ME 422 – Quiz 4
Fall 2012

In giving your answer, the answer alone is not enough. Make sure you clearly give your rationale for arriving at the answer. It must be clear to me how you arrive at your answer.

Plot your system’s Bode plot on the provided sheet.

Weights:

1. The accompanying Bode plotting sheet shows the composite asymptote of an open-loop system.
   a. Determine the open-loop transfer function. Give numerical results, not results in terms of variables.

\[
G_l = \frac{1}{3} \left( \frac{T_1 s + 1}{T_2 s + 1} \right) K
\]
\[
T_1 = \frac{1}{10}, \quad T_2 = \frac{1}{100}, \quad T_3 = \frac{1}{1000}
\]
\[
20 \log K = 40, \quad K = 10^2 = 100
\]

b. On the plotting sheet, draw the asymptotes for the components, which, when combined, give the composite asymptote. Identify clearly the component to which each asymptote belongs.

c. Plot the phase asymptotes of these components on the phase plot. Identify clearly the component for each phase-angle asymptote.

d. Plot the composite phase asymptote as a dotted line.

e. For a unit step input, what is the steady-state error?

Type 1, so \( e_{ss} = 0 \)

f. For a unit ramp input, what is the steady-state error?

\[
e_{ss} = \frac{1}{K_v}, \quad K_v = 100, \quad e_{ss} = \frac{1}{100} = 0.01
\]

g. For a unit parabolic input, what is the steady-state error?

\[
G_{ol} = \frac{100(0.1 s + 1)}{5(0.01 s + 1)(0.001 s + 1)}
\]
h. Plot the gain cross-over frequency on the Bode plot, on both plots.

i. Show the phase margin on the Bode plot. Give the phase margin.

j. What is the gain margin? (Hints: 1) All curves plotted are asymptotes. ii) How much could you raise \( K_p \) before the system goes unstable?)

\[ G_m = \infty \] because \( \phi \) curve never drops below \( \phi = -180^\circ \). Since \( \phi \) curve asymptotic, \( \phi \) never actually reaches \(-180^\circ \) & \( M \) is ever less.

k. If you wanted to de-tune the system, that is, make it less active, and were willing to accept a finite steady-state error of 0.1, what would an additional \( K_p \) be to make the system perform like this?

For \( e_s = 0.1 \),

\[ K_v = 10^3 \] So could lower \( M \) curve by \( 20 \) dB. \( 20 \) log \( K_p = -20 \), \( K_p = 10^{-1} = 0.1 \)

l. What would the phase margin of the de-tuned system be?

Then \( \omega_m \) would be \( 10 \) rad/sec. There

\[ \phi = -45^\circ \] so \( \phi_m = 180 - 45 = 135^\circ \)