UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING

EXAMINATION 2006 **(SUPPLEMENTARY)**

TITLE OF PAPER: CONTROL SYSTEMS

COURSE NUMBER: E430

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: ANSWER QUESTION 1 AND ANY OTHER THREE QUESTIONS.
EACH QUESTION CARRY 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)
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.	$e^{-at} \cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$	$\frac{z^2 - ze^{-aT}\cos \omega T}{z^2 - 2ze^{-aT}\cos \omega T + e^{-2aT}}$	$e^{-akT} \cos \omega kT$
			$\frac{z}{z+a}$	$a^K \cos K\pi$

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

...stituted for t in the table

Question 1

A) Draw a signal flow graph and use Mason's gain formula to find the transfer function for the system shown in Figure 1A (10 marks)

B) From the logarithmic plot shown Figure 1B obtain the transfer function G(s) (5 marks)

C) Obtain the pulse transfer function of the system shown in Figure 1C (5 marks)

D) (i) Write down the transfer function for a PID controller (3 marks)

(ii) What is meant by proportional band. (2 marks)

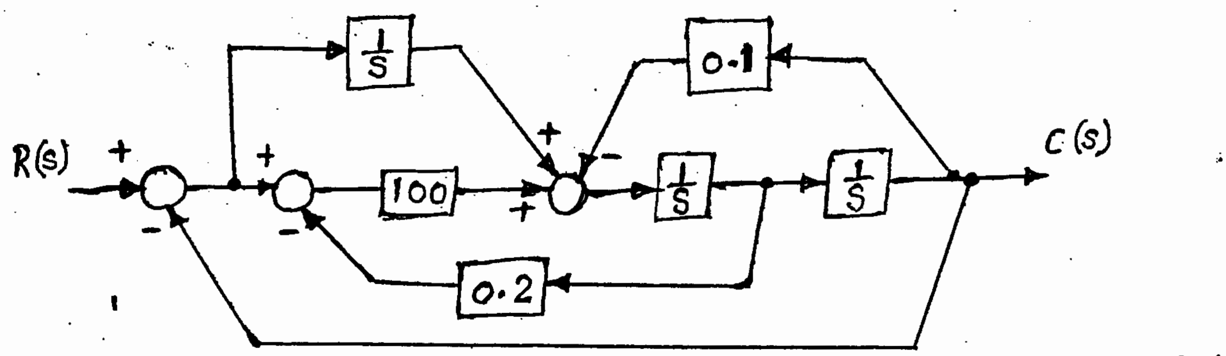

Figure 1 A

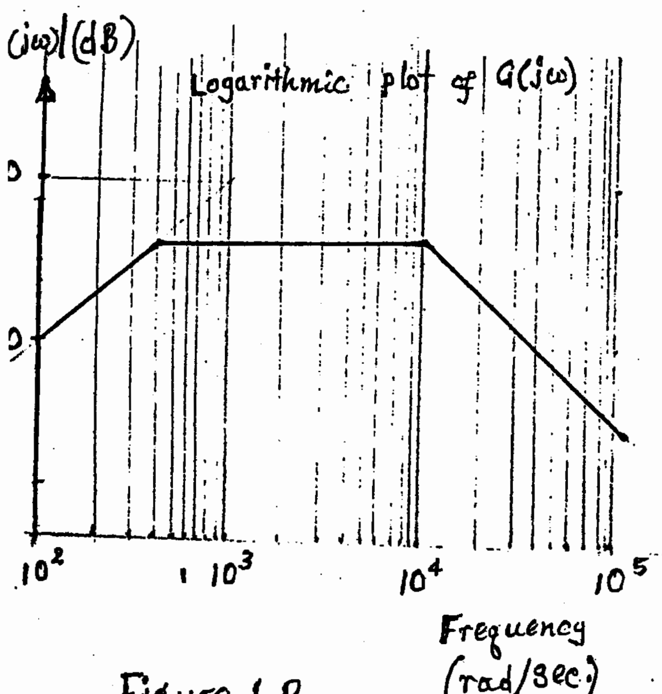

Figure 1 B

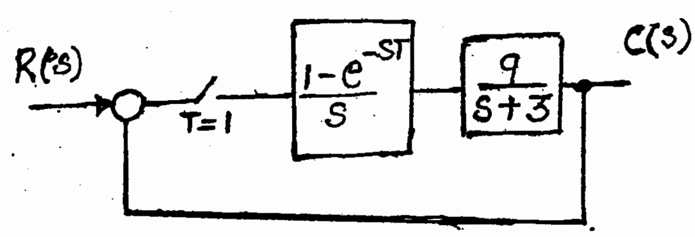

Figure 1C

Question 2

It is desired that the underdamped system shown in Figure 2 produce a maximum overshoot of 0.3 and a peak time of 0.8 seconds in response to a unit step.

