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

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: JULY 2025

TIME: 2 HOURS

DATE : July 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) With the aid of a suitable diagrams illustrate the difference between open loop control systems and closed loop control systems [6 marks]

b) Obtain the differential equations describing the electrical system shown in Fig. Q1 (b) and hence determine its transfer function [6 marks]

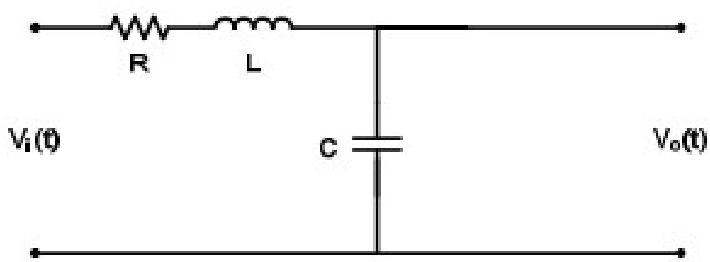

Fig. Q1 (b)

c) The car speed cruise control input-output differential equation is given by:

$$\frac{d}{dt}v+\frac{b}{m}v=\frac{b}{m}v_r$$

For a step input $v_r(t)$. Using the Laplace transform determine the car speed response [8 marks]

d) A control engineer designed a ship steering system represented by the block diagram in Fig. Q1 (d). using block diagram reduction techniques, determine its transfer function Y(s)/R(s) [10 marks]

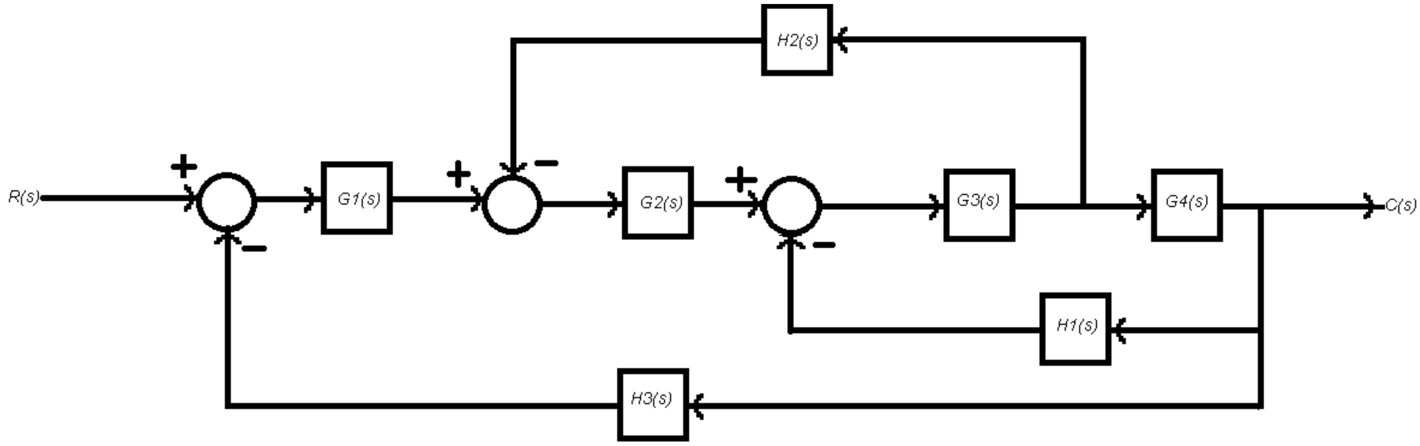

Fig. Q1 (d)

Question TWO

a) Find the system transfer function between function between the capacitance voltage to the source voltage in the RLC circuit as shown in Fig. Q2(a)

[7 marks]

