THE KENYA POLYTECHNIC UNIVERSITY

COLLEGE

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

HIGHER DIPLOMA IN ELECTRICAL ENGINEERING

END OF YEAR II EXAMINATIONS

NOVEMBER 2007

CONTROL SYSTEMS

3 HOURS

INSTRUCTIONS TO CANDIDATES:

You should have the following for this examination:

Answer booklet

Non-programmable calculator/ New Mathematical tables

Answer any FIVE of the following EIGHT questions.

All questions carry equal marks and the maximum marks for each part of a question are as shown.

This paper consists of **5** printed pages.

1. (a) Sketch a circuit diagram of a phase lead network and derive from first principles, an expression for the frequency of maximum phase shift.

   (b) Design a lead compensator for a system whose transfer function is

   $G(S) = \dfrac{50}{S(1+0.1S)(1+0.01S)}$ for a minimum phase margin of 350. Assume α to be less than unity. The phase plot details are:

$\omega(rad/s)$	0.1	1	2	3	4	8	10	20	30	40
$\angle G(j\omega)$ degrees	-91	-97	-102	-109	-114	-134	-141	-164	-178	-188

   (c) State any THREE effects of a phase lead compensator on a control system. (3 marks)

2. (a) (i) State the need for controllers in practical control systems. (2 marks)

   (ii) With the aid of a block diagram, derive expressions showing the effect of proportional plus integral control on a system. (10 marks)

   (b) Describe with the aid of a block diagram, the Ziegler-Nichol's open loop method of determination of controller settings. (8 marks)

3. (a) State the effect of increasing/decreasing damping on the following system parameters:

   (i) Settling time (ii) Dead zone

   (iii) Overshoot (3 marks)

   (b) Show that the expression for the steady state error of a single loop unity feedback system is given by $E_{SS} = \lim_{s\to 0} S\left[\dfrac{R(S)}{1+G(S)}\right]$. Hence deduce the steady state error for the following system types when subjected to a step input:

   (i) Type O (ii) Type I

   Comment on your answer. (9 marks)

   (c) With the aid of a diagram, derive the transfer function of an a.c. servomotor. (8 marks)

4. (a) Define the following with respect to IO stability:

(i) Gain margin (ii) Phase margin (2 marks)

(b) The open loop transfer function is given by: $G(S)H(S) = \frac{10}{S(1+0.5S)(1+0.1S)}$. The phase plot details are:

$\omega(rad/s)$	0.1	1	2	5	10	15
$\angle G(j\omega)$ degrees	-94	-123	-152	-185	-214	229

Using asymptotes for the magnitude curve, plot a Bode diagram and determine the following:

(i) Gain crossover frequency (ii) Phase crossover frequency

(iii) Gain margin (iv) Phase margin

Comment on the stability of the system. (12marks)

(c) A pole zero-map is shown in figure 1. Explain the significance of the pole locations. (6 marks)

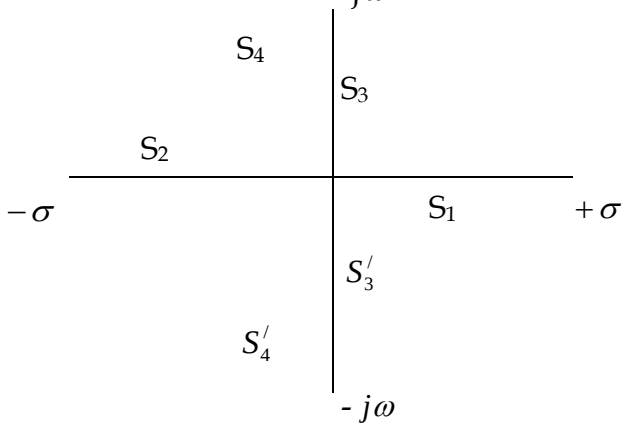

Figure 1

5. (a) State the Nyquist criterion. (2 marks)

(b) The open loop frequency response of a control system is given by:

$\omega(rad/s)$	2.5	3.0	3.5	4.0	5.0	7.0	10	20
Gain (ratio)	12	8.9	6.7	5.2	3.3	1.6	0.69	0.11
ϑ degrees	-155	-163	-169	-175	-185	-199	-214	-237

Table 2

Plot the Nyquist diagram and determine the phase and gain margins. Comment on your results.

