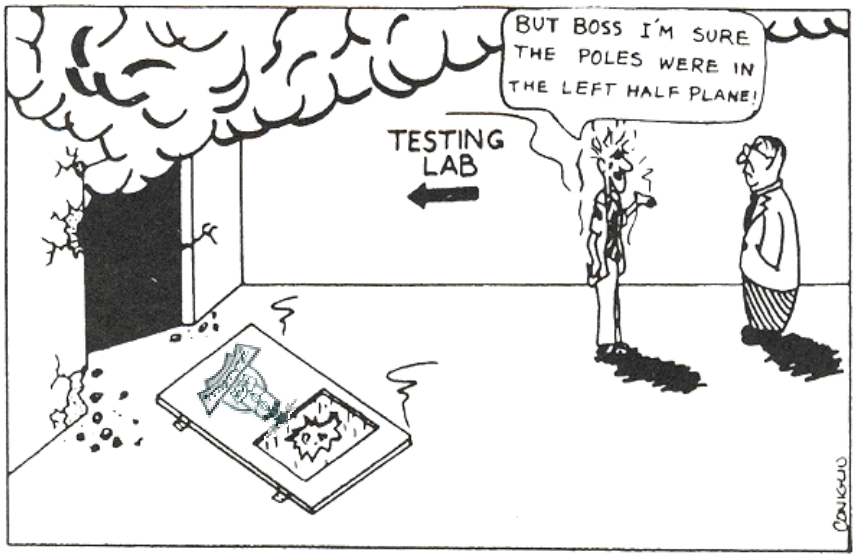
بسم الله الرحمن الرحيم

King Abdulaziz University
Engineering College
Department of Production and Mechanical System Design

Automatic Control
MENG366
Final Exam

Closed Book Exam
Time: 2 Hours
Saturday: 17/4/1425 H



Name:	Sec. No.:	ID No.:

Question 1		25
Question 2		25
Question 3		25
Question 4		25
TOTAL		100

Instructions

1. There are totally 4 problems in this exam.
2. Show all work for partial credit.
3. Assemble your work for each problem in logical order.
4. Justify your conclusion. I cannot read minds.

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Q1. The open-loop transfer function, $G(s)$, for a feedback control system

$$G(s) = \frac{K}{(s+1)(s+4)(s+9)} = \frac{K}{s^3 + 14s^2 + 49s + 36}$$

a) Use the Routh's array technique to determine the limits on K for a stable closed-loop system.

b) Sketch the root locus for the system as K varies from 0 to $+\infty$. You MUST draw on the graph paper shown in Figure 1. Show ALL important calculations.

c) Estimate the value of K when complex roots have a damping ratio of 0.707 (at $-2.1+j2.1$)

d) Is the point $s = -1 + j\,7.0$ on (or "almost on") the root locus? You must prove your answer!!!

