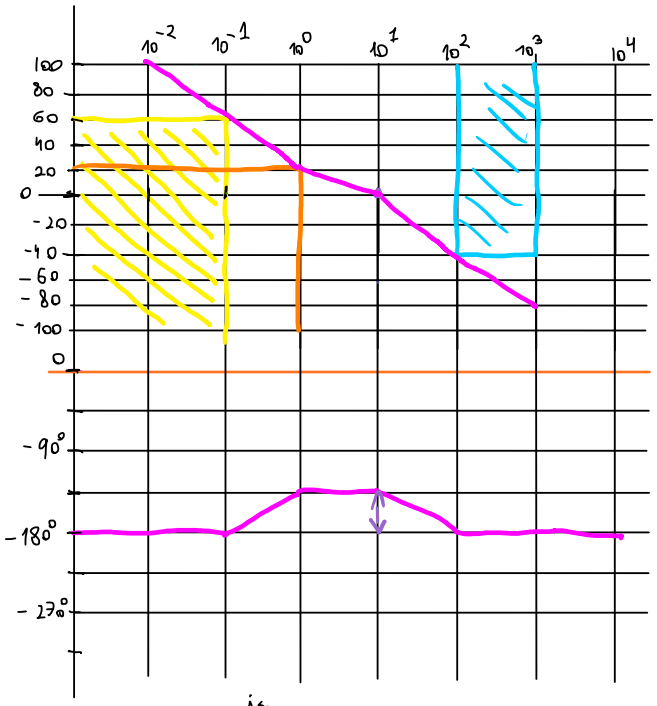
4)

$k=4$

$$G_M^+ = G_M^- = \frac{1}{|k\,G(s)H(s)|}\Big|_{s=j\omega_\pi} = \frac{1}{\left|4\cdot\frac{s+10}{s}\cdot\frac{1}{s-1}\right|}\Big|_{s=j\omega_\pi}$$

$\omega_\pi \approx 3$

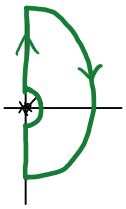
$$\frac{1}{\left|4\cdot\frac{j3+10}{j3}\cdot\frac{1}{j3-1}\right|} = -12.87\,dB$$



$\frac{K}{s^2}\cdot\frac{s+z}{s+p}$

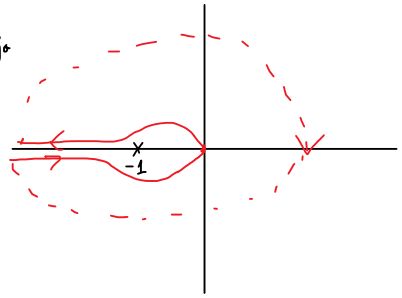
$z=1$
$p=10$
$k=10$

i) $\Rightarrow m=1$ ✓
ii) $\geq 60dB$ ✓
iii) $\leq -40dB$ ✓
iv) $G_M=\infty$ ✓
v) $P_M=45^\circ$ ✓



$s=\varepsilon e^{j\theta}$

$\frac{k}{\varepsilon e^{2j\theta}} = \frac{k}{\varepsilon}e^{-2j\theta}$



5)

$k=10$	$k=100$
$\omega_0=10$	$\omega_0=100$
$PM=45^\circ$	$PM=90^\circ$
$0=45^\circ-\omega_0 z$	$0=\frac{\pi}{2}-100z$
$\frac{\pi}{40}=z$	$\frac{\pi}{200}=z$

2.2) $-20dB$

2.3) Não, já que não conseguiu alterar o declive sem aumentar o número de integradores