

University of California, Davis
Society of Manufacturing Engineers at UC Davis

EME 172 and EEC 157A*

Control Systems

Unofficial

Unofficial Quiz

*Disclaimer: This document is a quiz that focuses on control systems theory. It is an unofficial quiz and does not necessarily reflect the format—in the length of any exams, content covered, the protocol, and other aspects—of an actual final exam of EEC 157A or EME 172 in University of California, Davis. However, this covers multiple topics that seems to be a complete agenda of those courses and this document is an attempt to give students extra practice. The problems in this document are written entirely by the author. Any similarity, either in part or in whole, is a complete coincidence. If an error is caught, or if you have any questions and inquiries, please contact the author at mnhyu@ucdavis.edu.

This quiz has eight (8) pages, including this front cover page and the formula sheet.

Although there are significant overlaps, some topics may not necessarily be in EEC 157A or EME 172, whichever you may be taking. Do not feel pressured to study those not covered.

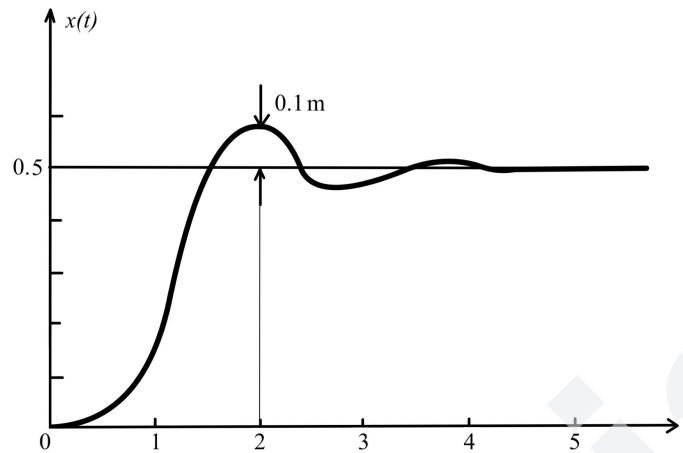
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Question 1) Time Domain Analysis	
Question 2) Root Loci	
Question 3) Nyquist Criterion	
Question 4) Controllers	

Note: j is used to represent the square root of -1 , and not i .

1) Time Domain Analysis

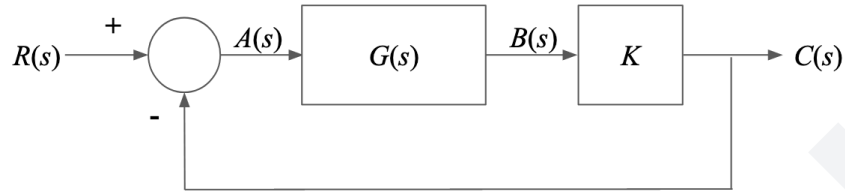
An open loop response, after applying a step function, is shown below (not drawn to scale)



- Find a numerical expression for $G(s)$, which is a second order transfer function that relates the output response over the input.
- Find $x(t)$ and the 96% settling time.

