UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE
DEPARTMENT OF ELECTRONIC ENGINEERING

MAIN EXAMINATION December 2006

TITLE OF PAPER: **ADVANCED CONTROL SYSTEMS**

COURSE NUMBER: **EIN530**

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: ANSWER **QUESTION 1** AND ANY OTHER **THREE QUESTIONS**

EACH QUESTION CARRIES 25 MARKS

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

THIS PAPER HAS 7 PAGES, INCLUDING THIS PAGE

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Partial Table of z- and s-Transforms

	f(t)	F(s)	F(z)	f(kt)
	$u(t)$	$\frac{1}{s}$	$\frac{z}{z-1}$	$u(kT)$
2.	t	$\frac{1}{s^2}$	$\frac{Tz}{(z-1)^2}$	kT
3.	t^n	$\frac{n!}{s^{n+1}}$	$\lim_{a\to 0}(-1)^n \frac{d^n}{da^n}\left[\frac{z}{z-e^{-aT}}\right]$	$(kT)^n$
4.	e^{-at}	$\frac{1}{s+a}$	$\frac{z}{z-e^{-aT}}$	e^{-akT}
5.	$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$	$(-1)^n \frac{d^n}{da^n}\left[\frac{z}{z-e^{-aT}}\right]$	$(kT)^n e^{-akT}$
6.	$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$	$\frac{z \sin \omega T}{z^2 - 2z\cos\omega T + 1}$	$\sin \omega kT$
7.	$\cos \omega t$	$\frac{s}{s^2+\omega^2}$	$\frac{z(z-\cos\omega T)}{z^2 - 2z\cos\omega T + 1}$	$\cos \omega kT$
8.	$e^{-at}\sin\omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$	$\frac{ze^{-aT}\sin\omega T}{z^2 - 2ze^{-aT}\cos\omega T + e^{-2aT}}$	$e^{-akT}\sin\omega kT$
9.	$e^{-at}\cos\omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$	$\frac{z^2 - ze^{-aT}\cos\omega T}{z^2 - 2ze^{-aT}\cos\omega T + e^{-2aT}}$	$e^{-akT}\cos\omega kT$
10.			$\frac{z}{z+a}$	$a^k \cos k\pi$

z-Transform Theorems

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

Note: kT may be substituted for t in the table.

Question 1

State the definitions and give one major difficulty of each of the following advanced control methods :

Adaptive control,
Robust control,
Predictive control,
Optimal control, and
Fuzzy control

Question 2

A) A system is described by the matrix equations

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

and $y(t) = x_1(t)$. Determine whether the system is controllable and observable.

[8 marks]

B) For a system described by the matrix equations

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$u = -(k_1 x_1 + k_2 x_2)$$

Determine the values of k1 and k2 so that a full-state variable feedback design is achieved to meet a settling time requirement of 0.8 seconds with $\zeta = 0.884$.

[17 marks]

Question 3

Consider a system with

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

$$u = -(x_1 + k_1 x_2)$$

and a performance index of $J = \int_0^\infty x^T x dt$.

A) Determine the optimum value of k_1 and the minimum value of J when $x^T = \begin{bmatrix} 1 & 0 \end{bmatrix}$

[19 marks]

B) Plot the performance index versus the gain k_1 [6 marks]

Question 4

A unity feedback control system has a loop transfer function

$$G(s) = \frac{10^4}{(s + 10^3)}$$

It is desired that the phase margin of this system be at least 40^0. Design a lead compensator using Bode diagrams to achieve this specification. [25 marks]

Question 5

Figure 5 shows a satellite tracking system. It is desired to design the controller D(z), so that this system is deadbeat and the steady state error to a step input R(z) is zero. The sampling interval is T = 0.01.

[25 marks]

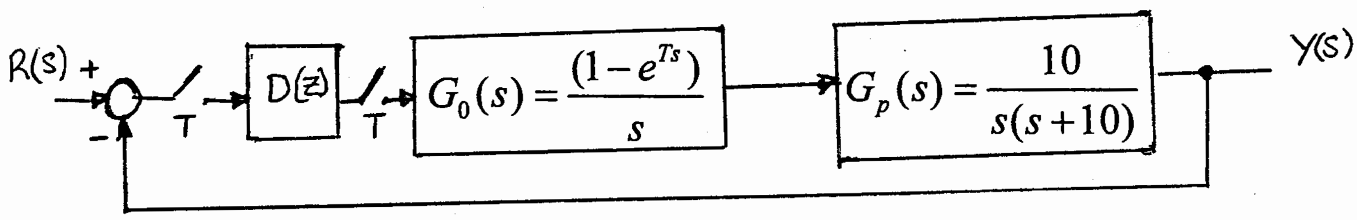

Figure 5