TECHNICAL UNIVERSITY OF MOMBASA

School of Applied and Health Sciences

Department of Mathematics and Physics

UNIVERSITY EXAMINATION FOR:

Bachelor of Science in Technology in Applied Physics

EEE 4251: Control I

END OF SEMESTER EXAMINATION

SERIES: APRIL 2025

TIME: 2 HOURS

DATE: April 2025

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition, attempt any Other TWO Questions.

Do not write on the question paper.

QUESTION ONE (Compulsory 30 marks)

a) i) Explain the concept of a control system and its significance in electrical engineering.

ii) Explain the significance of the damping ratio (ζ) in control systems?

iii) Define the transfer function of a control system and its importance

[6 marks]

b) Differentiate between open-loop and closed-loop control systems

[8 marks]

c) Discuss the advantages of using feedback in control systems

[2 marks]

d) Show that the system in Fig Q1(d), has the ability for both reference tracking and disturbance rejection

[10 marks]

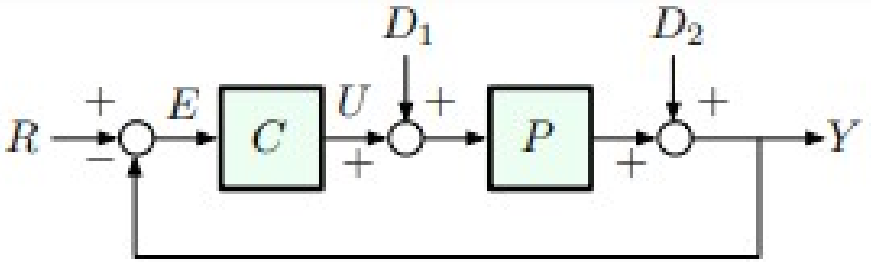

Fig. Q1(d)

e) Derive the closed loop transfer function for the system in Fig Q1 (e) [4 marks]

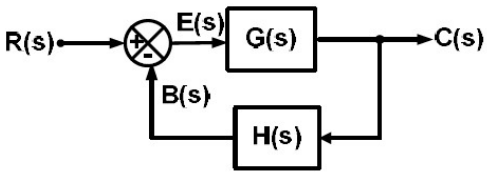

Fig. Q1(e)

Question TWO

a) Consider a dynamic system described by the following differential equation:

$$3\frac{d^2y(t)}{dt^2}+5\frac{dy(t)}{dt}+2y(t)=4u(t)$$

where y(t) is the output and u(t) is the input. Determine the transfer function of the system. [7 marks]

b) For the control system shown in Fig. Q2(b)
(i) Draw the corresponding Signal Flow Graph.
(ii) Determine the transfer function C(s)/R(s) using Signal Flow Graph.
(6 Marks)

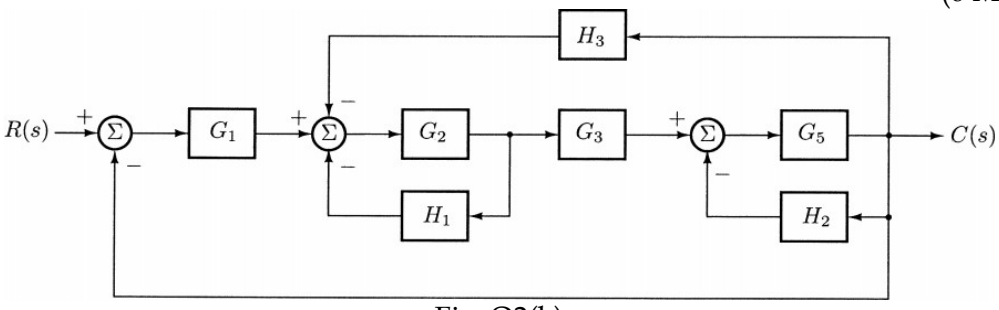

Fig. Q2(b)

c) Determine and plot the poles and zeros on the pole-zero diagram for the following control system transfer functions

i) $$G(s)=\frac{(s+1)(s+2)}{(s+3)(s+4)(s+5)(s+2-4j)(s+2+4j)}$$

ii) $$G(s)=\frac{(s-2)(s+5)(s+8)}{s(s+1)(s+6)(s+9)(s+1-j3)(s+1+j3)}$$

[7 marks]