(c) With the aid of a Nichol's chart, determine the following for a system whose open loop frequency response is shown in table 3.

$\omega(rad/s)$	1	2	3	5	7	10	15	20
$\lvert GH(j\omega)\rvert$ dB	20	14	10.5	6	0	-6	-14	-18
Phase lag	-100	-115	-125	-140	-155	-163	-180	-190

(i) The phase margin

(ii) The gain margin

(iii) The maximum value of the closed loop gain (Mp)

(iv) The frequency at which it occurs

(v) The 3dB bandwidth (12 marks)

6. (a) (i) Define the term PLC.

(ii) State THREE advantages of PLCs over older technology. (5 marks)

(b) With the aid of a suitable block diagram, describe the basic components of a PLC and state their functions. (11 marks)

(c) Distinguish between modular and single box types of PLCs. (4 marks)

7. (a) Draw a labeled diagram of the internal architecture of a PLC and state the function of the following components:

(i) User program RAM (ii) Opto-coupler

(iii) Data RAM (12 marks)

(b) With the aid of sketches, outline the main characteristic of the following PLC I/O channels:

(i) Relay type output channel (ii) D.C. input channel

(iii) Triac type output channel (8 marks)

8. (a) With reference to PLCs:

(i) Define the term operation cycle

(ii) Distinguish between continuous updating I/O processing and mass I/O copying I/O processing. (8 marks)

(b) Draw ladder diagrams to carry out the following tasks:

(i) Close either of two normally open switches in order to energize a coil and operate an actuator.

(ii) Switch on a lamp if there is input from sensor A or sensor B; then activate a solenoid valve if sensor A gives an input.

(iii) Switch on a motor by pressing a spring-return push button start switch; the motor remains on until another spring-return push button switch is pressed. One red lamp must be activated when the motor is powered and a green lamp activated otherwise. (6 marks)

(c) Draw a ladder diagram to achieve the same control as the sequential flow chart (SFC) shown in figure 1.

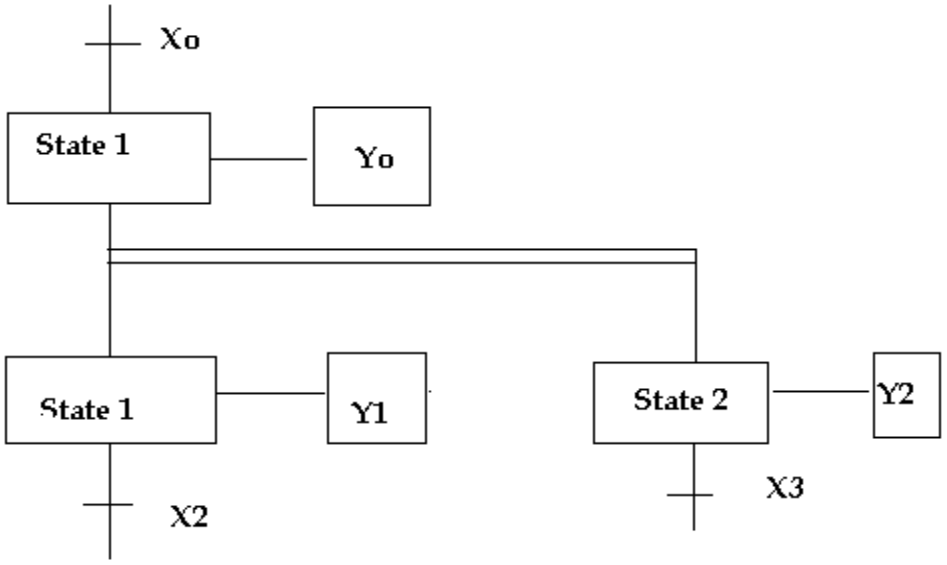

Figure 1