MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 310: CONTROL SYSTEMS I

DATE: 16/3/2022 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS

Question ONE is compulsory

Answer any other TWO questions

Requirements

Log-linear paper

Nichols plot paper.

QUESTION ONE

a) Differentiate between a source and a sink node in a signal flow graph. (4 marks)

b) For the network in fig.1:

(i) Determine the expression for $v_{o(t)}$ for unit step signal.

(ii) Determine value of the steady state error. (6 marks)

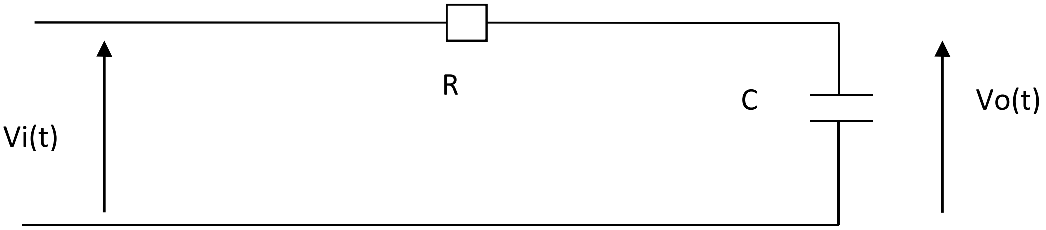

Fig.1

c) The circuit in fig.2 shows an armature controlled dc motor.

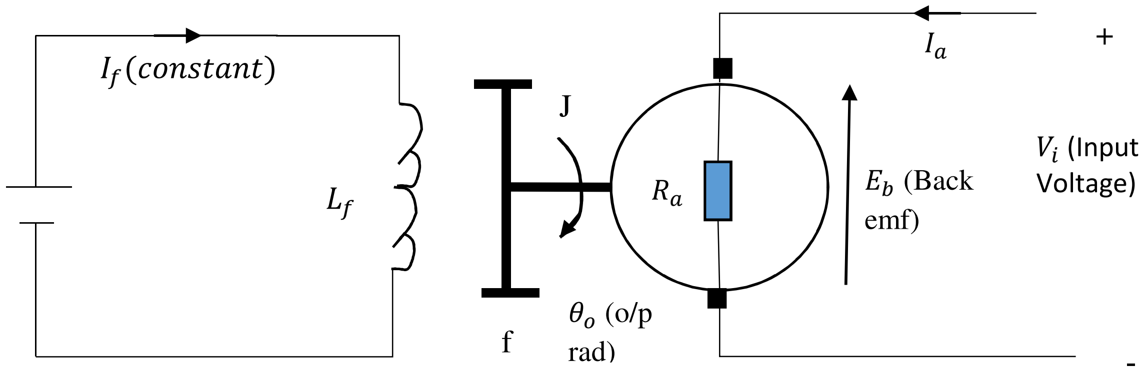

Fig.2

Given the following constants:

Km	=	motor torque constant
Kb	=	back emf constant
J	=	resultant moment of inertia
f	=	resultant damping resistance

i. Draw the system block diagram.

ii. From the block diagram determine the transfer function $\frac{\theta_0(s)}{V_i(s)}$

(10 marks)

d) A second order system has the following differential equation:

$$\frac{d^2\theta_0}{dt^2} + 2\frac{d\theta_0}{dt} + 5\theta_0 = 5\theta_i$$

Determine for a unit step input:

i. Output time response

ii. Peak time

iii. Settling time to a tolerance band of $\pm 2\%$. (10 marks)

QUESTION TWO (20 MARKS)

a) Distinguish between open and closed loop systems. (4 marks)

b) A mass spring damper system consists of M kg mass, a spring constant K N/m and a damping resistance f. Determine:

i. The system characteristic equation.

ii. With f=0 show using Routh array that the system oscillates with frequency $\sqrt{\frac{K}{M}}\ rad/sec.$ (8 marks)

c) The open loop response of a system is given in table shown:

ω (rad/sec)	1.0	2	5	10	20	30
Gain (dB)	36	24	0	-18	-36	-44
Phase(degrees)	-117	-135	-175	-210	-235	-249

Draw the response in a Nichol's chart and determine:

i. Gain margin
ii. Phase margin
iii. System bandwidth
iv. Comment on the closed loop system stability (8 marks)

QUESTION THREE (20 MARKS)

a) Explain the term transfer function as applied to the control systems. (3 marks)

b) For the circuit shown in fig.3:

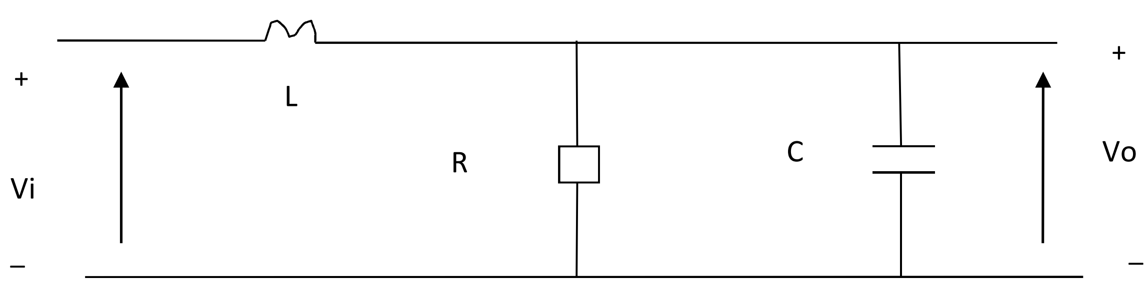

Fig.3

i. Determine its transfer function.
ii. Show that for system to be critically, $R = \sqrt{L/_{4c}}$

