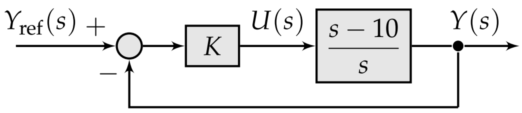
Midsem. # 2, EE 250 (Control System Analysis), 2011*

DEPARTMENT OF ELECTRICAL ENGINEERING, IIT KANPUR

1. Determine, using Nyquist stability theory, the values of $K \geq 0$ for which the following control system is stable. Each problem is of 1 point.



1.1. Sketch the BP.

1.2. Sketch the polar plot (PP) section of the NP. Show this section by a thick solid line. Mark the critical point.

1.3. If necessary, work out a few points on the s-plane contour and the $G(s)$-plane contour that will help complete the NP.

1.4. Sketch the NP. Label the sections of the s-plane contour $C1, C2, \cdots$ and the corresponding sections of the NP $C1', C2', \cdots$.

1.5. Use NST to determine the values of K for which the CL system is stable.

1.6. Is this system conditionally stable? Explain.

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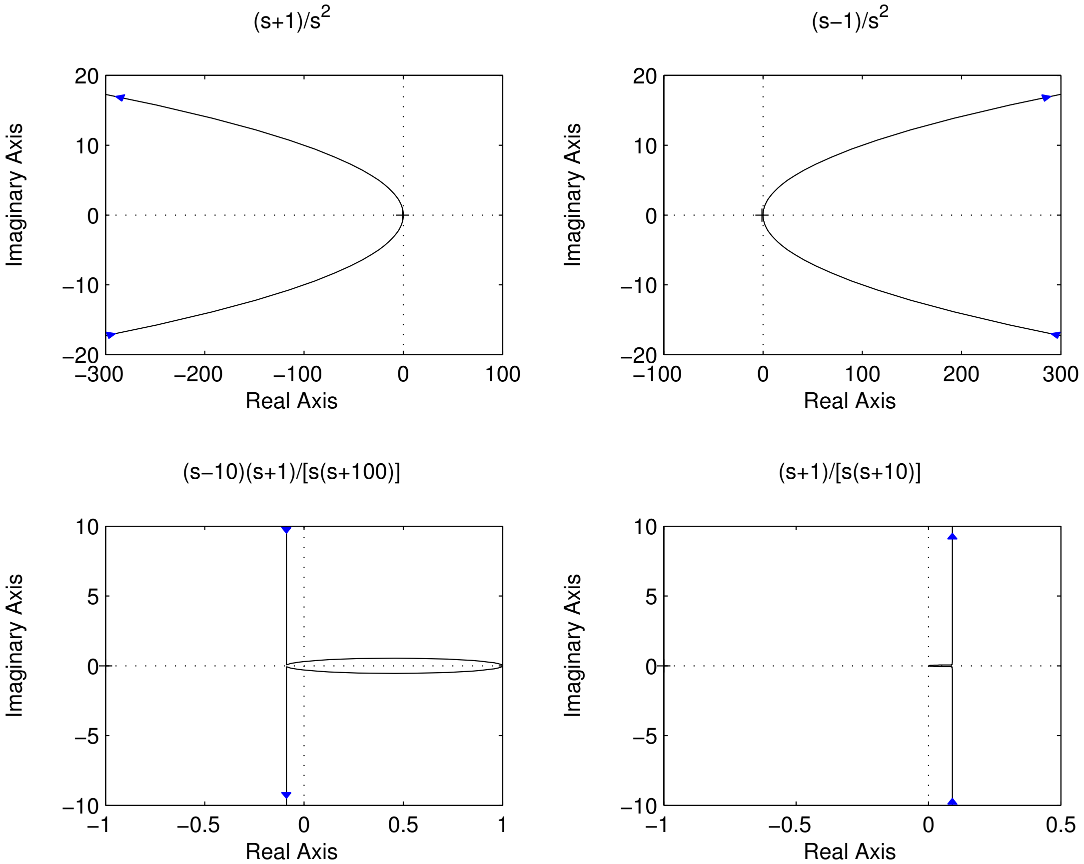
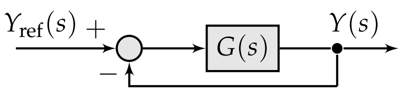
2. **[4 points]** The following are the plots generated by MATLAB's `nyquist` function. In whatever space you can squeeze out near each plot, complete each of these plots to obtain the Nyquist plot.



3. We wish to design $G(s)$ for the control system



to satisfy the following specifications: We wish to design a compensator $D(s)$ that satisfies the following design specifications:

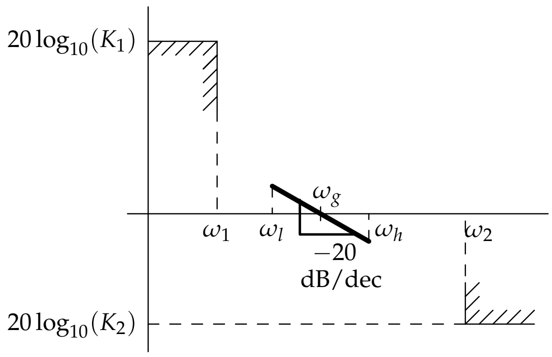
(a) Peak overshoot in the unit step response of approximately 20%.

