# 16.06 Principles of Automatic Control
# Recitation 7

**Draw Nyquist plot for following system:**

$$G(s) = \frac{(s+10)^2}{(s+1)^3}$$

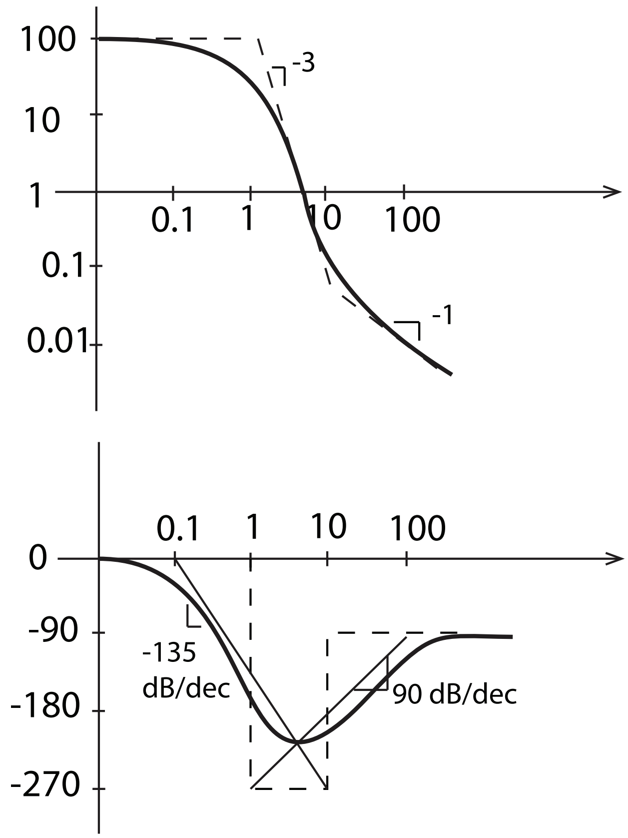
First put into Bode form:

$$\frac{100(\frac{s}{10}+1)^2}{(s+1)^3}$$

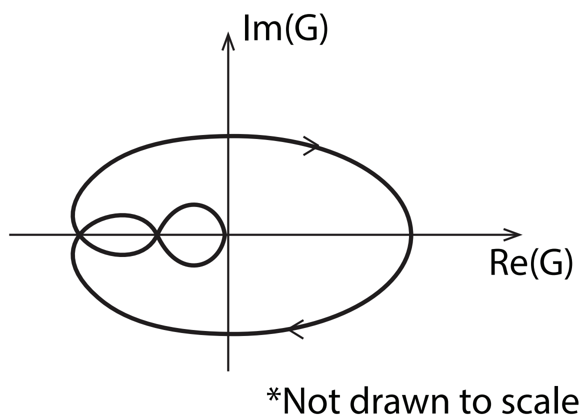
LFA: slope = 0, $1 \cdot 1 = 100$.

Break Points: 1 (triple), 10 (double).

First, sketch Bode plot



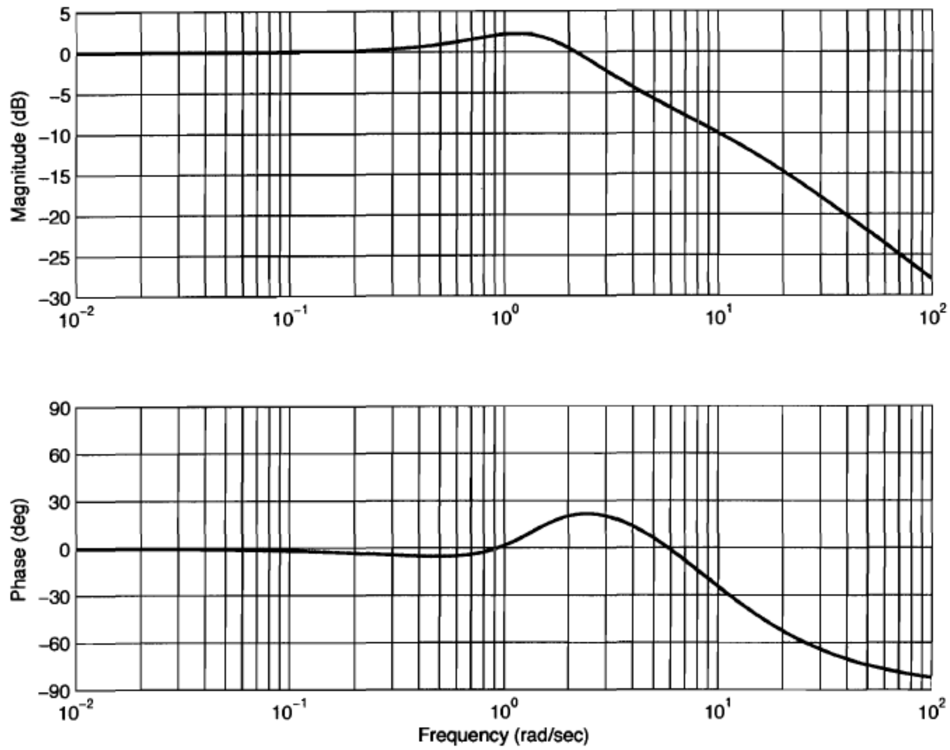

Now sketch Nyquist:




The Bode plot for the following system is sketched below:

$$G(s) = 4\frac{(s-1)(s-5)}{(s^2-2s+2)(s+10)}$$

Use the Bode plot to draw the Nyquist diagram for this system and determine the range of values of $K$ for which the closed-loop system is stable.




In general let's look at what is happening with phase:

Start out at $0°$, then we get slightly negative, then go back to $0°$, then increase to a maximum of about $25°$, decrease back to $0°$, keep decreasing to $-90°$.

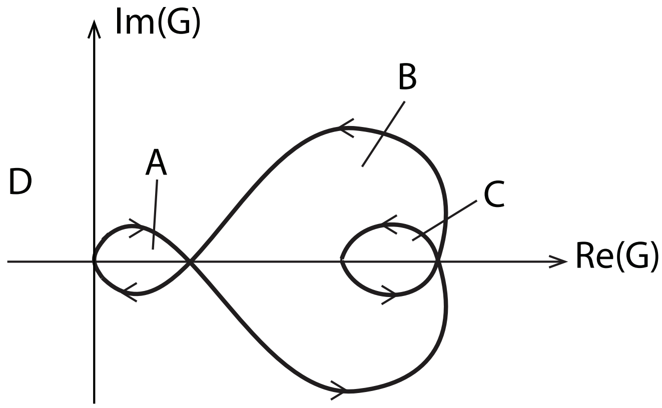
**General behavior of magnitude**

Important note: The magnitude plot is in dB so we have to convert it to magnitude:

$\text{dB} = 20 \log_{10} 1 \cdot 1$

$1 \cdot 1 = 10^{\text{dB}/20}$

Nyquist Plot:




$P = \#$ of open loop RHP poles

$Z = \#$ of closed loop RHP zeros

$N = \#$ of CW encirclements

Now we need to determine stability $Z = N + P$.

For stability we want $Z = 0$. For this system, $P = 2$, so we need $N = -2$ for stability. This minus sign indicates CCW encirclements.

We label four different regions on the Nyquist plot (A,B,C,D) and see that we have $N = -2$ in region C.

$$\begin{aligned} 1 < -1/K < 1.25 \\ -1 > 1/K > -1.25 \\ -1 < K < -0.8 \end{aligned}$$

$$\boxed{-1 < K < -0.8}$$

for stability.