

Copyright © 1998 by Levent Acar. All rights reserved. No parts of this document may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without the written permission of the copyright holder(s).

1. Sketch the asymptotes for the gain versus frequency plot for a system with the transfer function

$$G(s) = \frac{(s + 100)^2}{s(s + 1)}$$

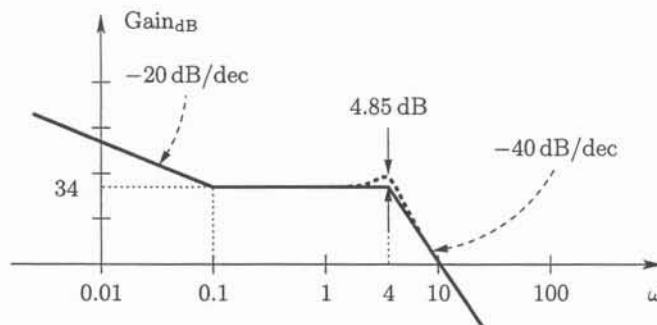
(15pts)

2. Determine the cut-off frequency or frequencies of a system with the transfer function

$$G(s) = \frac{10(s + 1)}{(s + 10)(s + 500)}$$

(15pts)

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

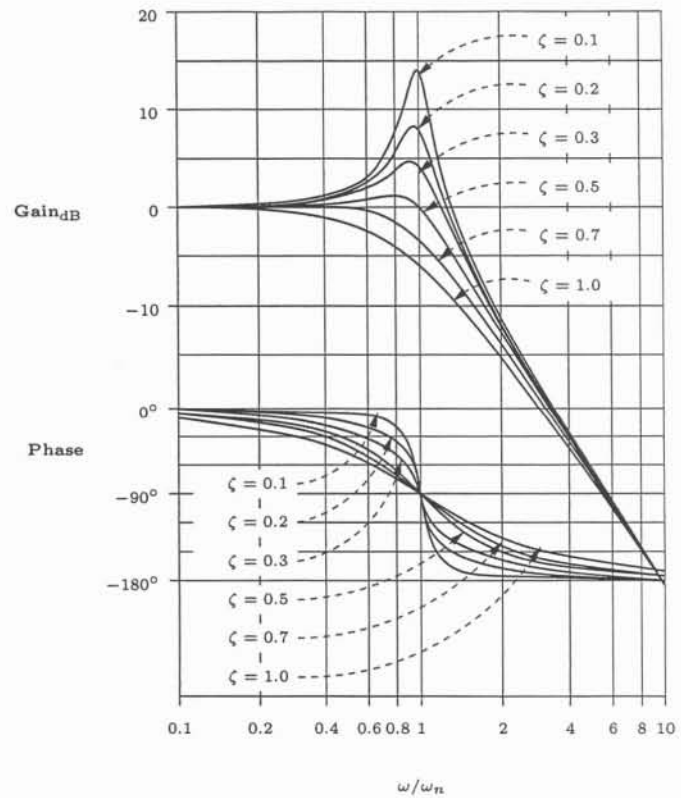


- (a) Determine the transfer function from the asymptotes. (20pts)
- (b) Sketch approximate phase versus frequency plot of the control system. (15pts)

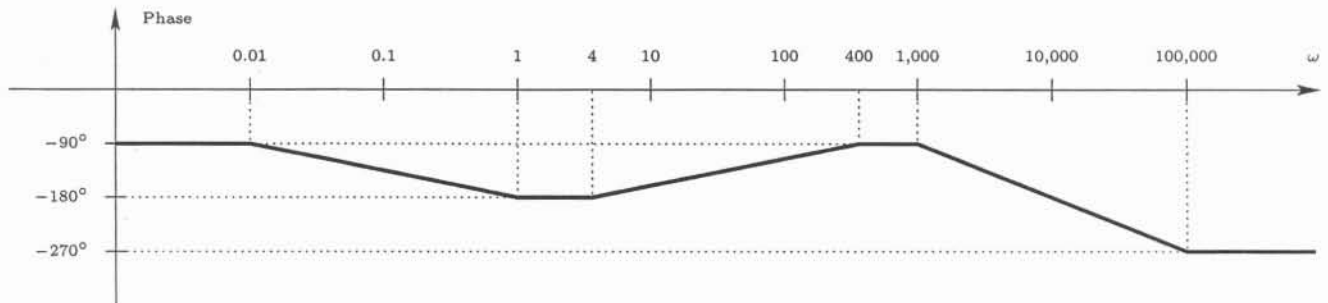
Make intelligent use of the figure on the right which shows the magnitude and phase versus frequency plots of