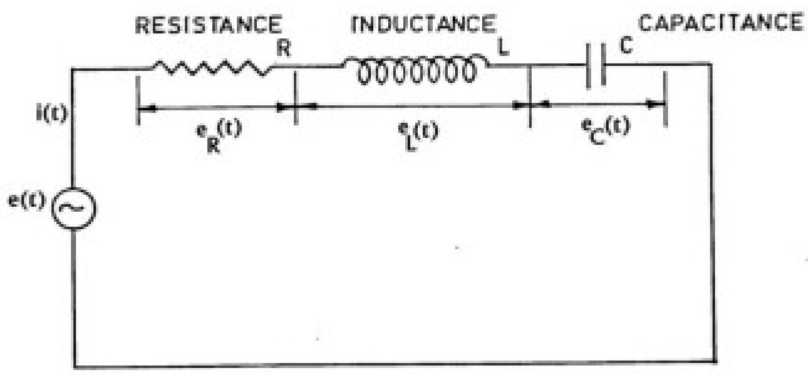

Fig. Q2 (a)

b) Expand the following equations of Laplace transforms in terms of their partial fractions and obtain its time-domain responses.

i) $Y(s)=\dfrac{2s}{(s+1)(s+2)}$

ii) $Y(s)=\dfrac{2s}{(s+1)^2(s+2)}$

8 Marks]

c) A second-order system has a damping factor of 0.3 (underdamped system) and an un-damped natural frequency of 10 rad/s. Keeping the damping factor the same, if the un-damped natural frequency is changed to 20 rad/s;

(i) locate the new poles of the system

(ii) comment on the response of the new system.

[5 marks]

Question THREE

a) The system Fig. Q3(a) is subjected to a unit step input and ζ = 0.5 and ω_n = 4.5 rad/sec. Determine the:

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

[8 marks]

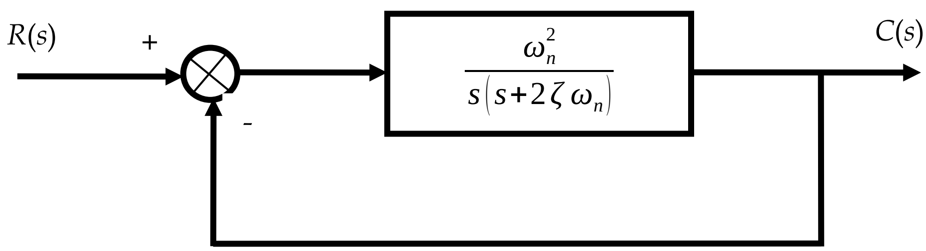

Fig. Q3(a)

b) A single degree of freedom spring-mass-damper system has the following data: spring stiffness 25 *kN/m*; mass 0.025 *kg*; damping coefficient 18 *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 the stability of the following system given by

$$B(s)=s^3+2s^2+3s+10$$

. [6 marks]

Question FOUR

a) Obtain the transfer function $Y(s)/U(s)$ of the motorcycle suspension system in Fig Q5(a). The input ***u*** is a displacement input. [12 marks]

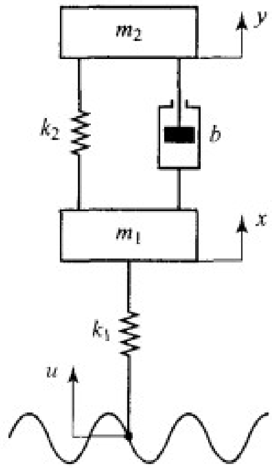

Fig Q5(a)

b) Define the following terms:

(i) Gain margin
(ii) Phase margin

[2 mark]

c) Evaluate analytically the expressions of magnitude and phase response for a system with feed forward transfer function

$$G(s)=\frac{1}{s(s+2)(s+4)}$$ [6 mark]

Question FIVE

a) Draw the root-locus of the feedback system whose open-loop transfer function is given by

$$G(s)H(s)=\frac{k}{s^4+5s^3+8s^2+6s}$$ [11 marks]

b) If

$$\frac{Y(s)}{U(s)}=\frac{s+3}{s^2+3s+2}$$

obtain the signal flow graph representation of this transfer function. [9 marks]