UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION DECEMBER 2009

TITLE OF PAPER:	**CONTROL SYSTEMS**
COURSE CODE: **E430**	
TIME ALLOWED:	**THREE** HOURS

INSTRUCTIONS:

1. Answer **<u>question 1</u>** and any other three (3) questions.
2. Each question carries 25 marks.
3. Marks for different sections are shown in the right-hand margin.

This paper has 5 pages including this page.

Partial Tables 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.	$e^{-at}\cos(\omega t)$	$\frac{s+a}{(s+a)^2+\omega^2}$	$\frac{ze^{-aT}\sin\omega T}{z^2-2ze^{-aT}\cos\omega T+e^{-2aT}}$	$e^{-akT}\cos(\omega kT)$
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) For a control system with a unit feedback and a feed-forward transfer function

$$G(s) = \frac{10}{s^2 + 2s + 10}$$

Determine

(i) the closed loop transfer function Y(s)/R(s) [2 marks]

(ii) the response $y(t)$ when the input is a unit step, and [9 marks]

(iii) the percent overshoot, rise time and the steady state error. [9 marks]

(iv) The human like face of the robot might have micro-actuators placed at strategic points on the interior of the malleable facial structure. Cooperative control of the micro-actuators position would then enable the robot to achieve various facial expressions. Sketch a block diagram for a facial expression control system of your own design.

[5 marks]

Question 2

For a system with $G(s)H(s) = \frac{Ks(s+2)}{s^2 + 2s + 10}$,

a) draw the locus of the roots, and [16 marks]

b) from the locus plot determine the minimum damping ratio and the value of gain K at this minimum damping ratio . [9 marks]

Question 3

For a system with $G(s)H(S)=\dfrac{10^5(s+1)}{(s+50)(s+200)}$,

a) draw Bode diagrams, and [22 marks]

b) find the gain cross-over frequency. [3 marks]

Question 4

For the computer compensated system shown in Figure 4 below

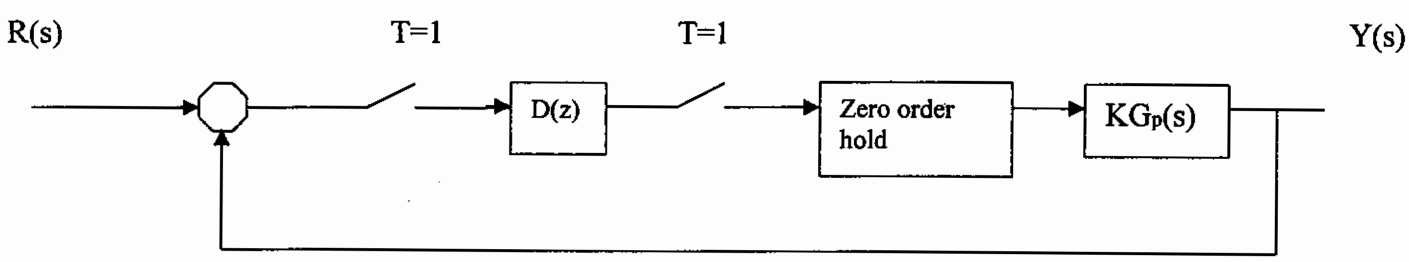

Figure 4

$$D(Z)=\frac{z-0.05}{z+0.203}$$

$$KG_p(s)=\frac{K}{s(s+2.995)}$$

$$K=\frac{5}{1.1}$$

Determine

a) Y(z)/R(z) [15 marks]

b) $y(k)$ when $r(t)=te^{-t}$ for $t\geq 0$. [10 marks]

Question 5

a) Consider the single –input, single output system described by

$$\dot{x}(t) = Ax(t) + Bu(t)$$
$$y(t) = Cx(t)$$

where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 3-k & -2 & -4-k \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}, C = \begin{bmatrix} 1 \\ -1 \\ 0 \end{bmatrix},$

Find the values of K for-which the system is stable. [12 marks]

b) State the difference between servos and sychros. [4 marks]

c) Describe, in general, the components of a servomechanism and give examples of each component.

[9 marks]