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

for different values of ζ .



4. The phase of a certain minimal-phase, stable feedback control system has been obtained experimentally, and the following asymptotes were obtained.

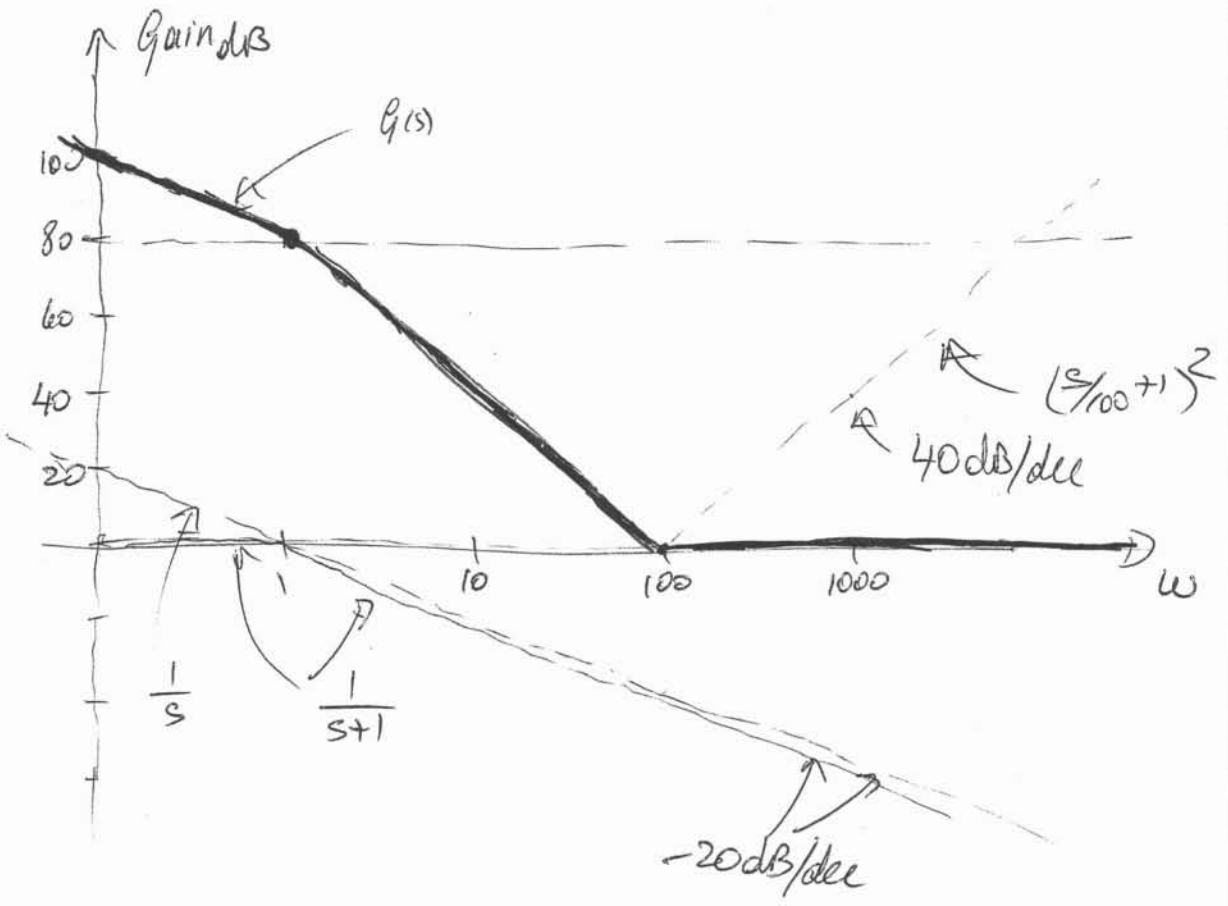


- Determine the transfer function from the asymptotes as much as possible, and leave the indeterminate quantities in parametric form. (20pts)
