MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE ELECTRICAL AND ELECTRONIC ENGINEERING

EEE310: CONTROL SYSTEMS I

DATE:9/3/2023 **TIME: 11:00-1:00 P.M**

INSTRUCTIONS

- Answer Question ONE and any other two questions.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Given network in fig.1 determine the transfer function $I_{2(s)}/V_{(s)}$. (6 marks)

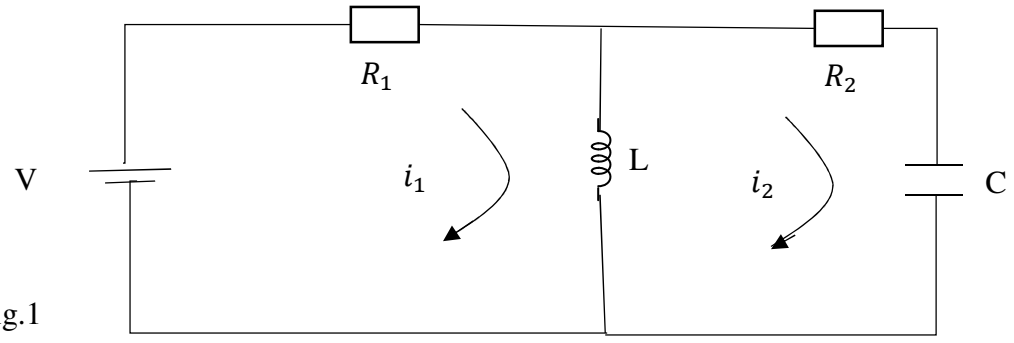

Fig.1

b) Convert block diagram in fig.2 into signal flow graph and determine the transfer function using mason's rule. (8 marks)

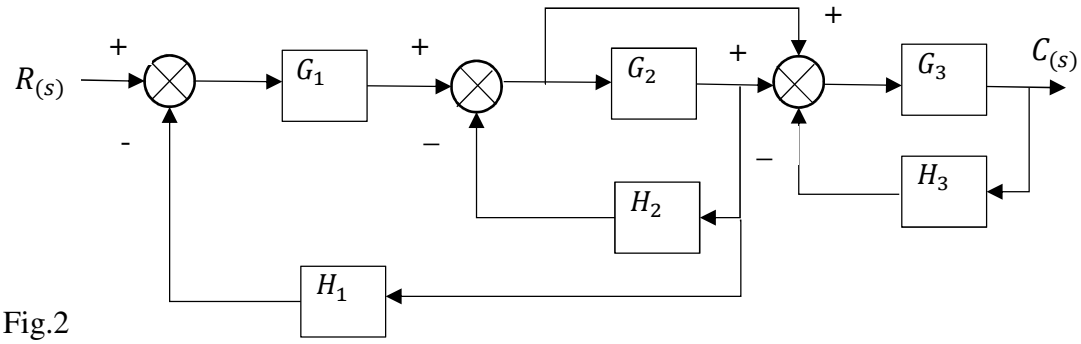

Fig.2

c) Determine the stability of the closed loop transfer function given below using Routh Hurwitz criterion. (6 marks)

$$T_{(s)} = \frac{10}{s^5 + 2s^4 + 3s^3 + 6s^2 + 5s + 3}$$

d) A second order system is represented by the differential equation:

$$2\frac{d^2\theta_o}{dt^2} + 4\frac{d\theta_o}{dt} + 8\theta_o = 8\theta_i$$

Where $\theta_o is\ the\ output\ and\ \theta_i\ is\ the\ input$. Determine for a unit step input:

i. Natural frequency
ii. Damping factor
iii. Damped frequency
iv. Rise time
v. Time to reach the peak overshoot. (10 marks)

QUESTION TWO (20 MARKS)

a) What is steady state error. (2 marks)

b) Find the transfer function $G_{(s)} = X_{(s)}/F_{(s)}$ for the translational mechanical system in fig.3, where K=1 Nm, M=1 kg and ŕ=1N-s/m . (6 marks)