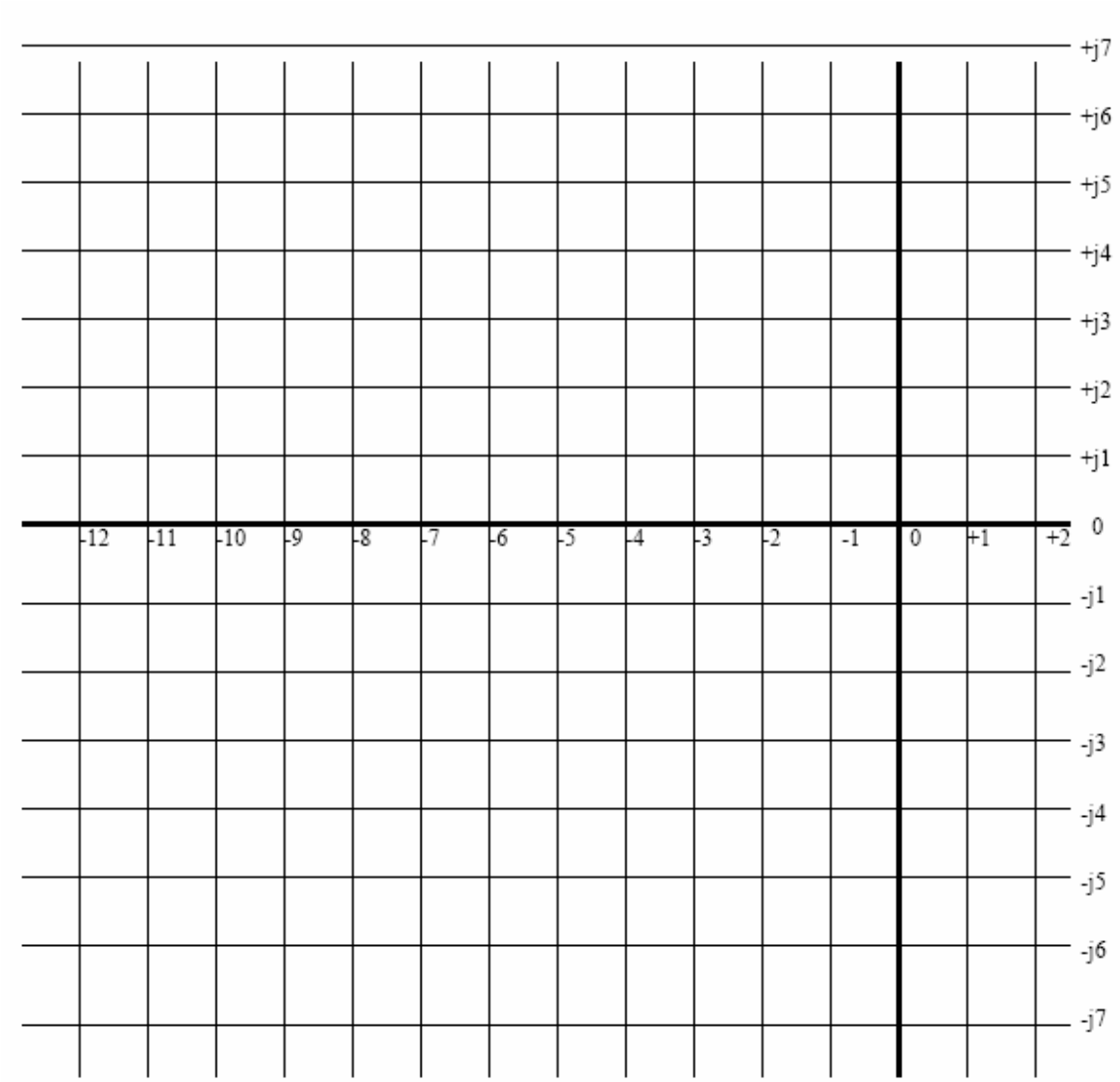

Figure 1

Q2. Determine the gain margin and phase margin for the system whose Bode plots are shown in Figure 2. Is the system stable or not? State why?

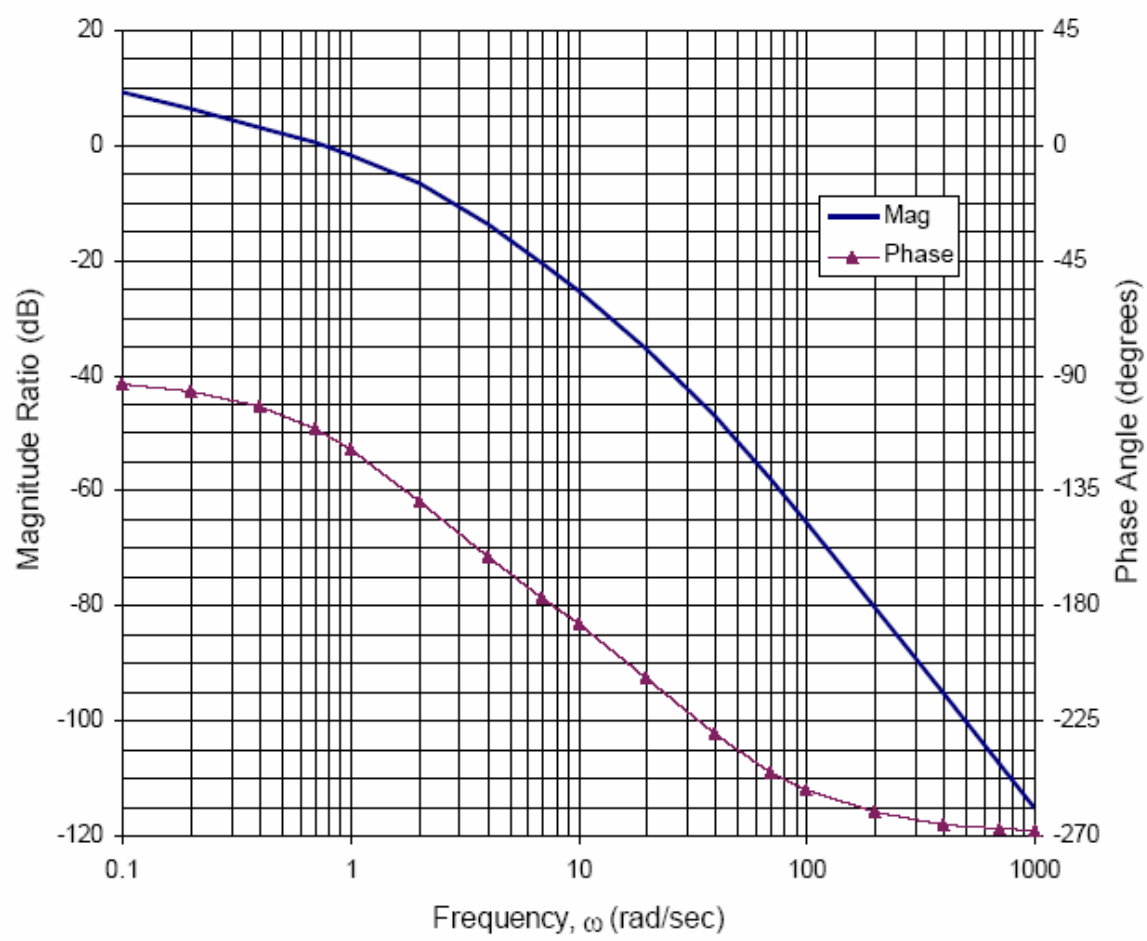

Figure 2

Q3. A unity feedback control system is shown in Figure 3:

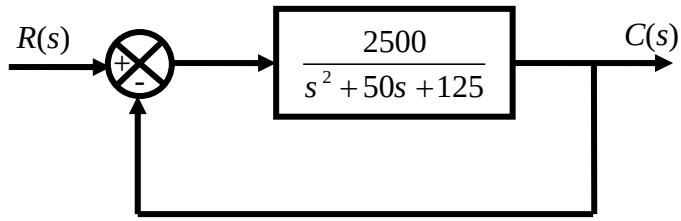

Figure 3

a) Find the natural frequency, damping ratio, and damped natural frequency of the closed loop system.

b) Determine the maximum overshoot %OS, peak time T_p, and settling time T_s for a step input to the closed loop system.

c) Sketch the unit step response of the closed loop system on the graph below in Figure 4 and clearly identify the steady-state error.

d) Analytically verify the steady-state error for c).

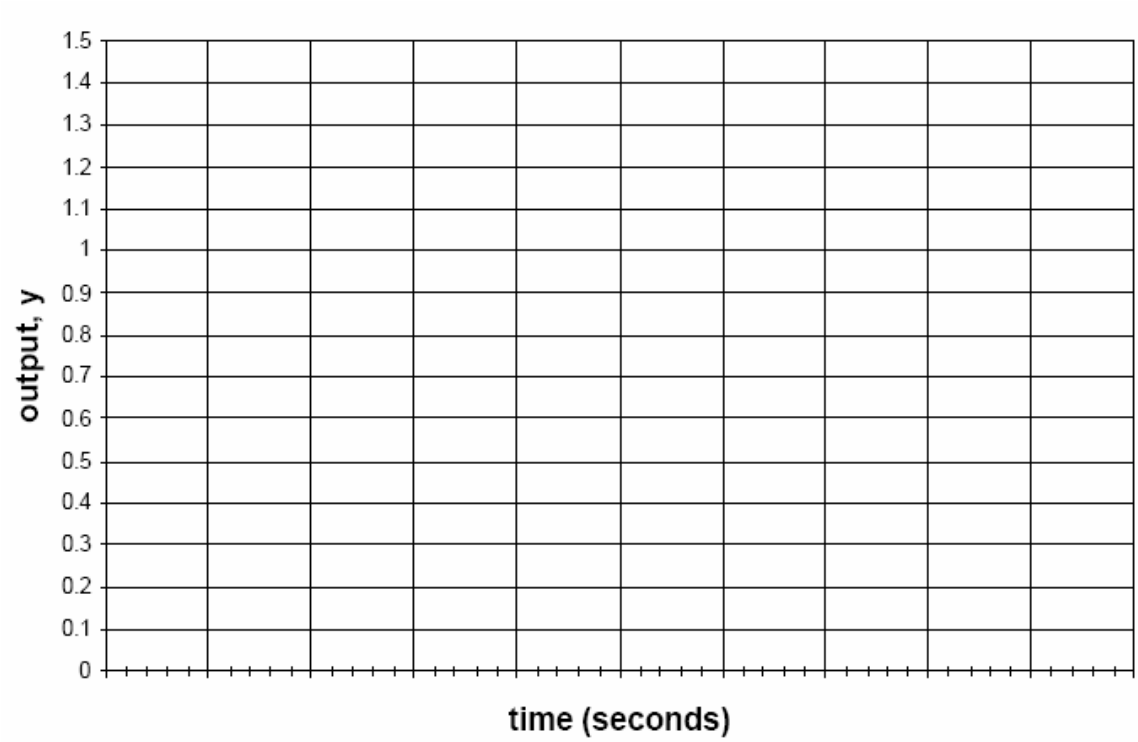

Figure 4

Recall that for a 2nd order system,

$$\%OS = 100e^{-\zeta\pi/\sqrt{1-\zeta^2}} \quad \rightarrow \quad \zeta = \frac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}} \qquad T_s = \frac{4}{\zeta\omega_n} \qquad T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$$

Q4. Consider the following system:

$$2\ddot{x} + 3\dot{x} - 5x = 2\dot{u} + 5u$$

a) What is the order of this system?

b) Calculate ω_n and ζ of the system.

c) Is the system undamped, underdamped, critically-damped, or overdamped?

d) Find the transfer function of the system.

e) Find the state space matrices (i.e. *A*, *B*, *C*, and *D*).

f) Discuss the state controllability.

أتمنى لك من أعماق القلب

أداء رائعا فأنت جدير بذلك

د. سعيد بن أحمد عسيري