MACHAKOS UNIVERSITY

University Examination 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 311: CONTROL SYSTEMS

DATE: 24/5/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Answer Question ONE and any other TWO Questions.

Requirements

Bode plot graph paper

QUESTION ONE (30 MARKS)

a) Define proportional band. (2 marks)

b) The waveform in fig.1 shows an eeror signal to a controller. Assuming zero initial conditions, sketch the output waveforms when the given error signal is applied to:

i. derivative controller

ii. Integral controller

iii. Proportional controller (7 marks)

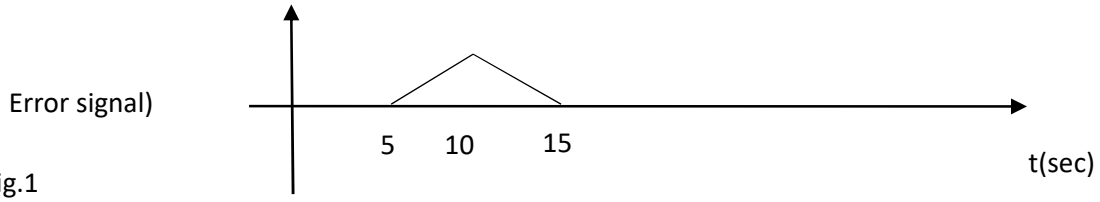

Fig.1

c) Derive the expression of ω_M, which is the frequency at which the maximum phase angle φ_M is obtained for a phase lead network shown in fig.2. (6 marks)

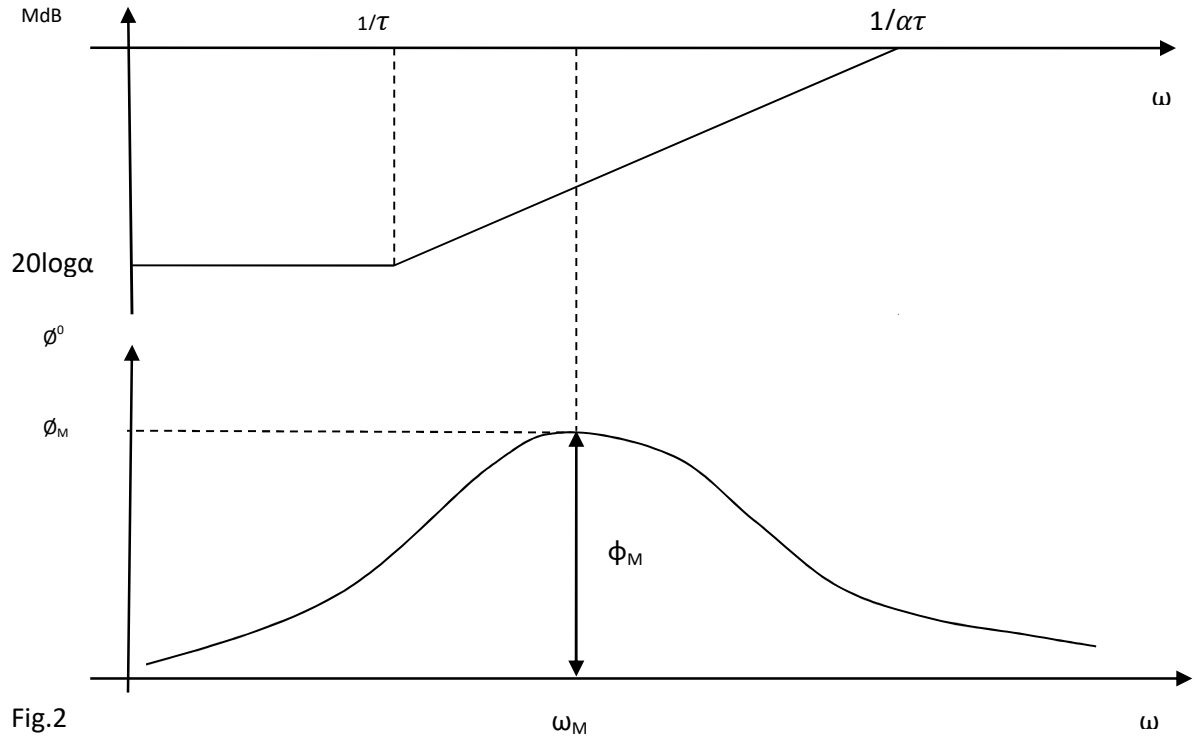

Fig.2

d) What are the advantages of using phase variables? (3 marks)

e) Draw the canonical block diagram representation for the system whose transfer function is given below. (7 marks)

$$T(S) = \frac{S^2 + 1}{(S-3)(S-2)(S-1)}$$

f) The circuit in fig.3 is an electronic circuit of a proportional controller. Derive the expression of $\mathrm{vo(t)}$. (5 marks)