- Sketch approximate gain versus frequency plot assuming "reasonable" values for the missing quantities. Show your assumptions clearly. (15pts)

COPYRIGHT © 1998 BY L. DEAR

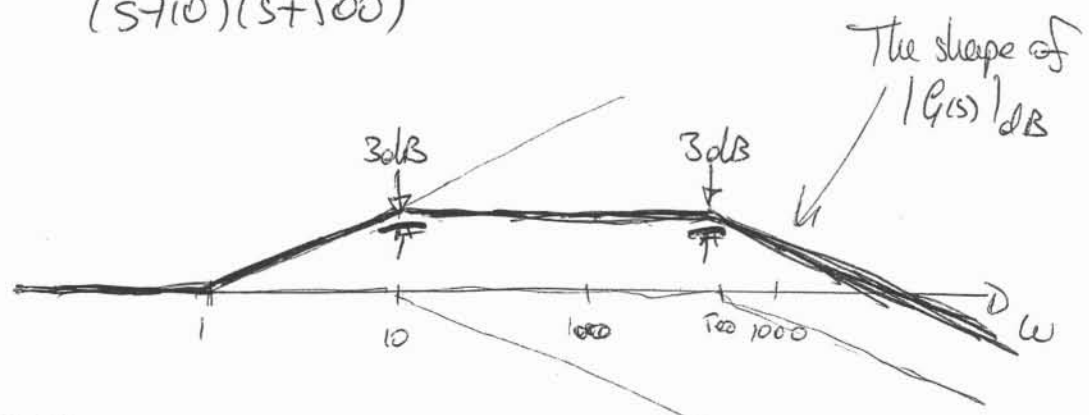
#1

$$G(s) = \frac{(s+100)^2}{s(s+1)} = \frac{100^2 (s/100 + 1)^2}{s(s+1)}$$



#2

$$G(s) = \frac{10(s+1)}{(s+10)(s+100)}$$

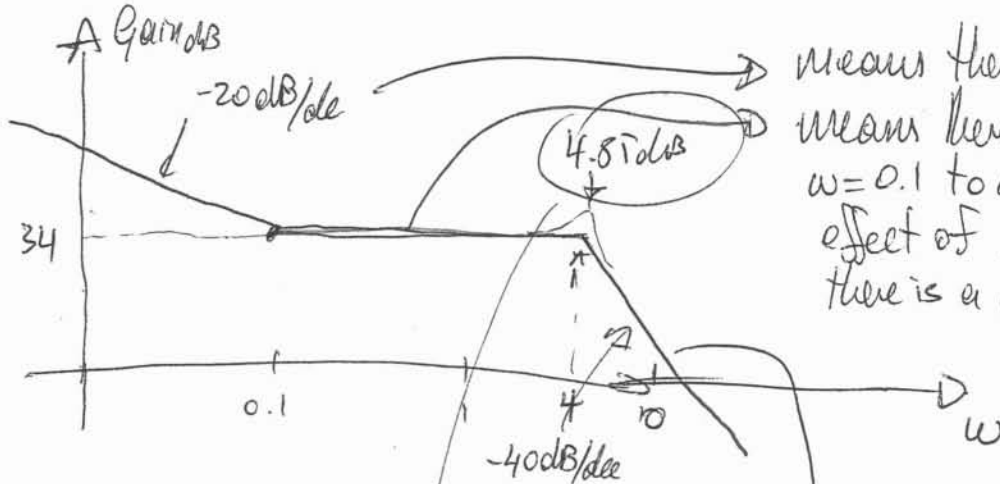


Cutoff freq when the gain is 3dB below the maximum since asymptotes are 3dB off at their change of direction locations,