Determine

(i) the damping ratio (4 marks)

(ii) the value of gain K (10 marks)

(iii) the velocity feedback constant K_h (3 marks)

(iv) the rise time , and (5 marks)

(v) the settling time for the 2% criterion (3 marks)

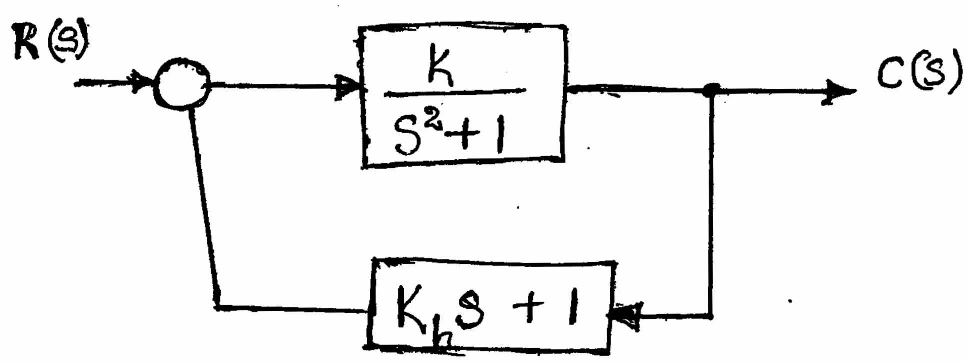

Figure 2

Question 3

A machine tool is designed to follow a desired path so that

$v(t) = (2 - t)u(t)$

where $u(t)$ is a unit step function

The machine tool control system is shown in Figure 3

(A) (i) Find the error function E(s) when v(t) is the desired path as given. [7 marks]

(ii) Find the steady state error [3 marks]

(B) (i) Find the error function e(t) in time domain for the desired path as given [6 marks]

(ii) Sketch the error function e(t) for $0 < t < 100$ milliseconds. Indicate minimum and maximum error values. [9 marks]

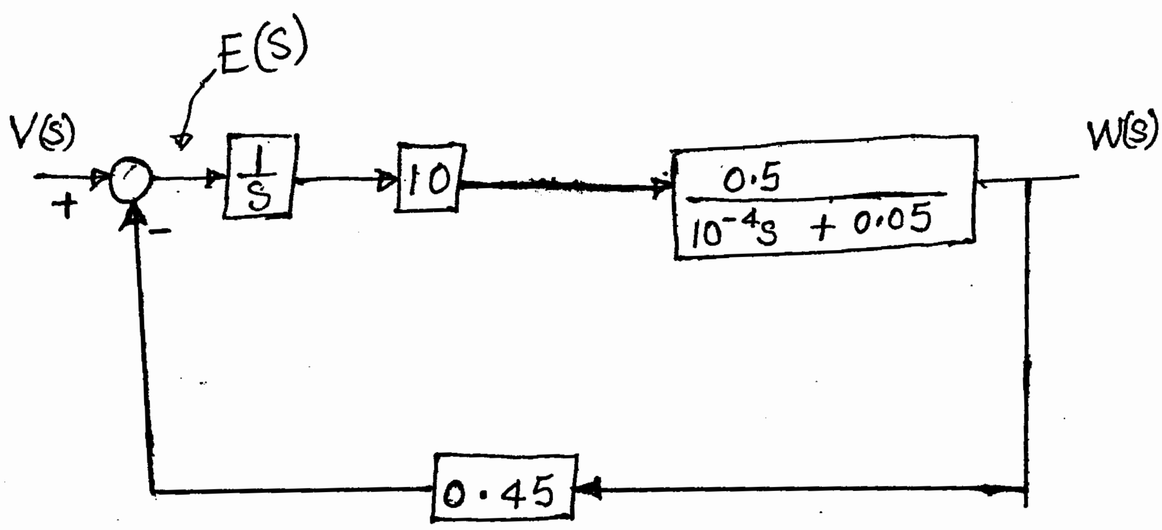

Figure 3

Question 4

Draw the Bode diagram for a system with unity feedback and an open loop transfer function

given as $$G(s) = \frac{2*10^5(s+5)}{(s+100)^2}\ .$$ (20 marks)

From your Bode diagram obtain the magnitude (dB) and the phase (degrees) at $\omega = 1000$ rad/sec (5 marks)

Question 5

Given the system shown in figure 5, find

(A) the transfer function $\dfrac{C(s)}{R(s)}$ (5 marks)

(B) the range of values of **K** for which the system is stable (10 marks)

(C) the roots when the system is critically stable. (10 marks)

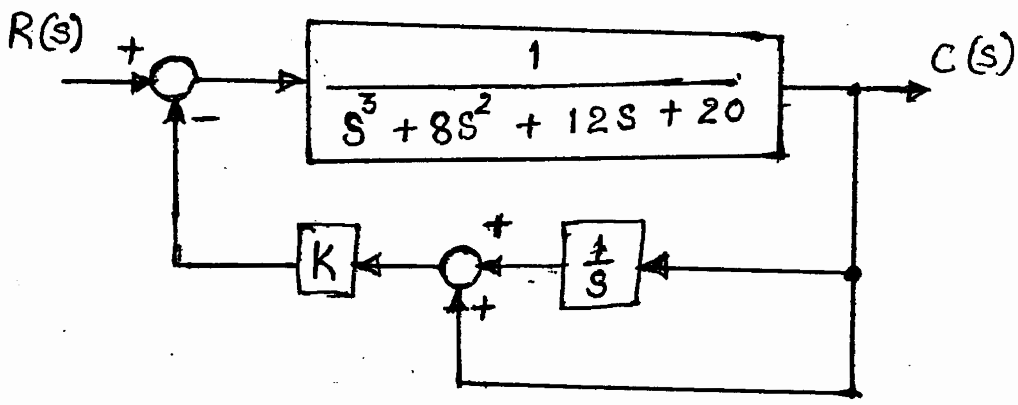

Figure 5