CM416 Exam 3
Open Books-Open Notes
February 16, 2000 7-9

Name:____ Box No.______________

1. (20 pts) Although the Bode plots for an unstable process can not be obtained using frequency response experiments, one can still extend the notion of Bode plots for a given unstable transfer function G(s) by still simply substituting $i\omega$ for s, and then using $|G(i\omega)|$ for amplitude ratio and $arg(G(i\omega))$ for phase shift. Comparing the Bode plots for a stable first order lag $G_1(s)$ with an unstable first order lag $G_2(s)$, where

$$G_1(s) = \frac{1}{\tau s + 1}$$

$$(\tau > 0)$$

$$G_2(s) = \frac{1}{-\tau s + 1}$$

show that the log modulus of both transfer functions are the same, i.e. $LM(G_1) = LM(G_2)$, but the phase shifts are negative of each other, i.e. $\phi(G_1) = -\phi(G_2)$.

2. (30 pts) From the feedback configuration shown in Figure 1, the Bode plots for the process G_p are shown in Figure 2, what would the tuning parameters of a PID controller be based on the Ziegler-Nichols method ?

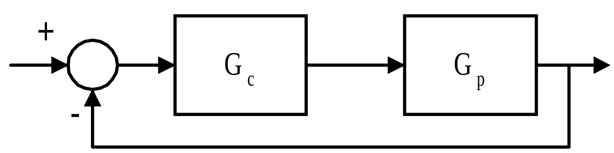


Figure 1.

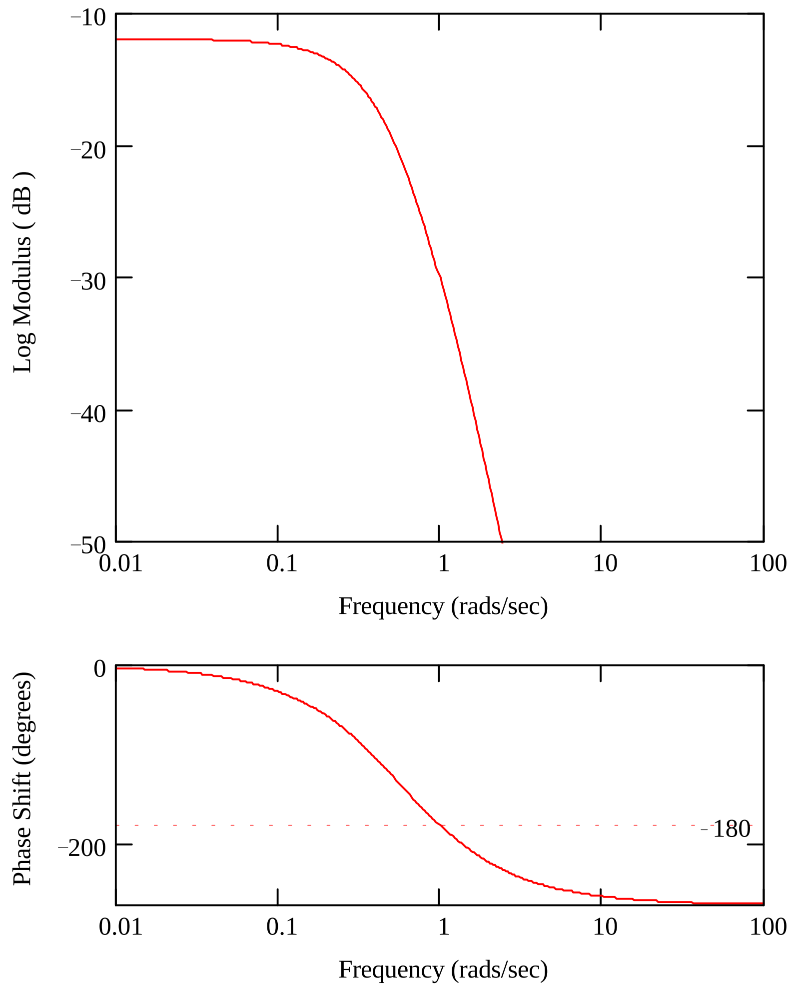


Figure 2. *(dotted line shows -180^o line).*

3. Given the transfer function:

$$G(s) = \frac{K}{(\tau s + 1)^3} \qquad (K > 0, \quad \tau > 0)$$

a) (15 pts) Show that the phase crossover frequency for G(s) is:

$$\omega_{pc} = \frac{\sqrt{3}}{\tau}$$

(*Hint: the phase crossover frequency for a third order lag is the nonzero, positive value of ω for which the imaginary part of G(iω) is zero*.)

