UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

SUPPLEMENTARY EXAMINATION JULY 2009

TITLE OF PAPER : **ADVANCED CONTROL SYSTEMS**

COURSE NUMBER : **EIN 530**

TIME ALLOWED : THREE HOURS

INSTRUCTIONS : **ANSWER ALL FOUR QUESTIONS**

EACH CARRY 25 MARKS.

MARKS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT-HAND MARGIN

THIS PAPER HAS 6 PAGES, INCLUDING THIS PAGE

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Partial Tables of z-and s-Transforms

	f(t)	F(s)	F(z)	f(kt)
A)	u(t)	$\frac{1}{s}$	$\frac{z}{z-1}$	u(kT)
B)	t	$\frac{1}{s^2}$	$\frac{Tz}{(z-1)^2}$	kT
C)	t^n	$\frac{n!}{s^{n+1}}$	$\lim_{a\to 0}(-1)^n \frac{d^n}{da^n}\left[\frac{z}{z-e^{-aT}}\right]$	$(kT)^n$
D)	e^{-at}	$\frac{1}{s+a}$	$\frac{z}{z-e^{-aT}}$	e^{-akT}
E)	$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$	$(-1)^n \frac{d^n}{da^n}\left[\frac{z}{z-e^{-aT}}\right]$	$(kT)^n e^{-akT}$
F)	$\sin(\omega t)$	$\frac{\omega}{s^2+\omega^2}$	$\frac{z\sin\omega T}{z^2-2z\cos\omega T+1}$	$\sin(\omega kT)$
G)	$\cos(\omega t)e^{-akT}\sin(\omega$	$\frac{s}{s^2+\omega^2}$	$\frac{z(z-\cos\omega T)}{z^2-2z\cos\omega T+1}$	
				$\cos(\omega kT)$
H)	$e^{-at}\sin(\omega t)$	$\frac{\omega}{(s+a)^2+\omega^2}$	$\frac{ze^{-aT}\sin\omega T}{z^2-2ze^{-aT}\cos\omega T+e^{-2aT}}$	kT)
I)	$e^{-at}\cos(\omega t)$	$\frac{s+a}{(s+a)^2+\omega^2}$	$\frac{ze^{-aT}\sin\omega T}{z^2-2ze^{-aT}\cos\omega T+e^{-2aT}}$	$e^{-akT}\cos(\omega kT)$
.10			$\frac{z}{z+a}$	$a^k\cos(k\pi)$

z-Transform Theorems

	Name	Theorem
1.	Linearity theorem	$z\{af(t)\} = aF(z)$
2.	Linearity theorem	$z\{f_1(t)+f_2(t)\}=F_1(z) + F_2(z)$
3.	Complex differentiation	$z\{e^{-at}f(t)\}=F(e^{aT}z)$
4.	Real translation	$z\{f(t-nT)\}=z^{-n}F(z)$
5.	Complex differentiation	$z\{tf(t)\} = -Tz\frac{dF(z)}{dz}$
6.	Initial value theorem	$f(0) = \lim_{z\to\infty} F(z)$ If the limit exists
7.	Final value theorem	$f(\infty) = \lim_{z\to 1}(1-z^{-1})F(z)$ if the limit exists and the system is stable

Question 1

(a) State the definition of a **distributed control system** (DCS) and name four processes in which DCSs are used. [10 marks]

(b) Outline the **design method** for a phase- lead compensation network using the Bode diagram.

[15 marks]

Question 2

Design of state a full-state feedback law and an observer that will satisfy the following requirements:

for the full state-feedback : settling time = **1** second and $\zeta =$ **0. 8**

for the observer : dominant roots are at **s = -4** $\pm$ **j5**

[25 marks]

$$\dot{x} = \begin{bmatrix} -5 & -2 \\ 2 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} x$$

Question 3

The control system shown Figure 3 must have a phase margin of 40^0 for the system to achieve expected performance. Design a compensator that would allow the required phase margin.

Follow the following steps to accomplish your design

A) Draw Bode diagrams for the uncompensated system. [14 marks]

B) Read out phase margin from the Bode diagrams [2 marks]

C) Obtain the compensator required [9 marks]

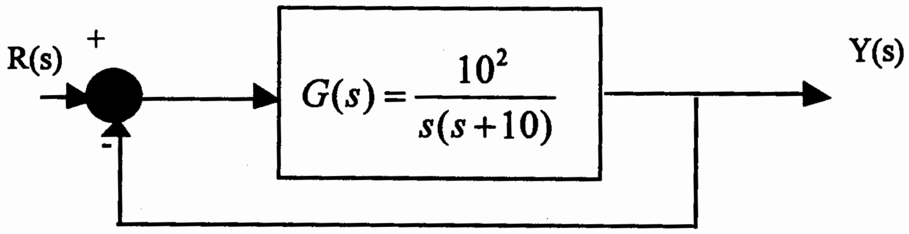

Figure 3

Question 4

A) Define sub-harmonic oscillations which occur in non-linear systems and explain how the oscillations are generated. [5 marks]

B) Why is it that intentional non-linearities may be introduced into a linear control system? [2 marks]

C) For the **deadbeat** system shown in Figure 4, design a controller D(z) so that the steady-state error to a step input is zero. [18 marks]

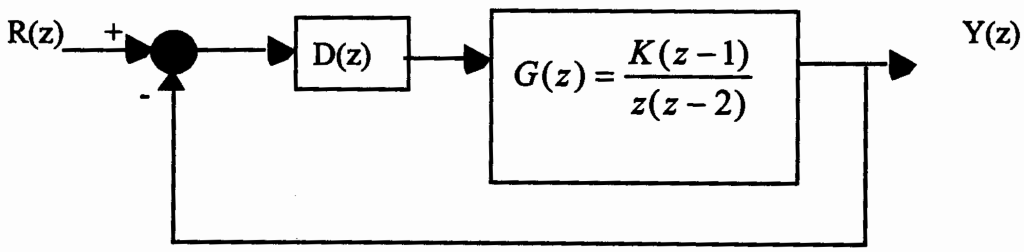

Figure 4

Five Cycle Semi-Log