13-702 500 SHEETS, FILLER, 2 SQUARE
 42-301 50 SHEETS EYE-EASE, 2 SQUARE
 42-302 100 SHEETS EYE-EASE, 2 SQUARE
 42-303 100 SHEETS EYE-EASE, 2 SQUARE
 42-304 100 SHEETS EYE-EASE, 2 SQUARE
 42-305 100 RECYCLED WHITE, 2 SQUARE
 42-306 200 RECYCLED WHITE, 2 SQUARE
 42-309 200 RECYCLED WHITE, 2 SQUARE
 Made in U.S.A.
 National Brand

in this case the cut-off frequencies are at

$$\omega = 10 \text{ and } \omega = 500.$$



means there is a $\frac{1}{s}$ term
means there is a zero at $\omega = 0.1$ to cancel the effect of $\frac{1}{s}$ i.e. there is a $(\frac{s}{0.1} + 1)$ term

means there is a double pole or a complex pair at $\omega_n = 4$

means there is a peak with 4.8 dB value, from the graph this corresponds to $\zeta \approx 0.3$

Therefore, there is a complex pair at $\omega_n = 4$ with $\zeta = 0.3$ or

$$\left(\frac{s}{4}\right)^2 + 2 \times 0.3 \times \left(\frac{s}{4}\right) + 1$$

So $G(s) = K \frac{s/0.1 + 1}{s \left(\left(\frac{s}{4}\right)^2 + 0.6 \left(\frac{s}{4}\right) + 1 \right)}$

To determine K , we can use the magnitude at any frequency. However, the sketch, we have is only the asymptotes. So we either incorporate the difference between the asymptotes and the real plot, or pick a point where the asymptotes are almost the same as the real plot.