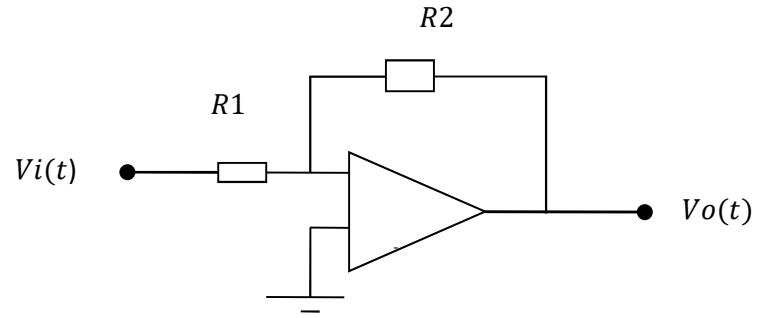

Fig3

QUESTION TWO (20 MARKS)

a) Write the state and output equations that defines state model of time invariant systems. (2 marks)

b) In a test on servomechanism, the open loop response G(S) in table1 was obtained:

Table 1

W (rads/sec)	0.1	0.2	0.5	1	2	5	10	20	50	100
Gain (dB)	32	32	32	31	28	19	9	-2	-18	-30
Phase angle(deg)	-4	-9	-21	-41	-72	-120	-147	-163	-173	-177

Design a phase lead network to ensure phase margin of 45 degrees. (10 marks)

c) Derive the transfer function of the circuit in fig. 4. (8 marks)

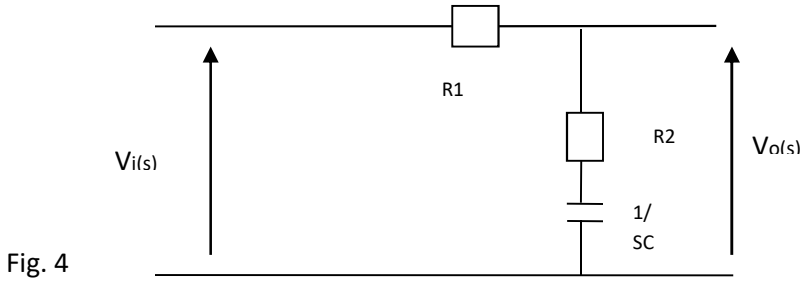

Fig. 4

QUESTION THREE (20 MARKS)

a) Discuss the advantages of introducing a derivative controller in a proportional plus Integral plus derivative controller. (3 marks)

b) An engineer was requested to design a controller that apart from energizing its input signal, it would also reduce the controlled variable steady state error. He designed an electronic controller:

i. Sketch a labeled diagram of the electronic controller.

ii. Derive expression of its output. (7 marks)

c) The circuit in fig.5 is a schematic diagram representing a dc motor and load. The field is maintained constant. Determine the state equations in the vector matrix form for the state variable $x1 = \theta,\ x2 = \frac{d\theta}{dt}$ and $x3 = \frac{d^2\theta}{dt^2}$. Assume:

Moment of inertia of motor and load $=j$

Back emf contstant $=kb$

Coefficient of friction of motor and load $=f$

Motor torque constant $=K_T$ (10 marks)

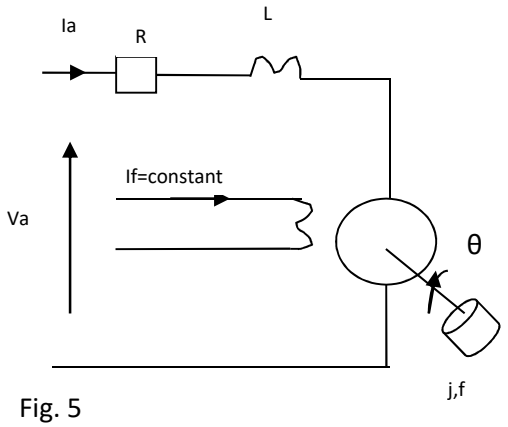

Fig. 5

QUESTION FOUR (20 MARKS)

a) The Bode plot for a given system is given in figure 6. Design a phase lag compensator to improve the stability of the system to achieve a phase margin of 30^o. (10 marks)