(b) Sinusoidal inputs of up to 1 rad/sec to be reproduced with $\leq 5\%$ error.

(c) Sinusoidal inputs with a frequency of greater than 100 rad/sec to be attenuated at the output to $\leq 10\%$ of their input value.

(d) Steady-state error to a unit step to be less than 1%.

With respect to the following figure



3.1. **[2 points]** Determine K_1 and K_2.

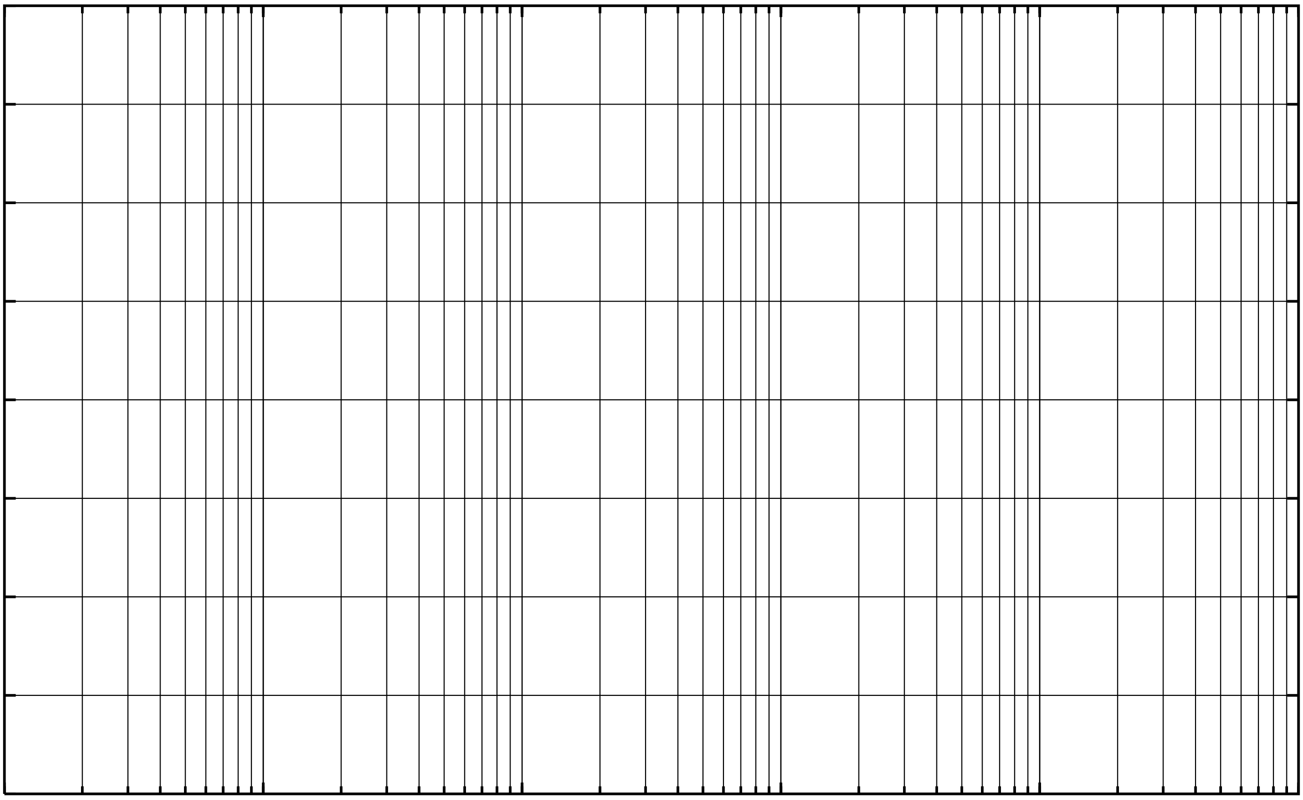
3.2. **[1 points]** $\omega_1 =$? and $\omega_2 =$?

3.3. **[1 points]** What is the decade distance needed between the corner frequencies ω_l and ω_h for the desired Bode plot?

3.4. **[1 points]** Is this DD the distance on the BMP or on the ABMP or both?

3.5. **[3 points] On the semilog grid provided**, draw the ABMP of the desired $G(s)$. Your figure must contain all the necessary labels.

3.6. **[1 points]** For the resulting CL system, given that $\omega_{\mathrm{B}} \in [\omega_{\min}, \omega_{\max}]$, where ω_{B} is the bandwidth, what are the values of $\omega_{\min}$ and $\omega_{\max}$?



Useful information:

25°	40°	60°	70°
45%	25%	10%	5%

	90° (−90°)	60° (−60°)	45° (−45°)	30° (−30°)
	∞	1.1439	0.76555	0.47712
		≈ 1.144	≈ 0.766	≈ 0.477