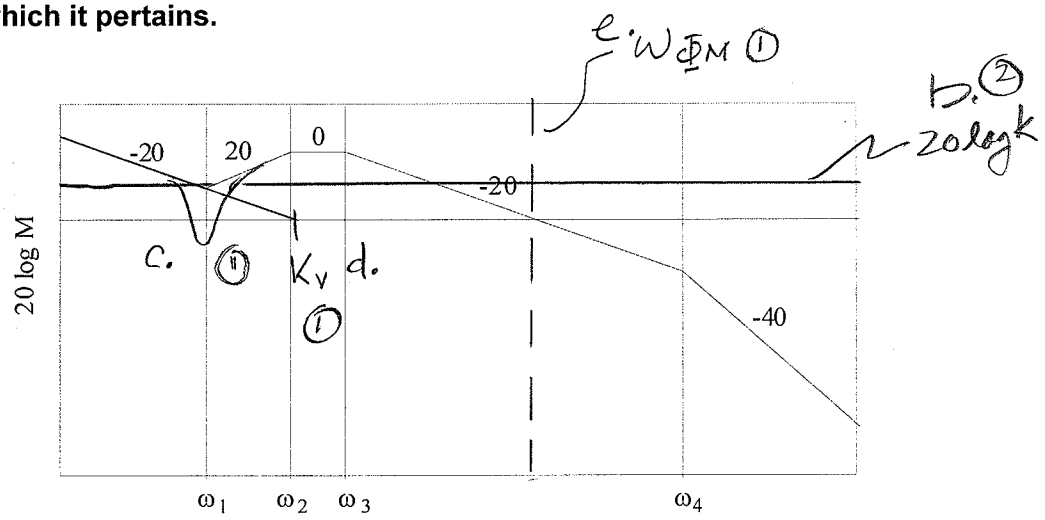
Name _____ Section 0810 0910

ME 422 – Quiz 4

19 November 2010

In answering this problem, show all work. It is your obligation to show clearly how you arrived at your solution, that is the complete train of logic that leads to your answer. In your solution clearly label each part of the solution with the lower case letter to which it pertains.

1.



The magnitude plot of the Bode diagram above shows the composite asymptote of an open-loop transfer function that has unity feedback. The numbers shown on the plot are the values of the slopes in dB/decade. Also, ω_1 = 1 rad/sec, ω_3 = 10 rad/sec, and ω_4 = 1000 rad/sec.

a. Determine the open-loop transfer function using the ωs given above.

b. On the plot above, draw the asymptote for the system's gain.

c. If it is possible for the real system curve (not the asymptote) to have "humps", draw the hump(s) on the above plot. Under what conditions would there be a hump, i.e. what is needed for there to be a hump?

d. Draw on the plot above the static error constant that will allow you to plot a finite steady state error. What input to this system will cause this error? What will be the approximate value of e_{ss}?

e. Draw ω_{GM} or $\omega_{\Phi M}$ on the plot above. For stability, what has to be true about the phase curve at this frequency?

f. Does this system have an integrator or differentiator? Explain your answer.

g. What order is the above open-loop system? Explain your answer.

Quiz 4

a. $$G(s) = \frac{1}{s}\left(\frac{1}{\omega_1^2}s^2 + \frac{2\zeta}{\omega_1}s + 1\right)\frac{1}{\frac{1}{\omega_2}s+1}\cdot\frac{1}{\frac{1}{\omega_3}s+1}\cdot\frac{1}{\frac{1}{\omega_4}s+1} * K$$

(7) ① ② ① ① ①

$$\omega_1 = 1,\ \omega_2 = 3,\ \omega_3 = 10,\ \omega_4 = 1000$$

(2) = b. chart

$$G(s) = \frac{K\left(s^2 + 2\zeta s + 1\right)}{s\left(\frac{1}{3}s+1\right)\left(\frac{1}{10}s+1\right)\left(\frac{1}{1000}s+1\right)}$$ ①

c. Hump only if 2nd order & $\zeta < 0.707$.

(2) Since switch from −20 dB/dcd to +20 dB/dcd, this is a change of 40 dB/dcd, so 2nd-order lead must have ω_n @ $\omega_1 = 1$ rad/sec.

+① hump on chart

d. This is a Type 1 system because initial slope is −20 dB/dcd, the signature of a single integrator. A Type 1

(3) has e_{ss} = finite for a ramp input.

+① K_v on chart

$$e_{ss} \approx \frac{1}{K_v} \approx \frac{1}{3\ \text{rad/sec}} = \frac{1}{3}\ \frac{\text{sec}}{\text{rad}}$$

e. (1) At ω_{BW} for stability the phase must be $> -180°$ (1)
+ (1) on chart

(2) f. See d.

(2) g. Order = 3 : order is order of highest order derivative in denom − order of lowest order derivative there. So an integrator doesn't increase the order. Or, using this rule, $4 - 1 = 3$.

22 Total