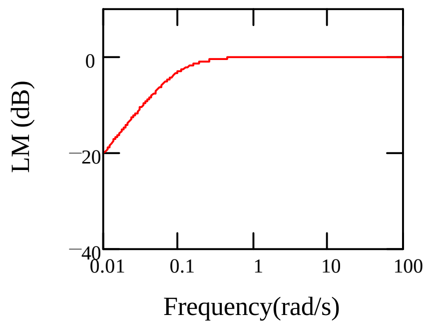
(Additional Tip: Recall that $(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$*)*

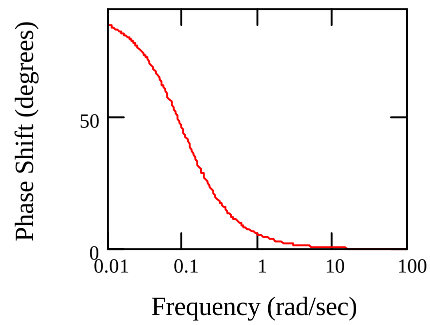
b) (15 pts) Using the crossover frequency in (a), show that the gain margin is given by: GM=*8/K* .

4. For the given cases in Table I, determine which transfer function from Table II matches the different cases.

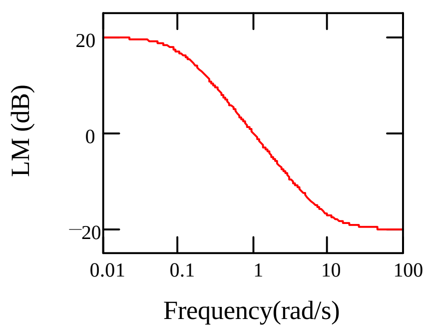
Table I.

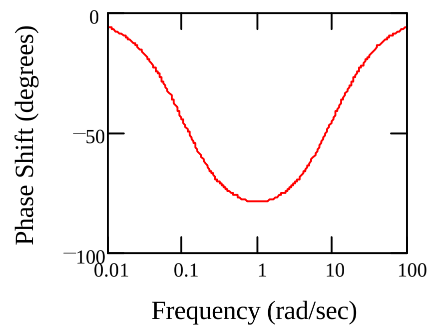
Case 1



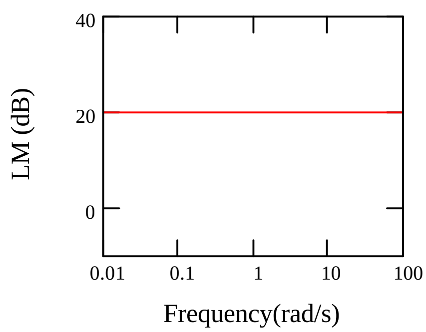


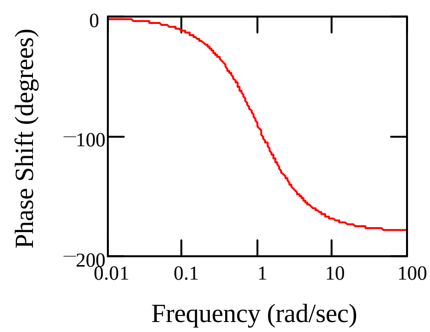
Case 2



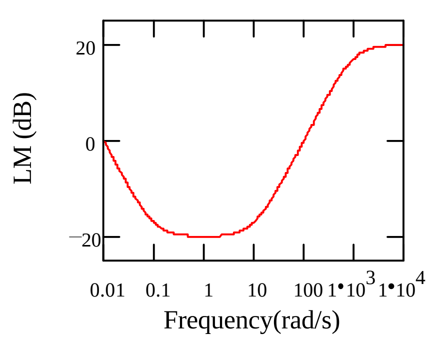


Case 3





Case 4



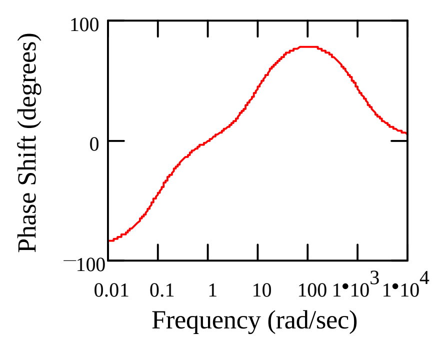


Table II.	
G_1	$10\cdot\frac{-s+1}{s+1}$
G_2	$\frac{10}{s+10}$
G_3	$1+\frac{1}{10\cdot s}$
G_4	$10\cdot\frac{0.1\cdot s+1}{10\cdot s+1}$
G_5	$\frac{10\cdot s+1}{(s+1)\cdot(0.1\cdot s+1)}$
G_6	$10\cdot\frac{s}{10\cdot s+1}$
G_7	0.01
G_8	$0.1\cdot\left[\frac{(10\cdot s+1)}{10\cdot s}\right]\cdot\left(\frac{0.1\cdot s+1}{0.001\cdot s+1}\right)$

5. (Bonus: 5pts) A sample plot of a frequency response experiment is shown in Figure 3, what is the phase shift (in degrees)?