



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

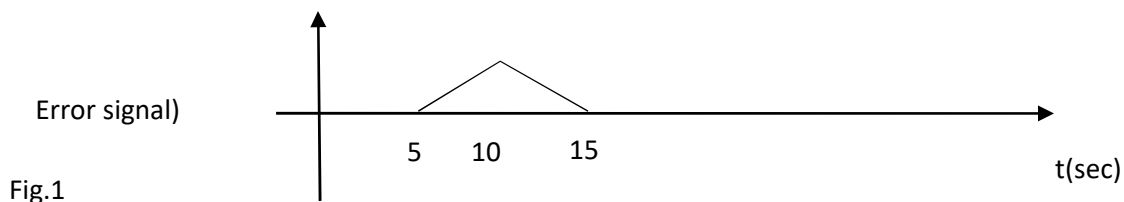
Answer Question ONE and any other TWO Questions.

Requirements

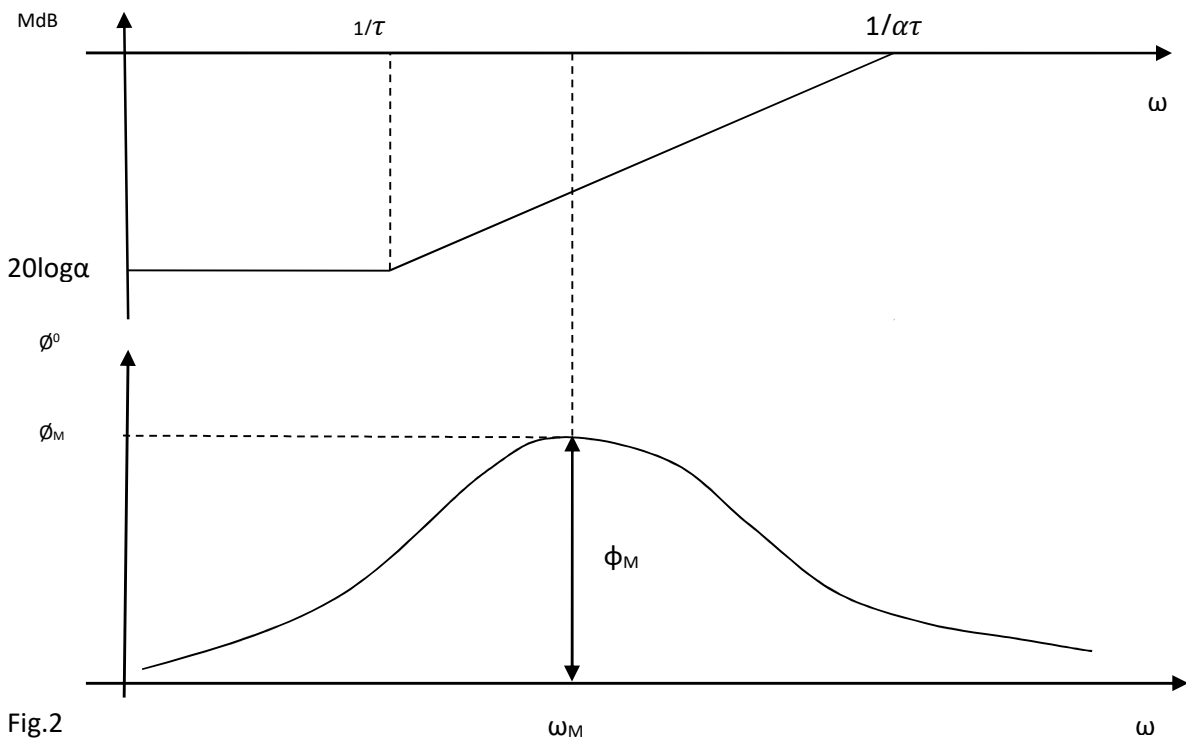
Bode plot graph paper

QUESTION ONE (30 MARKS)

- a) Define proportional band. (2 marks)
- b) The waveform in fig.1 shows an error 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)



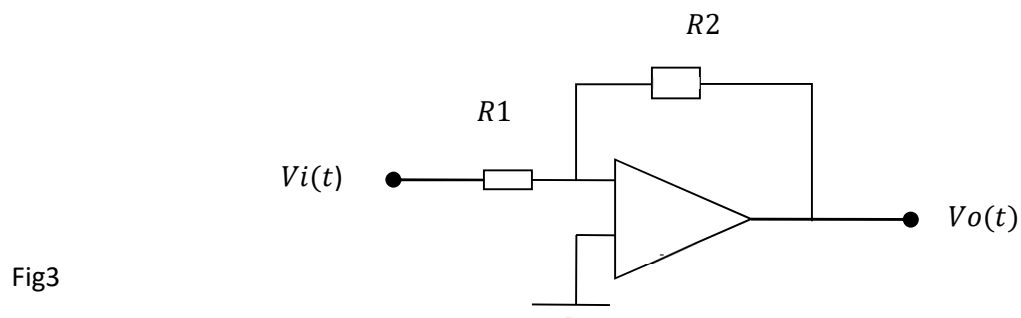
- c) Derive the expression of ω_M , which is the frequency at which the maximum phase angle ϕ_M is obtained for a phase lead network shown in fig.2. (6 marks)



- 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 $v_o(t)$. (5 marks)



