UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE
DEPARTMENT OF ELECTRONIC ENGINEERING

SUPPLEMENTARY EXAMINATION JULY 2008

TITLE OF PAPER: **CONTROL SYSTEMS**

COURSE CODE: **E430**

TIME ALLOWED: **THREE** HOURS

INSTRUCTIONS:

1. Answer all four questions.
2. Each Question carries 25 marks.
3. Marks for different sections are shown in the right-hand margin

This paper has 6 pages including this page.

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Partial Table of z- and s-Transforms

	$f(t)$	$F(s)$	$F(z)$	$f(kt)$
1.	$u(t)$	$\frac{1}{s}$	$\frac{z}{z-1}$	$u(kT)$
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

A system is given by the following transfer function

$$\frac{Y(s)}{R(s)} = \frac{10(s+2)}{(s+0.2)(s^2+5s+100)}$$

A) Determine response y(t) when the input r(t) is a unit step. [10 marks]

B) Draw the Bode diagram (Magnitude only) for this system. [15 marks]

SEMI-LOG PAPER (5 CYCLES x 1/10")

Question 2

A) The student-teacher learning process is inherently a feedback process intended to reduce the system error to a minimum. In this process knowledge is transferred. With the aid of Figure 2 construct a feedback model of the learning process and identify each block of the system.

[6 marks]

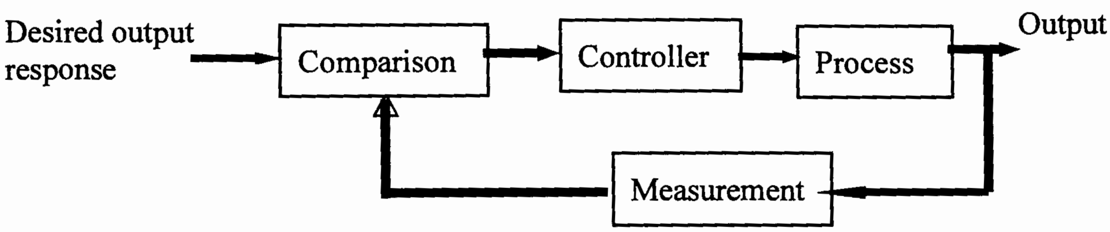

Figure 2

B) The characteristic equation of a sampled system is $z^2 + (K - 1.5)z + 0.5 = 0$
Find the range of the gain K so that the system is stable. [8 marks]

C) (i) Determine y(k) for k = 0 to 3 when $Y(z) = \dfrac{z+2}{z^2 - 1}$ [6 marks]

(ii) Determine the closed form solution for y(k) as a function of k [5 marks]

Question 3

A) Represent the following transfer function in state space, use any format.

$$T(s) = \frac{s^2 + 7s + 10}{(s+1)(s^2 + 5s + 9)}$$ [10 marks]

B) Find the damping ratio, natural frequency, percent overshoot and peak time for the system shown in Figure 3. [15 marks]

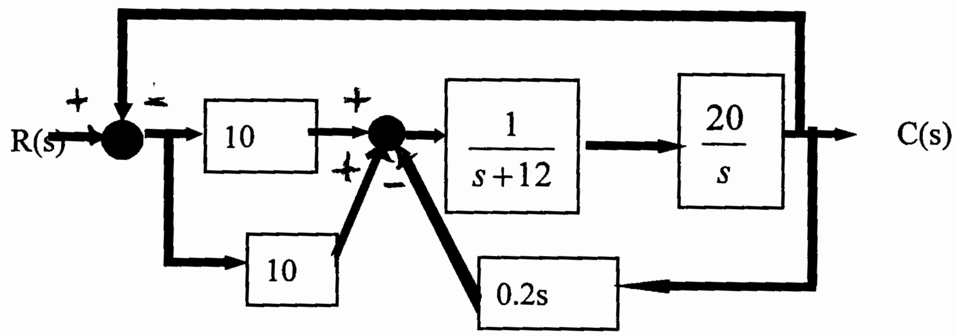

Figure 3

Question 4

A unity feedback system has an open-loop transfer function

$$KG(s) = K\frac{s+10}{(s+2)(s+4)(s+8)}$$

A) Determine the breakaway point and the value of K at this point [5 marks]

B) Is there a value of K that will make this system critically stable? Show. [5 marks]

C) Determine the centre of asymptotes and the angle of the asymptotes [2 marks]

D) Determine the roots when K=1 and K=10 [4 marks]

E) Sketch the root locus [9 marks]