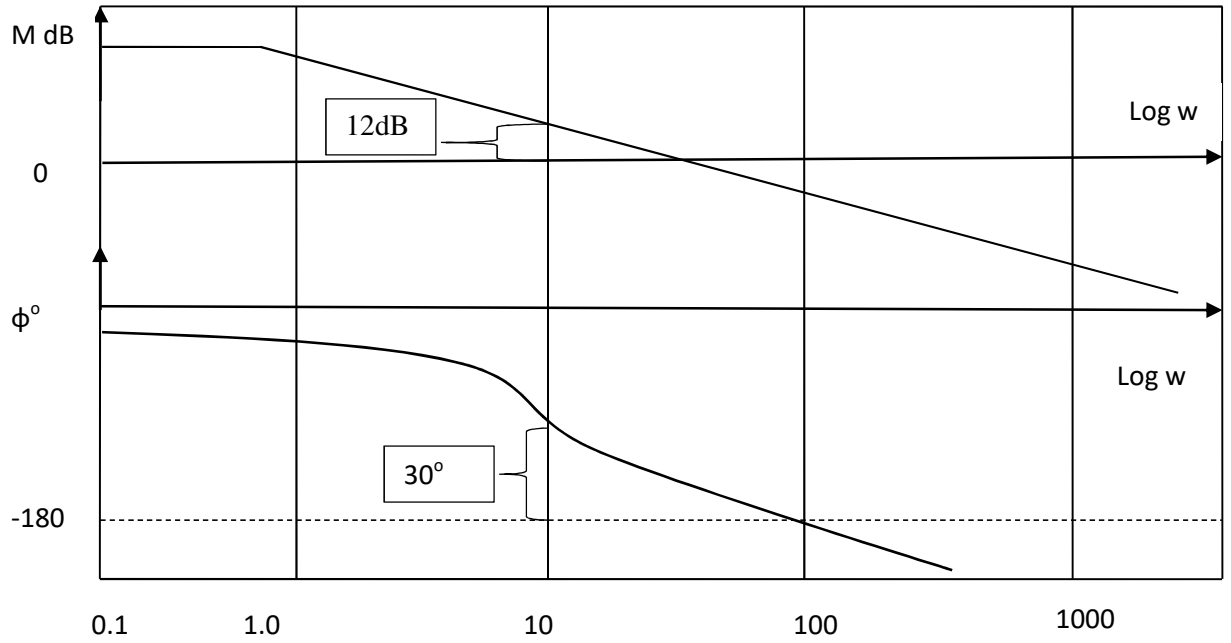

Figure6

b) Determine the values of R1 and R2 of an electronic proportional plus integral controller with a proportional gain of 4 and integral action of 40 seconds. Use 10 microfarad capacitor. If the controller has an output of 40% at time t=0. Using error graph in fig.7, determine controller output for the following times:

i. At t=30 seconds.

ii. At t=50 seconds.

iii. At t=100 seconds (10 marks)

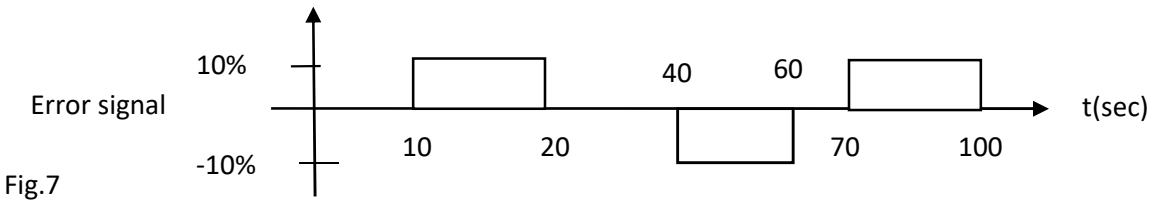

Fig.7

QUESTION FIVE (20 MARKS)

a) A gas pressure control system LINEARLY converts a pressure of 20 to 30 Pascal into 5 to 25mA control signal. A contactor serves as the two position controller to open and close an inlet valve. The contactor closes at 15mA and opens at 12mA. Find:

i. The relationship between pressure and current.

ii. Pressure gap (neutral zone) in Pascal. (6 marks)

b) A lead-lag compensator is used to compensate a controlled system by introduction of attenuation and also phase lead. For a lead-lag compensator:

i. Sketch a well labeled circuit diagram.

ii. Derive the transfer function.

iii. By reorganizing the transfer function into a general format, sketch the magnitude and phase plots for the network. (10 marks)

c) Construct the state model for a system characterized by the differential equation below and give the block diagram representation. (4 marks)

$$u = 10\frac{d^2y}{dt^2} + 20\frac{dy}{dt} + 8y$$