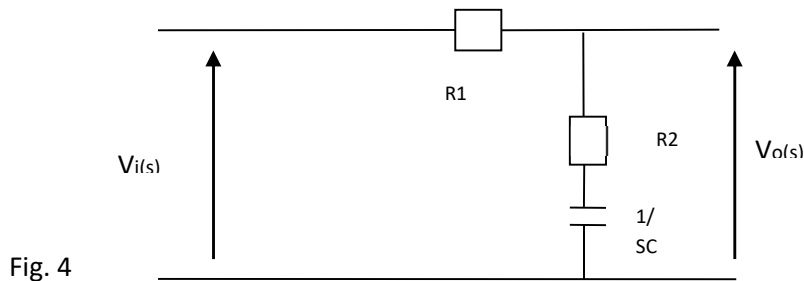
QUESTION TWO (20 MARKS)

- 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)



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:
- Sketch a labeled diagram of the electronic controller.
 - 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 $x_1 = \theta$, $x_2 = \frac{d\theta}{dt}$ and $x_3 = \frac{d^2\theta}{dt^2}$. Assume:

Moment of inertia of motor and load $=j$
 Back emf constant $=kb$
 Coefficient of friction of motor and load $=f$
 Motor torque constant $=K_T$

(10 marks)

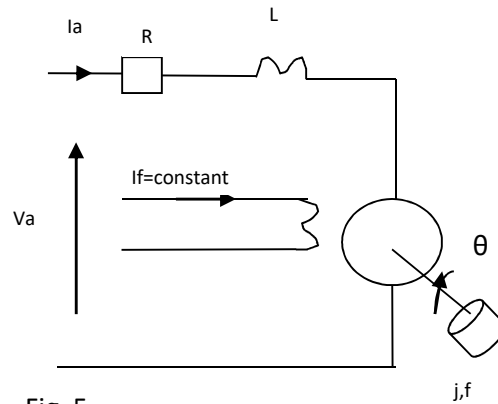


Fig. 5

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° . (10 marks)

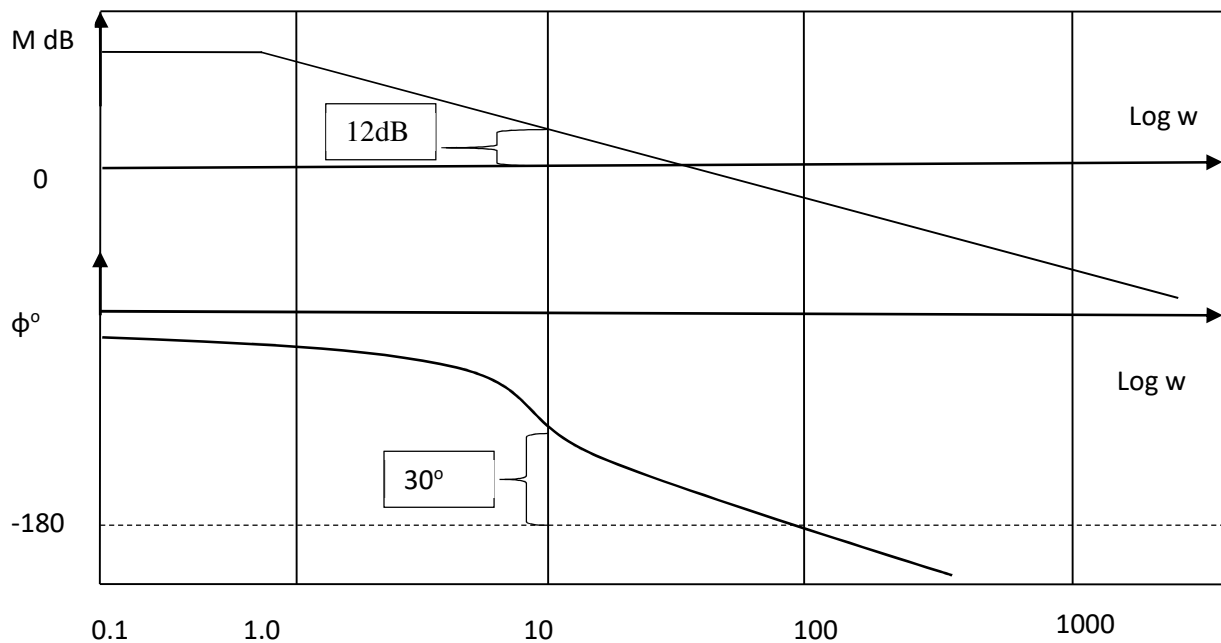
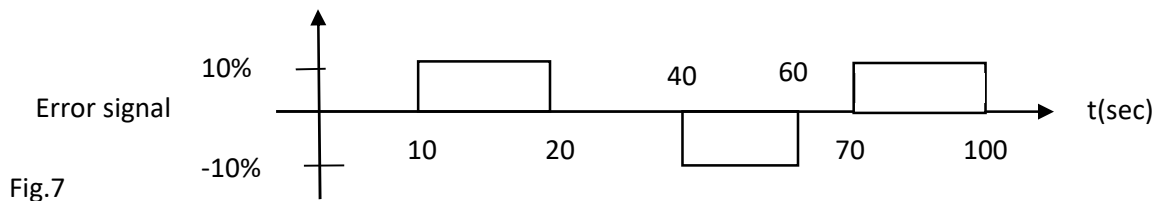


Figure6

- 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:
- At t=30 seconds.
 - At t=50 seconds.
 - At t=100 seconds
- (10 marks)



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:
- The relationship between pressure and current.
 - 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:
- Sketch a well labeled circuit diagram.
 - Derive the transfer function.
 - 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)

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