EE 231 **Exam#3** **Apr. 27, 1989**

75 minutes

1. Consider a negative feedback control system with the open-loop transfer function

$$G(s)H(s) = \frac{K(s+2)(s-6)}{s^3}$$

   (a) Construct the root locus diagram. Indicate important features like asymptotes, imaginary axis crossings, break-away and break-in points. (25pts)

   (b) Determine the positive values of K such that the closed-loop system is stable. (05pts)

   (c) Determine the positive value(s) of K such that the system has sustained oscillations. (05pts)

   (d) Determine the positive values of K such that all the poles of the closed-loop system are real. (05pts)

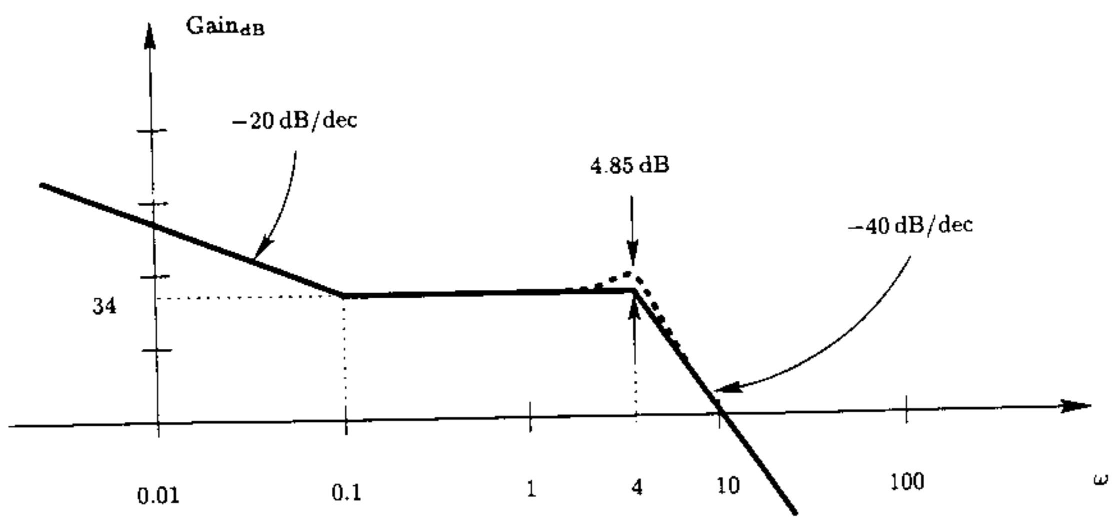
2. Consider a negative feedback control system with the open-loop transfer function

$$G(s)H(s) = \frac{(s+2)(s+6)}{s^3}$$

   (a) Design a compensator so that the complex closed-loop poles are approximately located at $s = -3 \pm j\,3\sqrt{3}$ and the compensator gain is as large as possible. (20pts)

   (b) Determine the static error coefficient (the one which is nonzero and finite) and the corresponding steady state error for the compensated system. Design another compensator for the compensated system which reduces this steady state error to approximately one half of its previous value and doesn't change the desired pole locations much. The closest compensator pole or zero to the origin should be located at $s = -0.01$. Use the approximate pole locations to determine the new system gain. (10pts)

3. The frequency response of a minimum-phase, stable control system has been obtained experimentally, and the following asymptotes have been fitted.



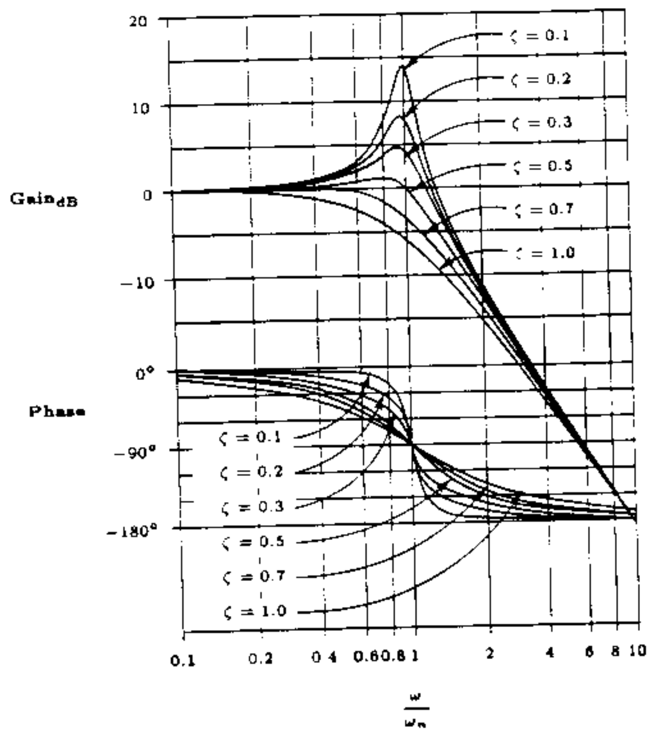
   (a) Determine the transfer function from the asymptotes. (20pts)

(b) Sketch approximate phase versus frequency plot of the control system. (10pts)

Make intelligent use of the figure on the right which shows the magnitude and phase versus frequency plots of

$$\frac{1}{(j(\omega/\omega_n))^2 + 2\zeta\,(j(\omega/\omega_n)) + 1}$$

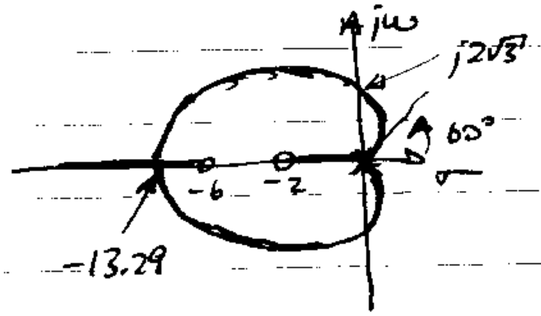
for different values of ζ.



EE231

EXAM#3
ANSWERS

#1 a//



b// $K > 1.5$

c// $K = 1.5$

d// $K \geq 28.52$ (and K=0 trivial)

#2 a// $D_1(s) = 8.27 \frac{s+4.94}{s+7.29}$

b// $K_v = 67.25$, $e_{ss} = 0.015$

$D_2(s) = 1.001 \frac{s+0.02}{s+0.01}$

#3 a// $G(s) = \frac{756.8(s+0.1)}{s(s^2+2.4s+16)}$

b//