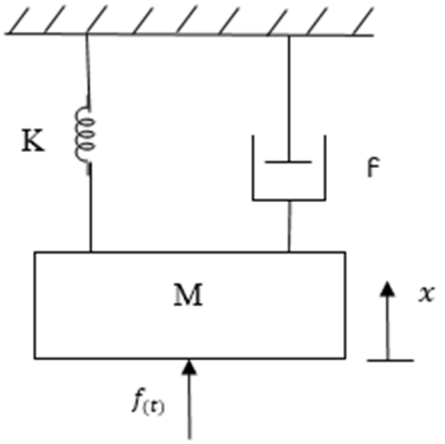

Fig.3

c) Convert the signal flow graph in fig.4 into a block diagram. (6 marks)

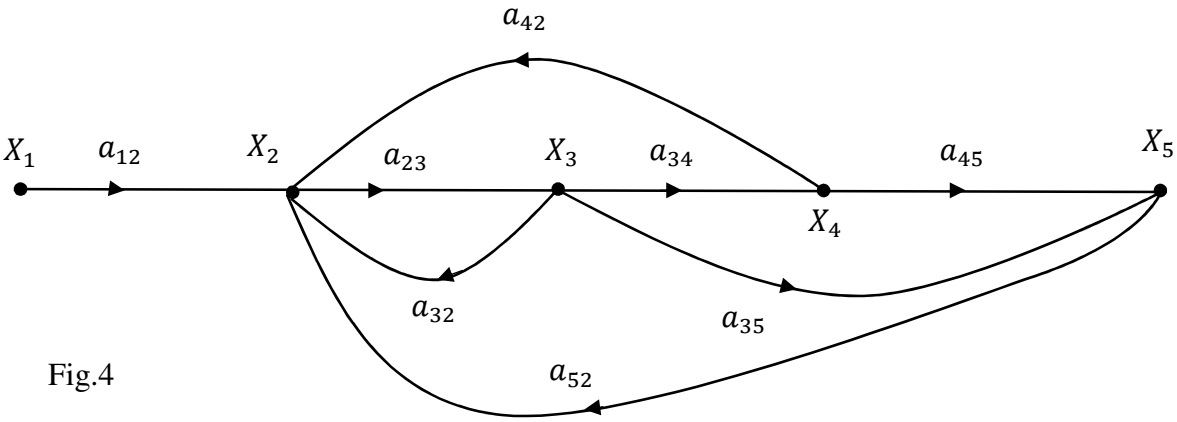

Fig.4

d) Figure 5 are roots in the s-plane. Plot the corresponding impulse response in time domain. (6 marks)

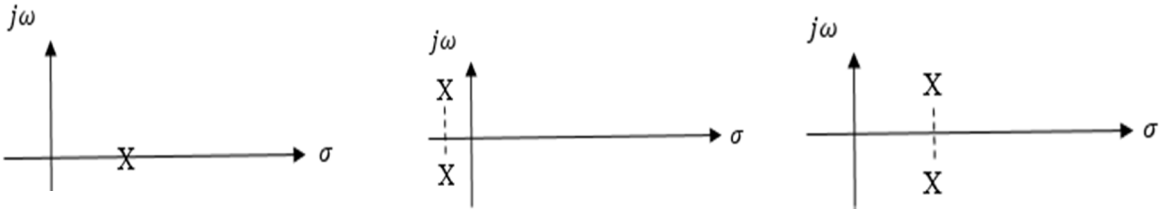

Fig.5

QUESTION THREE (20 MARKS)

a) With aid of graphical representation, describe any THREE standard test signals and give their time and s-domain expressions. (6 marks)

b) Figure 6 is a temperature control system.

