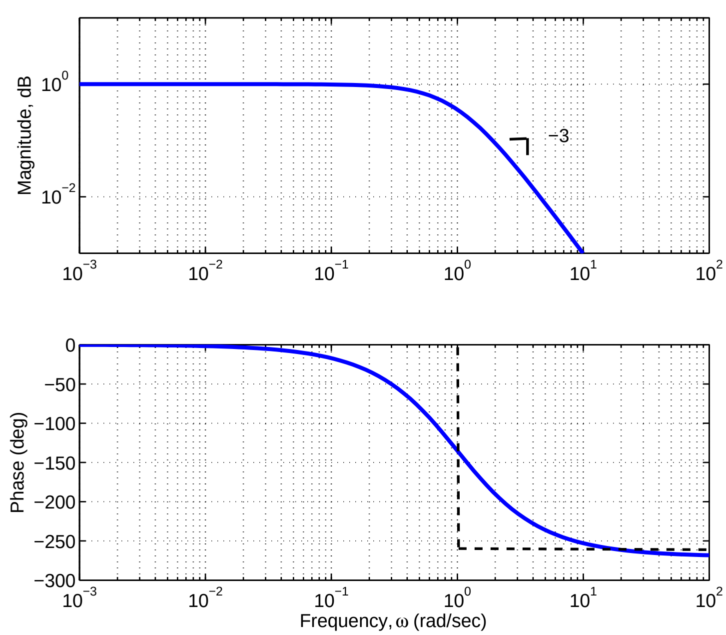
# 16.06 Principles of Automatic Control
# Recitation 11

Sketch a Nichols plot of:

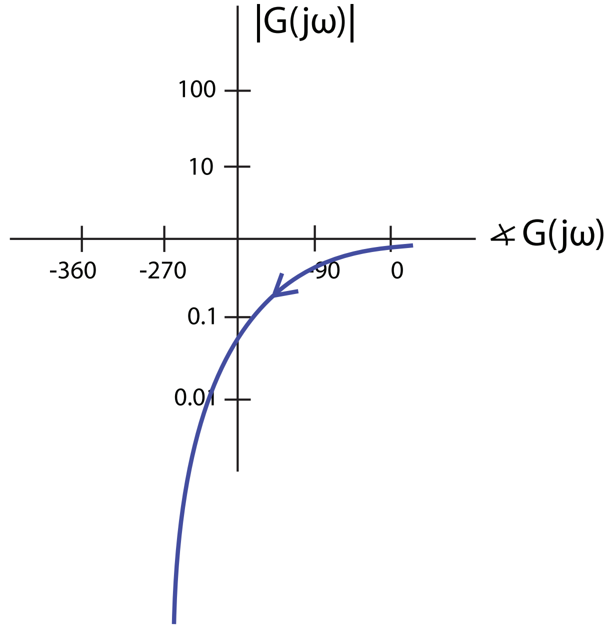
$$G(s) = \frac{1}{(s+1)^3}$$

$$s = -3\tan^{-1}(\omega) = -180^\circ$$
$$\omega = 1.73$$
$$\therefore\ K = \left(\frac{1}{\sqrt{1+3}}\right)^3 = \frac{1}{(\sqrt{1+3})^3} = \frac{1}{8} = K$$

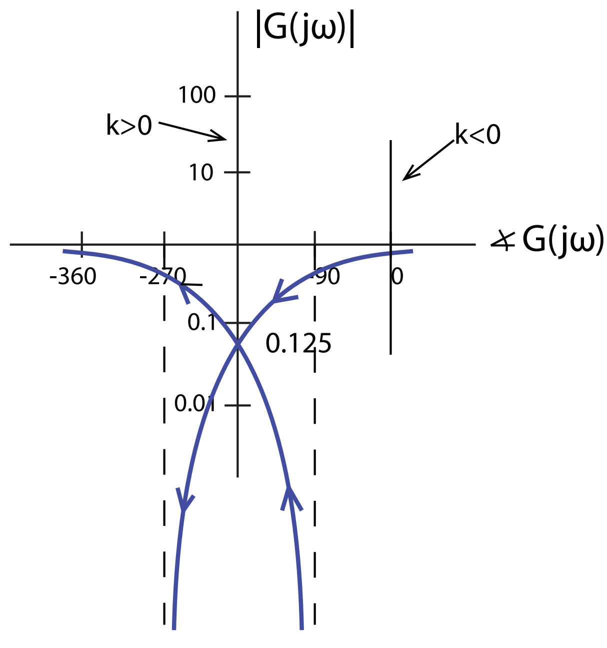
Start with Bode plot of the system:



Nichols:




But, similar to Nyquist, we need to reflect the plot, so what we really have is:




Now the question is how do we count the number of encirclements? $Z = N + P$ still applies! A clockwise encirclement in Nyquist is equivalent to leftward crossing in Nichols. In Nyquist, when counting encirclements, always on imaginary axis. In Nichols, this corresponds to $0^\circ$ vertical line. Along $0^\circ$ line there is one leftward crossing, which makes $N = 1$. Along $-180^\circ$

line for magnitudes greater than 0.125, $N = 0$. For magnitudes lower than 0.125, $N = 2$. What gain corresponds to boundary point?

$$\begin{aligned} \infty > & \frac{1}{K} > \frac{1}{8} \\ 0 < & K < 8 \\ 0 < & \frac{-1}{K} < 1 \\ K > & -1 \\ \text{so stable for } -1 < & K < 8 \end{aligned}$$

Check with Nyquist and get the same result!

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