Mid Semester Exam # 2
EE 250 (Control Systems Analysis) Spring 2010 *

DEPARTMENT OF ELECTRICAL ENGINEERING, IIT KANPUR.

Dear student,

1. Before you turn in your answer books, please verify that your answer booklet contains one semilog graph paper.
2. Use a ruler to draw the BPs.
3. You may use a pencil for trial and error, but your final drawing should be using a pen.
4. Show all your assumptions.
5. If you need a calculator, you may not borrow it during the exam.

Problem 1

Consider the control system of Figure 1. We wish to design a compensator $D(s)$ that satisfies the following design specifications:

(a) $K_v = 100$.

(b) PM $\approx 60^\circ$.

(c) Sinusoidal inputs of up to 1 rad/sec to be reproduced with $\leq 2\%$ error.

(d) Sinusoidal inputs with a frequency of greater than 100 rad/sec to be attenuated at the output to $\leq 5\%$ of their input value.

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1. **[2 points]** Determine K_1 and K_2 of Figure 2.
2. **[1 points]** Write the numerical values of ω_1 and ω_2 of Figure 2.
3. **[1 points]** What is the decade distance needed between the corner frequencies ω_l and ω_h for the desired Bode plot of Figure 2?
4. **[1 points]** Is this DD the distance on the BMP or on the ABMP or both?
5. **[4 points] On the semilog grid provided**, draw the ABMPs of the desired $D(s)G(s)$ and of $G(s)$. Your figure must contain all the necessary labels.
6. **[1 points] On the semilog grid provided**, show the ABMP of the resulting $D(s)$. Write the TF of $D(s)$.
7. **[1 points]** For the resulting CL system, given that $\omega_B \in [\omega_{min}, \omega_{max}]$, where ω_B is the bandwidth, what are the values of ω_{min} and ω_{max}?

Problem 2

1. **[2 points]** For the standard second order system shown in Figure 3, derive the expression for the bandwidth ω_b (same as 3-dB frequency) in terms of ω_n and ζ.
2. **[2 points]** Derive the expression for the OL gain crossover frequency ω_g.

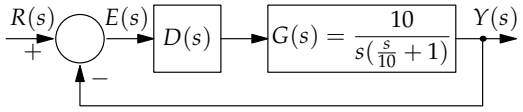

Figure 1: Control system to be designed in Problem 1.

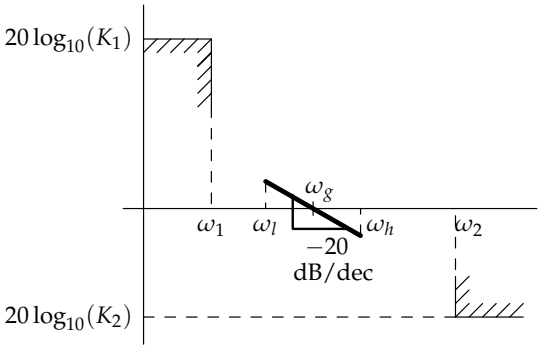

Figure 2: Parameters for loop-shaping for Problem 1.

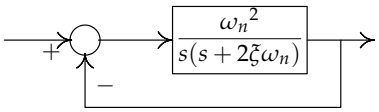

Figure 3: Block diagram of standard second order system for Problem 2.

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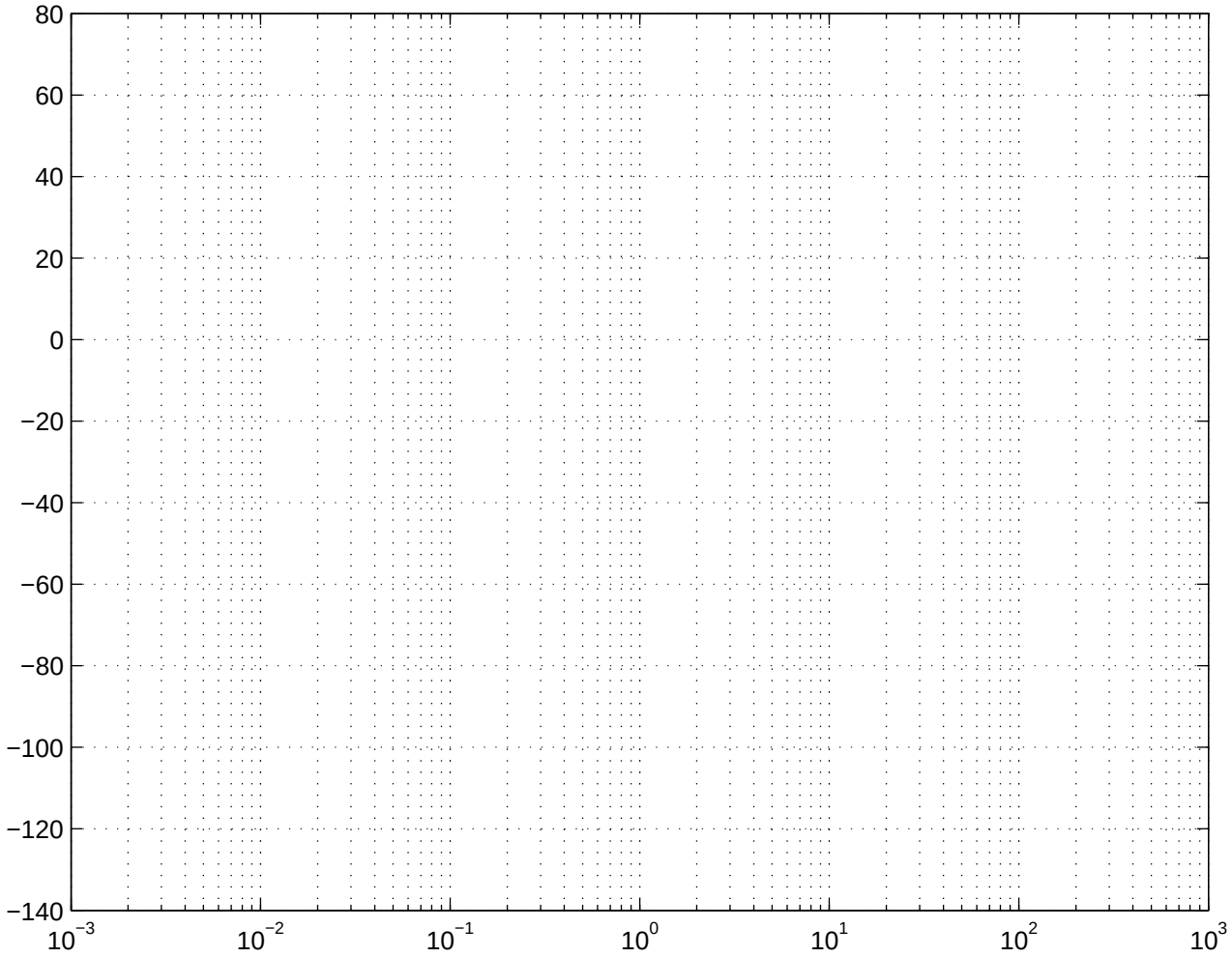
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