UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE
DEPARTMENT OF ELECTRONIC ENGINEERING

SUPPLEMENTARY EXAMINATION JULY 2007

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.	$u(t) = 1$	$\frac{1}{s}$	$\frac{z}{z-1}$	$u(kT)$
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.	$f(0) = \lim_{z\to\infty} F(z)$	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) The transfer function of a system is $\frac{Y(s)}{R(s)} = \frac{10(s+2)}{s^2+8s+15}$ determine response y(t) when the input r(t) is unit step. [8 marks]

B) Draw a signal flow graph for the system shown in Figure 1 and then use Mason's gain rule to find the transfer function for this system. [17 marks]

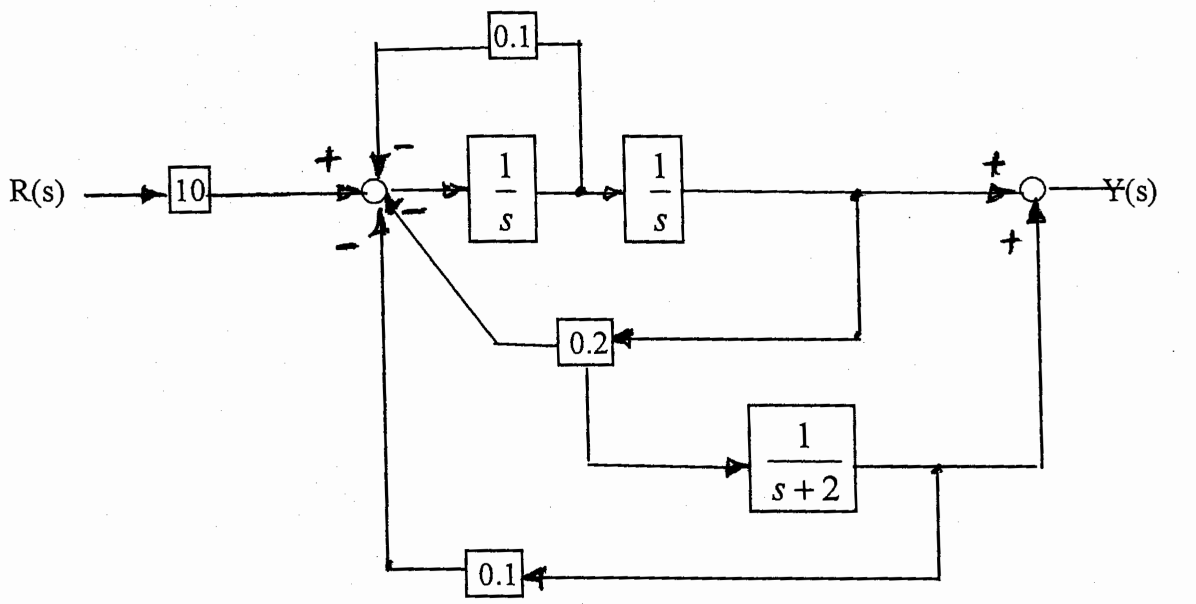

Figure 1

Question 2

An RLC network is shown in Figure 2. Define the state variables as $x_1 = i_L$, $x_2 = v_c$, input variables as $v_1 = u_1$, $v_2 = u_2$, and output variable as $v_R = y$. Obtain the state differential equations [25 marks]

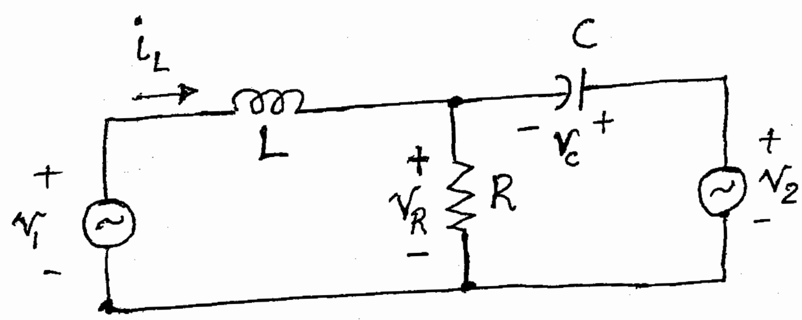

Figure 2

Question 3

For a second order system shown in Figure 3 A, with the input being a unit step,

A) determine the steady state error [6 marks]

B) determine the damping ratio and the maximum percentage overshoot [6 marks]

C) determine the value of gain *K*, as shown in Figure 3 B, that will make the system to have a 1% maximum overshoot, and what will the steady state error be [13 marks]

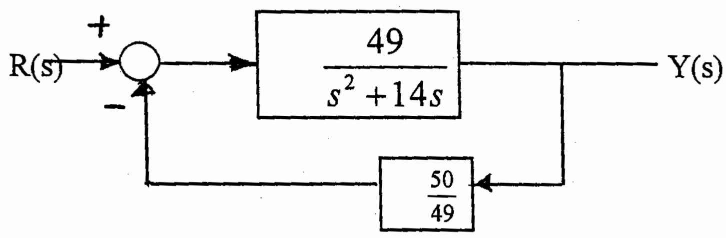

Figure 3 A

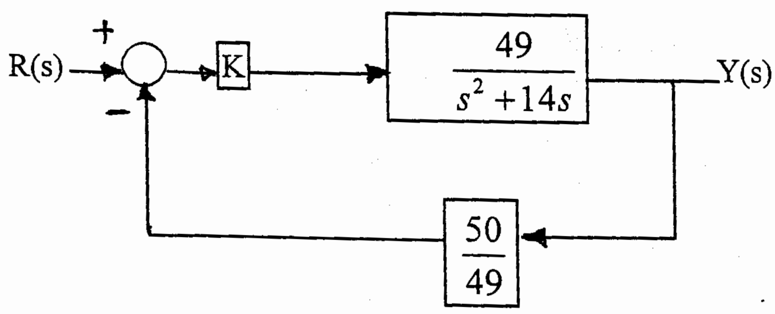

Figure 3B

Question 4

Draw the Bode plot (Magnitude and Phase) of

$$G(s)=\frac{12*10^5(s+100)^2}{(s+10)^2(s+1200)}$$