$$\text{at } \omega = 0.1 \quad |G(s)|_{dB} = (34 + 3) dB = 37 dB$$

$$\text{or } |G(s)|_{s=j0.1} = 10^{37/20} = 70.8$$

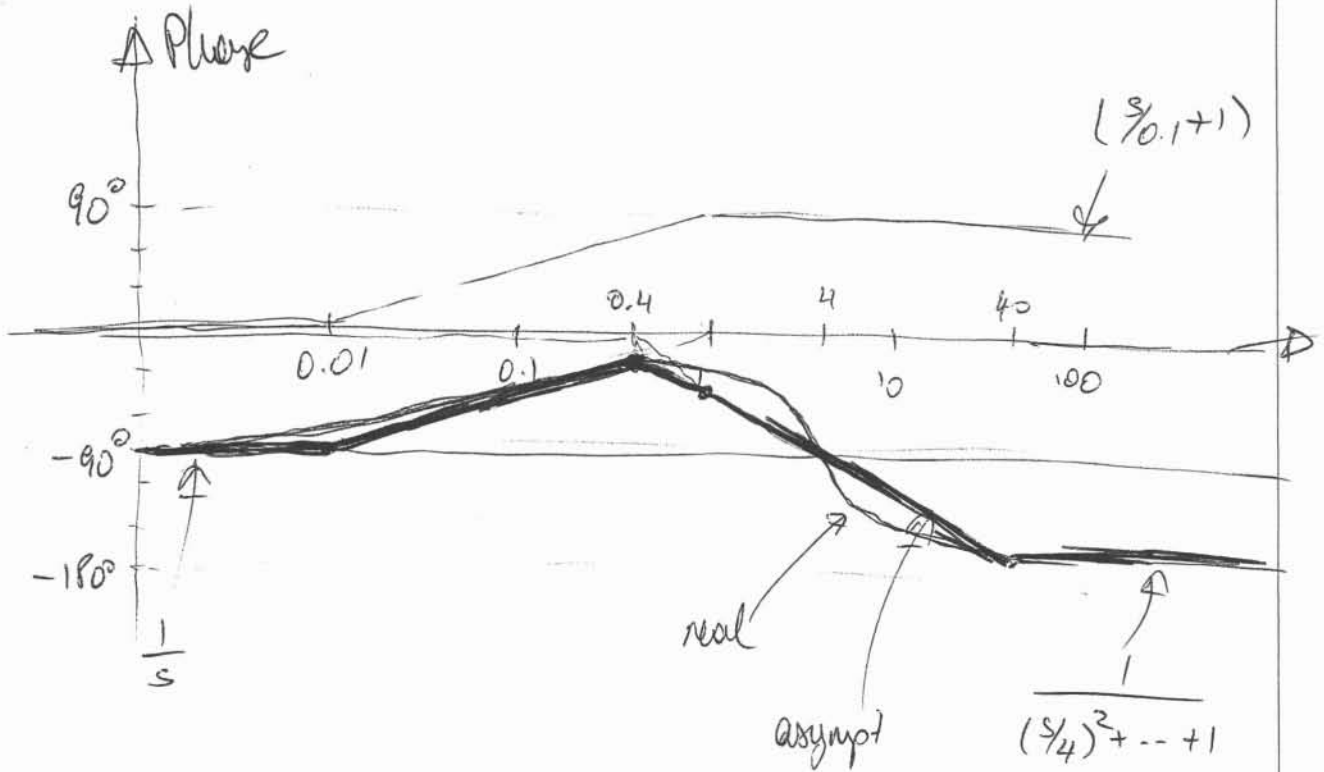
$$\left| K \frac{j^{0.1}/0.1 + 1}{j^{0.1} \left((j^{0.1}/4)^2 + 0.6(j^{0.1}/4) + 1 \right)} \right| = 70.8$$

