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UNIVERSITY EXAMINATIONS 2024/2025

FOURTH YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION TECHNOLOGY IN ELECTRICAL AND ELECTRONIC ENGINEERING

EET 3357: CONTROL SYSTEMS I

DATE: JANUARY 2025 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) The following characteristic equation represents a given control system, analyse whether the system is stable using Hurwitz criterion (7 Marks)

$$A(s) = 250s^4 + 752.5s^3 + 607.5s^2 + 17 = 0$$

b)

i. Discuss Mason's gain formula

ii. Find the transfer function of the Fig. Q1b signal flow graph (10 Marks)

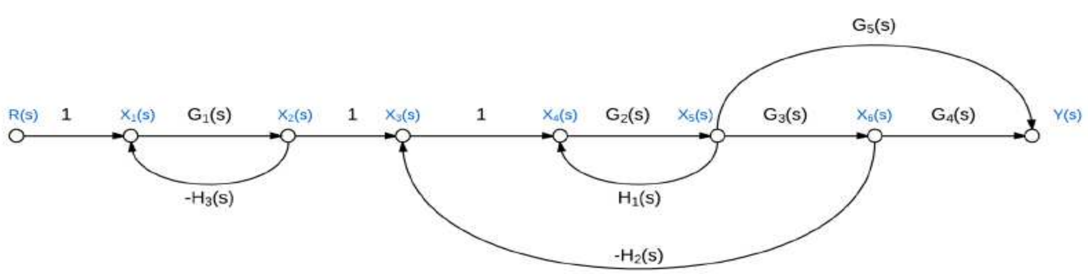

Fig. Q1b.

c) Discuss the following terms as applied to control system
   i. Stochastic systems
   ii. Open loop system
   iii. Closed loop system
   iv. Transient state
   v. Steady state error
   vi. Time invariant systems

(6 Marks)

d) Consider the electrical system Fig. Q1d. with the applied voltage V_i as the input and V_0 as the output.
   i) Write down loop equations
   ii) Write the node equations
   iii) Find the transfer function of the system and the order of the Transfer function of the system (7 Marks)

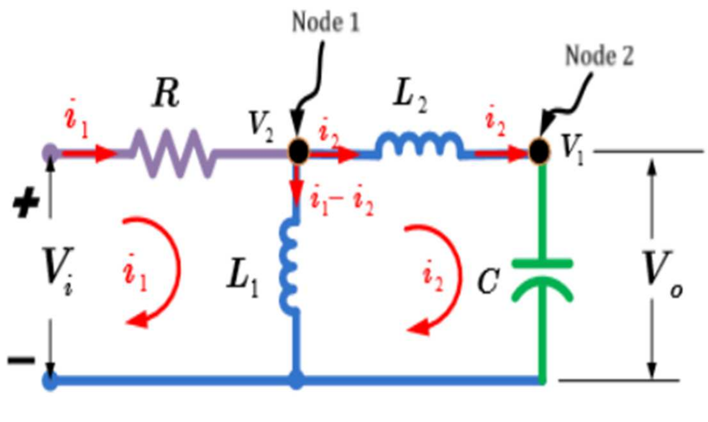

Fig Q1d

QUESTION TWO (15 MARKS)

a) The transfer function of an open loop is given where K=5, τ = 0.5sec. Analyse the stability of the closed loop system using Routh Criterion.

$$G(s) = \frac{K}{(1+\tau s)^3} \ ,$$

(6 Marks)

b) A block diagram of a system is represented in Fig.Q2b, find its equivalent transfer function given the following (9 Marks)

$$W_1(s) = \frac{k_1}{T_1 s+1} \ , W_2(s) = \frac{k_2}{s(T_2 s+1)} \ , W_3(s) = \frac{k_3}{s}$$

$$k_1 = 0.25, \quad k_2 = 0.1, \ k_3 = 0.48, \ T_1 = 0.64 \ , \quad T_2 = 0.13$$

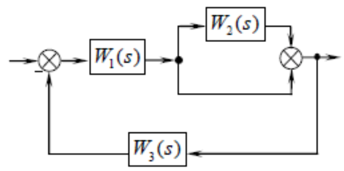

Fig.Q2b

QUESTION THREE (15 MARKS)

a) Find the closed-loop transfer function of the following system (fig 3a.) through block-diagram simplification (7 Marks)

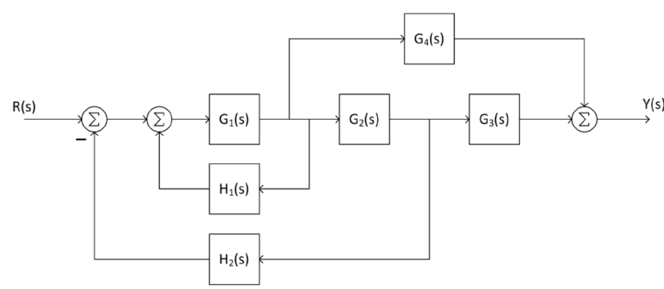

Fig. Q3a

b) Derive a comparison between open and closed loop type of control system (5 Marks)

c) The transfer function below that describes dynamics of a control system where y(t) is the output while x(t) is the inputs. Find the differential equation governing the control system

$$G(S) = \frac{7s^3 + 5.5}{(s - 0.5)(3s^2 + 2)}$$

(3 Marks)

QUESTION FOUR (15 MARKS)

a) Given the differential equation below that describes dynamics of a control system where y(t) is the output while x(t) and u(t) are the inputs. Find the transfer function of the control system (4 Marks)

$$6.25\frac{dy^2}{dt^2} + 4\frac{dy}{dx} + y = 9x - 1.2\frac{dx}{dt} - 5\frac{du}{dt}$$

b) i. Discuss Routh stability criterion and

ii. check whether the following system given by its characteristic equation is stable or not (8 Marks)

$$q(s) = s^5 + 10s^4 + 45s^3 + 90s^2 + 164s + 200 = 0$$

c) Discuss the properties of negative feedback. (3 Marks)

QUESTION FIVE (15 MARKS)

a) Formulate the Nyquist stability criterion. Give the definitions of the phase margin and gain margin. (4 Marks)

b) Analyse the following transfer function using Nyquist diagram (6 Marks)

$$G(s) = \frac{1}{s^2 + 3s + 2}$$

c) Determine the stability of the control system in Fig.Q 5c using Hurwitz criterion given that

$W_p(s) = \frac{1+3s}{s}$, $W_{oy}(s) = \frac{3s+1}{2s^3+3s^2+2s+1}$

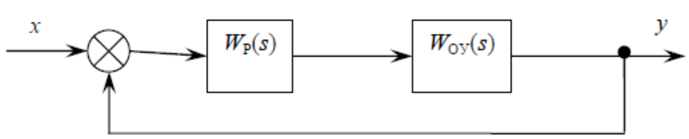

Fig 5Qc (5 Marks)