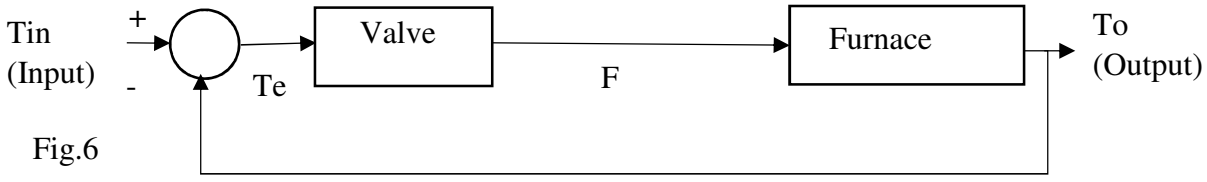

Fig.6

The amount of fuel F delivered to the furnace is related to error temperature T_e by the equation $K_1 \frac{dF}{dt} + F = K_2 T_e$. The furnace temperature T_o is related to the rate of fuel flow F by the equation $K_3 \frac{dT_o}{dt} + T_o = K_4 F$.

i. Draw the block diagram for the system.
ii. Obtain the transfer function of the system
iii. Obtain the expression of the system natural frequency. (8 marks)

c) With aid of a diagram describe the following terms for an underdamped second order system subject to unit step input.
i. Maximum overshoot
ii. Rise time
iii. Settling time (6 marks)

QUESTION THREE (20 MARKS)

a) Define the following terms with respect to signal flow graphs:
i. Forward path
ii. Loop gain
iii. Input node (3 marks)

b) Determine C for the multi-input system in fig.7. (4 marks)

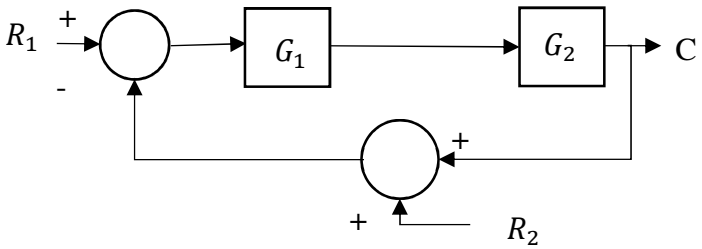

Fig.7

c) With aid of diagrams, explain the Nyquist stability criterion. (4 marks)

d) A system has transfer function:

$$T_{(s)} = \frac{10}{S(1 + 0.2S)(1 + 0.02S)}$$

Draw a Bode plot for the system and use it to determine the phase and gain margin.(9 marks)

QUESTION FIVE (20 MARKS)

a) State any THREE advantages of closed loop system over open loop controlled systems. (3 marks)

b) Open loop transfer function is given by:

$$\frac{K}{j\omega(j\omega T_1 + 1)(j\omega T_{2+1)}}$$

i. Sketch its Nyquist plot

ii. Proof that cut off frequency $\omega_2 = \frac{1}{\sqrt{T_1 T_2}}$ (5 marks)

c) The result of an open loop frequency response test on a system are shown in table.

ω (rad/s)	1	2	3	4	5
Gain (dB)	13	4	-2	-7	-10
Phase angle (degrees)	-127	-152	-168	-180	-188

Draw the response on a Nichols chart and determine:

i. Gain margin

ii. Phase margin

iii. System bandwidth (8 marks)

d) The circuit in fig.8 was subjected to unit step input. Sketch the response curve.(4 marks)

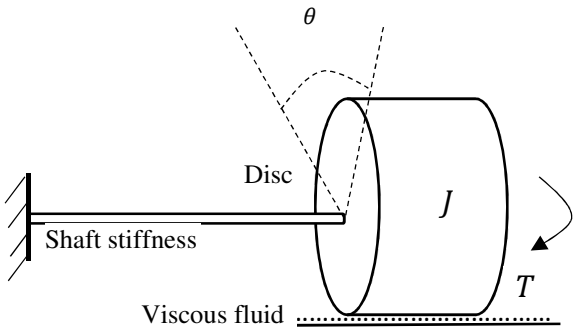

Fig.8