$$\Rightarrow K \approx 5$$

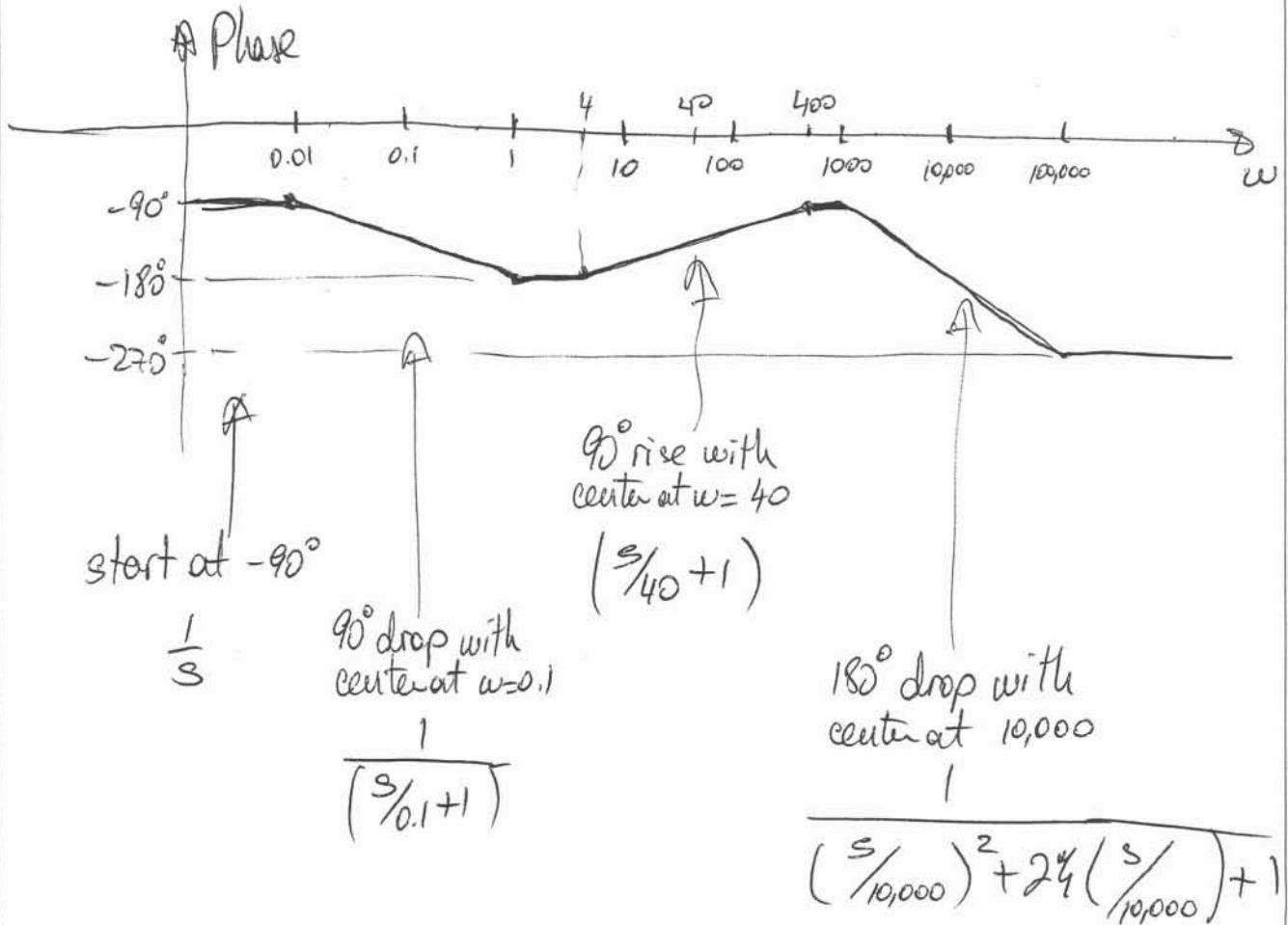
$$\text{or } G(s) = 5 \frac{s/0.1 + 1}{s \left((s/4)^2 + 0.6(s/4) + 1 \right)}$$

$$= 800 \frac{s + 0.1}{s(s^2 + 2.4s + 16)}$$

13-782 500 SHEETS, FULLER, 5 SQUARE
42-281 50 SHEETS, EYE-EASE, 5 SQUARE
42-282 200 SHEETS, EYE-EASE, 5 SQUARE
42-283 100 SHEETS, EYE-EASE, 5 SQUARE
42-382 100 RECYCLED WHITE, 5 SQUARE
42-389 200 RECYCLED WHITE, 5 SQUARE
Made in U.S.A.