(9 marks)

c) For a second order system:

i. Sketch the output time response to a unit step input signal.
ii. Define the following terms in relation to the sketch in (i)
   I. Maximum overshoot
   II. Rise time
   III. Settling time. (8 marks)

QUESTION FOUR (20 MARKS)

a) Briefly describe the unit ramp standard input signal. Give it graphical and mathematical representation in time and complex s-domain. (4 marks)

b) In a test on a servomechanism, the open loop response below was obtained:

ω (rad/sec)	0.05	0.1	0.3	1	3	10	20
Gain (dB)	36	30	21	10	-10	-40	-60
Phase lag(degrees)	96	100	110	145	210	250	260

Plot the response on a Bode diagram and determine:

i. Gain margin
ii. Phase margin (6 marks)

c) Using block diagram reduction techniques, determine the transfer function of the block diagram in fig.4. (10 marks)

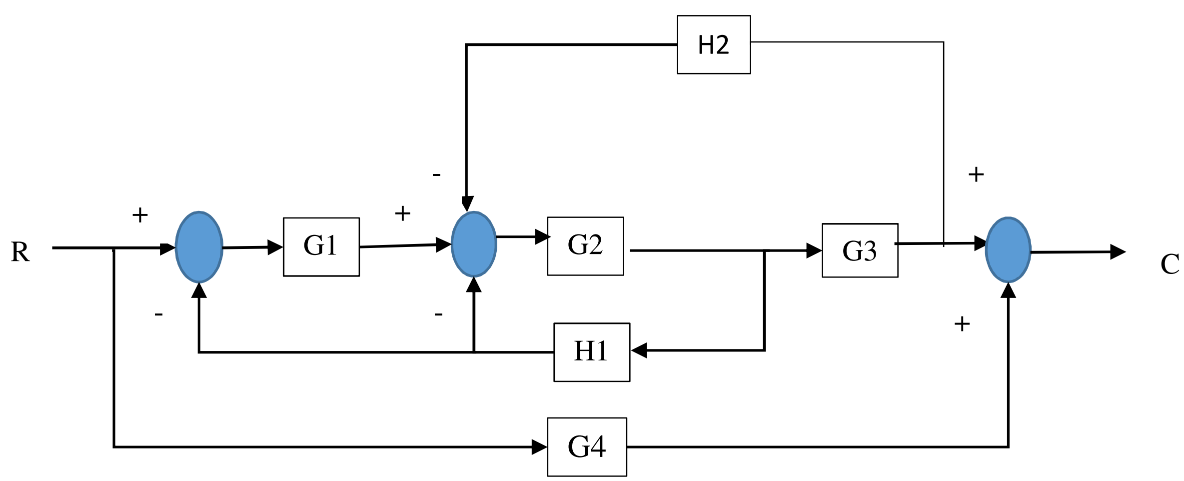

Fig.4

QUESTION FIVE (20 MARKS)

a) Convert the diagram in fig.5 into a signal flow graph. (4 marks)

b) Using Mason's rule, determine the transfer function of the derived signal flow graph. (8 marks)

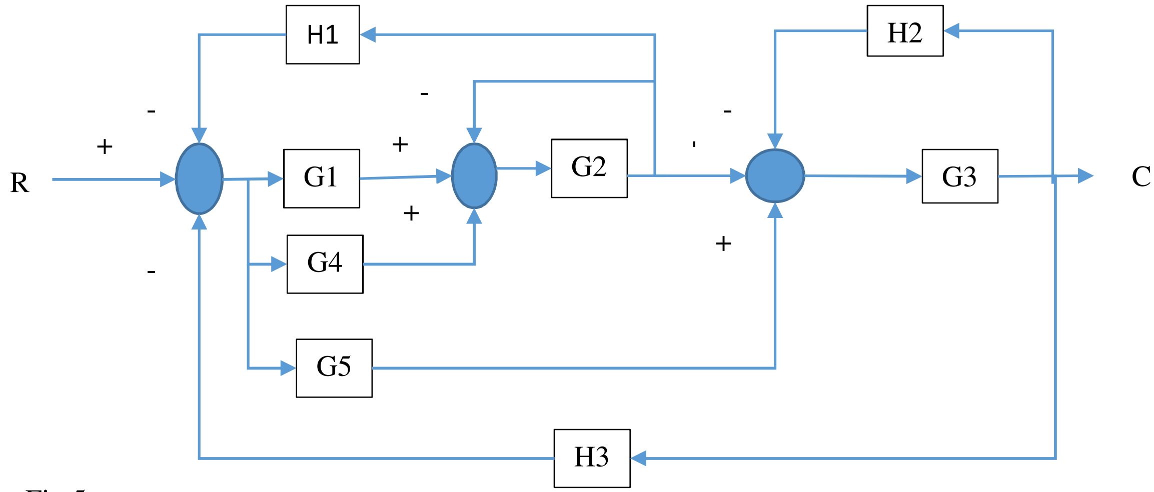

Fig.5

c) Explain what is meant by analogous systems. (2 marks)

d) Use the Ruth array to determine the stability for the system whose characteristic equation is given below:

$$s^5 + s^4 + 2s^3 + 2s^2 + 3s + 5 = 0$$

(6 marks)