Question THREE

a) The system in Fig. Q3(a) is subjected to a unit step input and $\zeta = 0.6$ and $\omega_n = 5$ rad/sec. Determine the:

(i) Rise time
(ii) Peak time
(iii) Maximum overshoot
(iv) Settling time.

[8 marks]

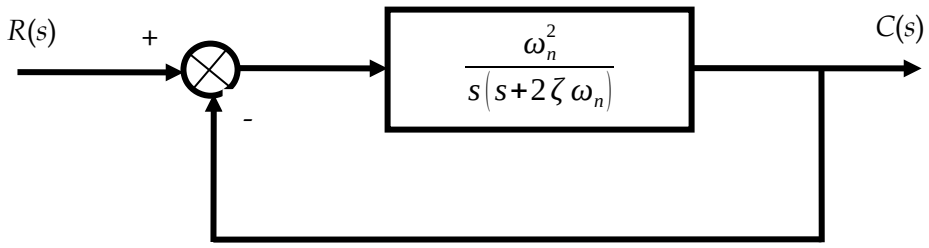

Fig. Q3(a)

b) A single degree of freedom spring-mass-damper system has the following data: spring stiffness 20 *kN/m*; mass 0.05 *kg*; damping coefficient 20 *N-s/m*. Determine:

(i) undamped natural frequency in *rad/s* and *Hz*
(ii) damping factor
(iii) damped natural frequency *n rad/s* and *Hz*.

[6 marks]

c) Using Routh-Hurwitz stability criterion, find stability of the following system given by

$B(s) = s^3 + 5s^2 + 10s + 3$ [6 marks]

Question FOUR

a) With the aid of a diagram, define the following terms as applies to control system performance
i) Stable system
ii) Marginally stable system
iii) Unstable system,

[9 marks]

b) Given two parallel blocks, $G_1(s) = \frac{2s}{s+3}$ and $G_2(s) = \frac{3}{s+4}$

i) Derive the equivalent transfer function of the parallel combination.

ii) Determine the resulting transfer function when the output of the combination is fed into a unity feedback loop.

[5.5 marks]

c) Given two blocks in series, $G_1(s) = \frac{1}{s+2}$ and $G_2(s) = \frac{1}{s+5}$

i) Reduce the series connection to a single block.

ii) Determine the overall transfer function of the series combination.

[5.5 marks]

Question FIVE

a) (i) Given the Laplace transform $F(s)=\frac{2s+5}{s^2+3s+2}$, find the inverse Laplace transform to obtain the time-domain function $f(t)$.

(ii) Find the time domain function from the frequency domain function $F(s)=\frac{1}{(s+3)^2}$

[8 marks]

b) Define the following terms:

(i) Find the transfer function of the following circuit in Figure Q5 (b)
(ii) State the order of the circuit in Figure Q5 (b)

[6 mark]

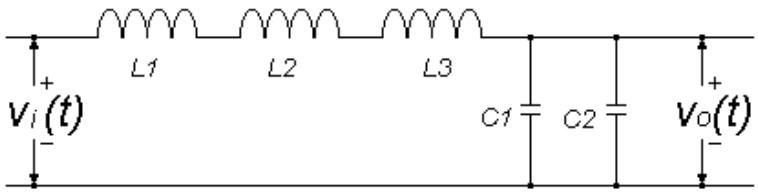

Figure Q5 (b)

c) Let $x(t)$ be the input to a Linear Time Invariant system. The required output is $4x(t\text{-}2)$. Find the transfer function of the system as a function of frequency

[6 mark]