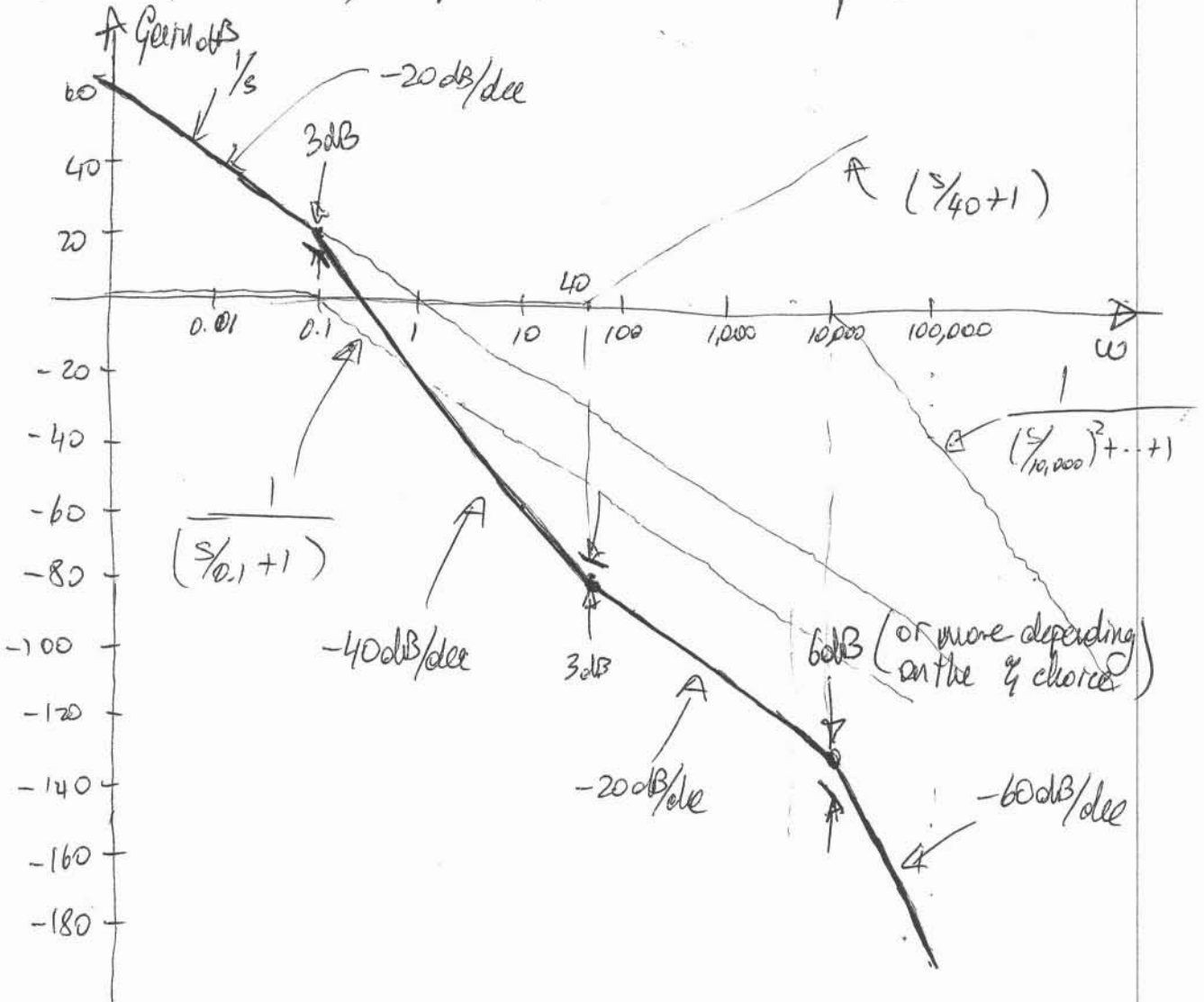


#4



$$G(s) = \frac{K(s/40 + 1)}{s(s/0.1 + 1) \left((s/10,000)^2 + 2\zeta(s/10,000) + 1 \right)}$$

b) let $K=1$, $\zeta=1$ ← double pole



500 SHEETS TILDA 5 SQUARE
400 SHEETS TILDA 5 SQUARE
300 SHEETS TILDA 5 SQUARE
200 SHEETS TILDA 5 SQUARE
100 SHEETS TILDA 5 SQUARE
50 SHEETS TILDA 5 SQUARE
25 SHEETS TILDA 5 SQUARE
10 SHEETS TILDA 5 SQUARE
5 SHEETS TILDA 5 SQUARE
2 SHEETS TILDA 5 SQUARE
1 SHEET TILDA 5 SQUARE
100 RECYCLED WHITE 5 SQUARE
50 RECYCLED WHITE 5 SQUARE
25 RECYCLED WHITE 5 SQUARE
10 RECYCLED WHITE 5 SQUARE
5 RECYCLED WHITE 5 SQUARE
2 RECYCLED WHITE 5 SQUARE
1 RECYCLED WHITE 5 SQUARE
MADE IN U.S.A.

