Controls Qualifying Examination August 2014

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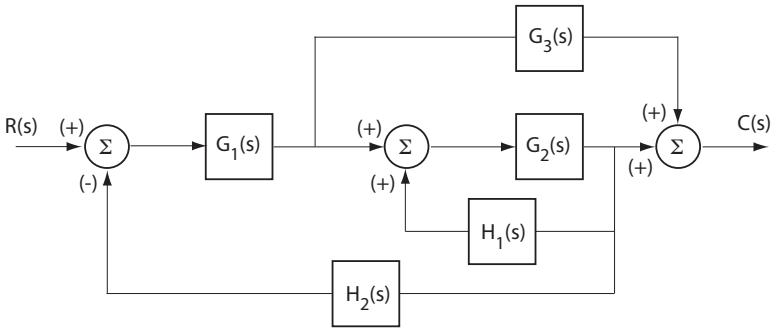
Open Book
Answer All Questions
All Questions Weight Equally

Time: 3.0 hours

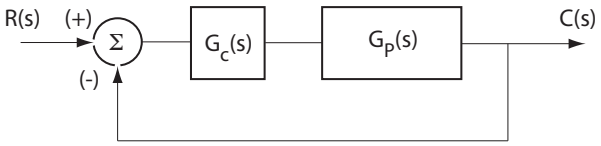
Problem 1.

Find the transfer function $T(s) = C(s)/R(s)$ from the block diagram given below.



Problem 2.

For the system shown in the figure below



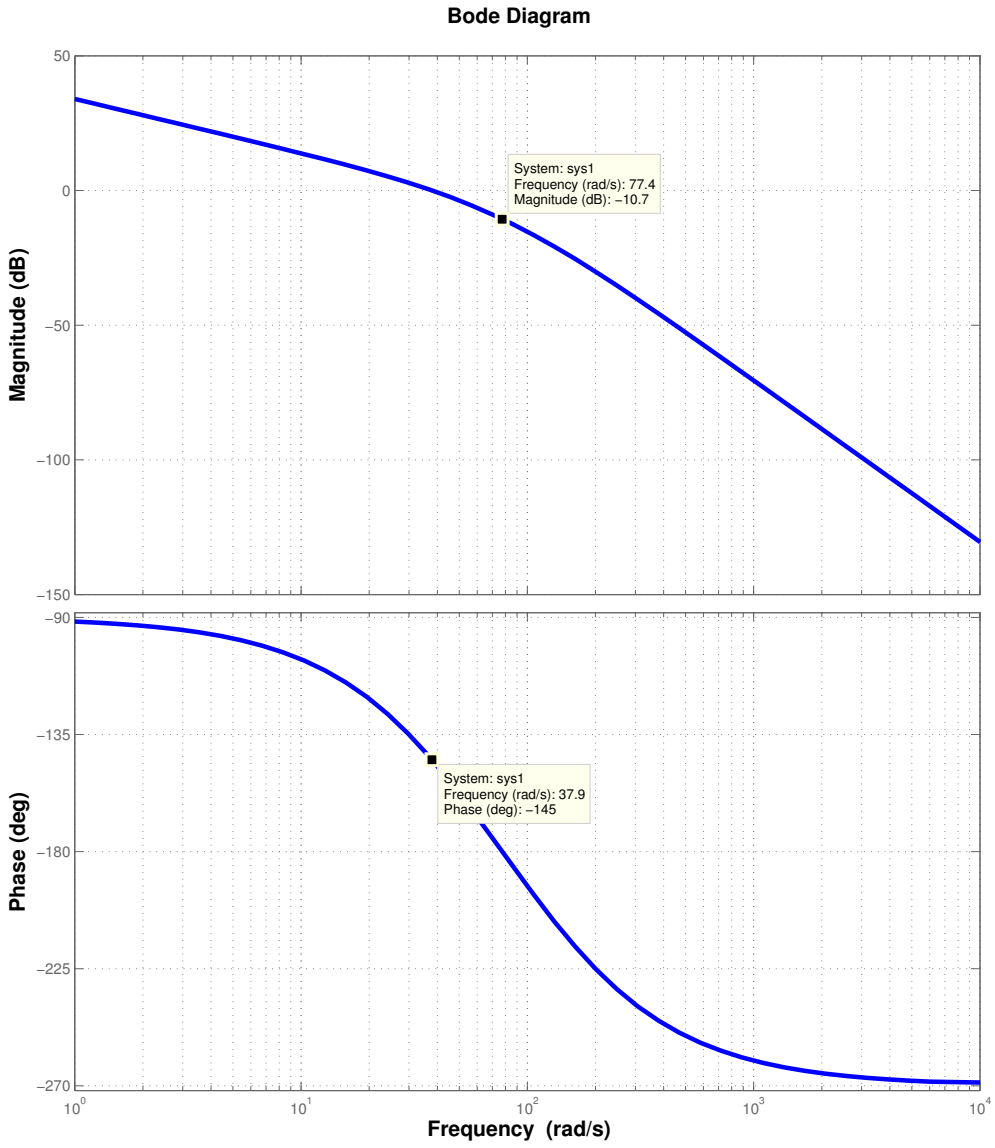
sketch the root locus for

$$G_c(s) = K, \qquad G_p(s) = \frac{(s+0.4)}{s^2(s+3.6)}$$

[Hint: Find all break away points before drawing the root locus.]

Problem 3.

Consider a unity (negative) feedback with KG as the open-loop system transfer function. The open-loop system transfer function of $K(s)G(s)$ was measured for $K(s) = 1$ and the Bode Diagram is given as follows.



(a) What is the closed-loop system's Gain Margin?
(b) What is the closed-loop system's Phase Margin?
(c) Is the closed-loop system stable at $K = 1$?
(d) What is the maximum closed-loop stable value of K ?

Problem 4.

Consider the feedback system with the open-loop transfer function $K(s)G(s)$ in Problem 3.

The objective of the feedback control is that the close-loop system's phase margin is 50° and the steady state error for a unit ramp signal $r(t)$ is 0.01. Note that for this tracking control, the input to $K(s)G(s)$ is now replaced with $u(t) = r(t) - y(t)$, where $u(t)$ and $y(t)$ are input and output signals of $K(s)G(s)$.

(a) Choose a type of a compensator for $K(s)$. Justify your answer and state design targets.

(b) Determine the DC gain of your compensator necessary to meet the steady state error requirement when

$$\lim_{t\to\infty} sG(s) = 50.$$

(c) Assume that your controller $K(s)$ from (a) stabilizes the closed-loop system. Compute the steady state error of the closed-loop system with your choice of the compensator $K(s)$ for unit step input $r(t)$.