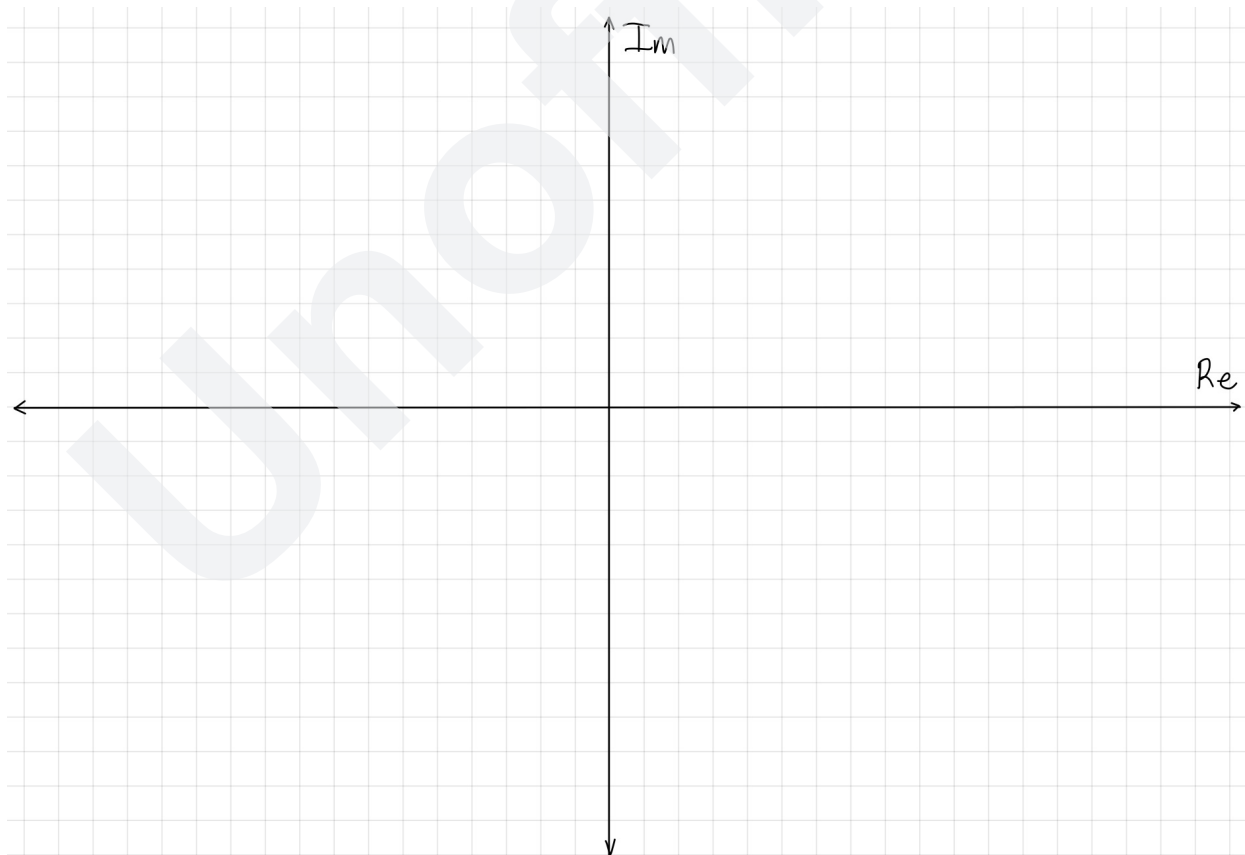
2) Root Loci

In the following feedback system, the relationship between point $A(s)$ and $B(s)$ are described by the following equation in the time domain, (note, d_t is another notation for d/dt)



$$d_t^2 b(t) + 14 d_t b(t) + 97 b(t) = d_t a(t) - 2 a(t)$$

- a) Completely sketch the root locus for this system, $0 \leq K \leq \infty$. Numerically mark
 - i) The critically damped point(s) and its/their corresponding K 's, if any.
 - ii) The closed loop pole(s) where the plot crosses $j\omega$ axes and its/their corresponding K 's.
 - iii) The angle of departure from complex poles, if any.
 - iv) The asymptote(s) as s approach extremely high frequencies.
- b) For part a) i), find $c(t = \infty)$ for a step response.
- c) For part a) ii), if we apply a step response as an input, does the system oscillate? If so, find its oscillation frequency. Otherwise, why not?

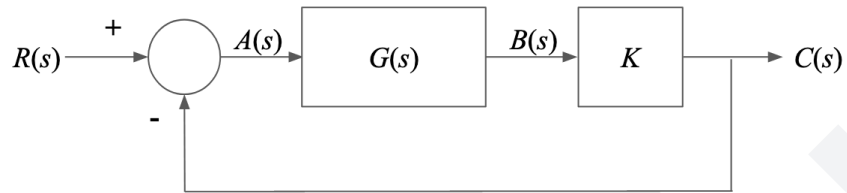


Extra space for question 2)

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3) Nyquist Criterion

In the following feedback system, the relationship between point $A(s)$ and $B(s)$ are described by the following equation in the time domain, (note, d_t is another notation for d/dt)



$$d_t^4 b(t) + 10 d_t^3 b(t) = a(t)$$

Completely sketch the Nyquist plot. What values of K , if any, would this system be stable?

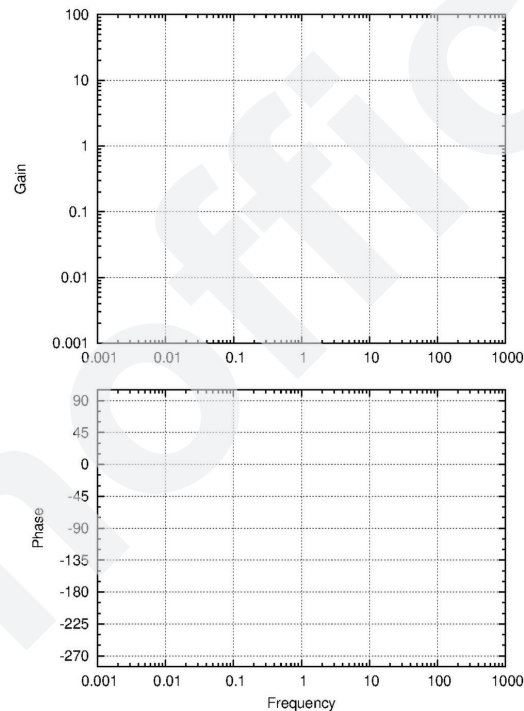
4) Controller

For a unity feedback system, the open loop transfer function is $G(s) = K[s(s+10)]^{-1}$.

- What is the value of K where the system is critically damped?
- For the K you found in part a), find the gain margin and phase margin for both an open loop response and the unity feedback.
- Implement a controller so that
 - Ramp input steady state error is zero
 - Peak time is 500 ms when the damping factor is $1/\sqrt{2}$

and draw a simple root locus for the closed loop system that has the controller. The locus needs not be polished, but do draw a line for where the damping factor is $1/\sqrt{2}$. You don't need to find the gain of the controller; simply find its essential roots.

- Should your controller worsen the phase margin, or improve it? Why?



Extra space for question 4)

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Formula Sheet

$f(t)$	$F(s)$
$\delta(t - T)$	e^{-Ts}
$(t - T) u(t - T)$	$e^{-Ts} s^{-2}$
$e^{-a(t-T)} u(t - T)$	$e^{-Ts} (s + a)^{-1}$
$t^{n-1} e^{-at} u(t)$	$(n - 1)! (s + a)^{-n}$
$\cos(\omega t) e^{-at} u(t)$	$(s + a) ((s + a)^2 + \omega^2)^{-1}$
$\sin(\omega t) e^{-at} u(t)$	$\omega ((s + a)^2 + \omega^2)^{-1}$
$d_t^n f(t)$	$s^n F(s) - \sum_{i=1}^n s^{n-i} d_i f(0^-)$
$\int f(t) dt$	$F(s) / s$
$A e^{-at} t^{n-1} u(t) / (n - 1)!$	$A / (a + s)^n$