Reg. No. 2021UG4011

Indian Institute of Information Technology Ranchi

Department of Electronics & Communication Engineering

B. Tech End Semester Examination – Spring Semester 2022-23

Semester: IV **Course Instructor: Dr Nishit Malviya**

Course Code: EC-2010/EI-2010 **Course Name: Control System**

QUESTION PAPER

Duration: 3 Hrs. *Max Marks: 100*

Instructions:

(1). Number in [ ] indicates marks.
(2). Any missing data can be assumed suitably.
(3). Symbols have their usual meaning.
(4). Non-programmable scientific calculator is allowed.

Section A: Answer all the questions.

1 **(a)** What is the control system? Explain the open and closed loop control systems. [5]

(b) Draw a free body diagram and write differential equation describing the dynamics of the system given in Fig. 1. Also obtain the overall transfer function $\frac{\theta(s)}{T(s)}$. [7]

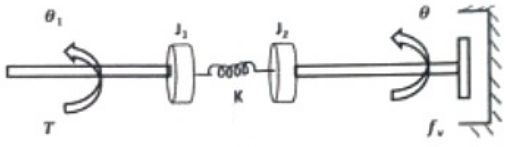

Fig. 1

(c) Find out the block diagram and transfer function for the armature-controlled DC motor system? [8]

2 **(a)** Obtain transfer function by block diagram reduction method for a control system given below: [10]

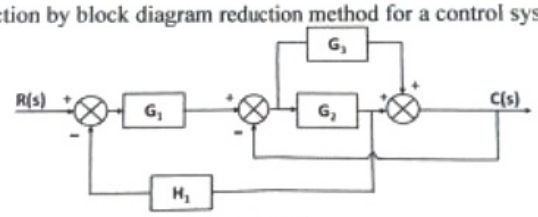

Fig. 2a

(b) Draw the signal flow graph and obtain the overall transfer function through Mason's Gain formula? Also, identify the forward path, individual loop, graph determinant. [10]

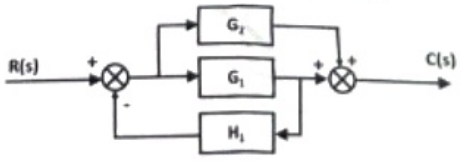

Fig. 2b

3 **(a)** The characteristic equation of the closed loop control system is given as: [5+5]

$$s^3 + 5s^2 + (9 - K)s + K = 0$$

i) Investigate stability using Routh-Hurwitz criterion when K = 8.

ii) Determine the limiting positive value of K which give the stable response of control system using Routh-Hurwitz criterion.

(b) Sketch the root locus for the open-loop transfer function of the unity feedback control system given below and determine the value of K for marginal system. **[10]**

*Hint: Linear graph paper

$$G(s) = \frac{K}{s(s+2)(s+4)}$$

Section B: Answer any **two** questions.

4 (a) A unity feedback system is characterized by the open-loop transfer function: **[10]**

$$G(s) = \frac{1}{s(1+0.5s)(1+0.2s)}$$

Determine the static error coefficient and steady-state error for unit-step, unit-ramp and unit-acceleration input.

(b) Discuss the following controller with the help of suitable diagrams: **[5x5]**

i) Proportional Derivative Controller

ii) Proportional Integral Controller

5 (a) Sketch the Bode plot for the open loop transfer function of the unity feedback system given below: **[10]**

$$G(s) = \frac{50}{(s+1)(s+2)}$$

Determine the following:

i) Phase cross frequency ii) Gain crossover frequency iii) Gain margin iv) Phase margin v) Stability?

*Hint: Semi-log Paper

(b) What is the significance of the type and order of open loop transfer function in the construction of polar plots? **[5]**

(c) Construction of polar plot for given open loop transfer function **[5]**

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

*Hint: Linear graph paper;

6 (a) Consider the second order differential equation, **[5]**

$$\frac{dy^2(t)}{dt^2} + 2\frac{dy(t)}{dt} + 2\,y(t) = x(t)$$

Subjected to $y(0+) = 0$ and $y'(0+) = 0$.

Find out the overall transfer function $\frac{Y(s)}{X(s)}$ and y(t) when $x(t) = \delta(t)$.

(b) Explain the effect of damping factor on the performance of second-order control system for a unit step input? **[5]**

(c) A closed loop control system is given as: **[10]**

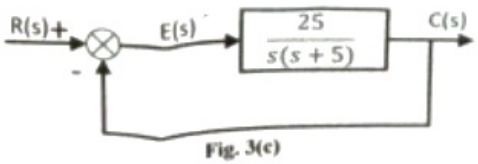

Fig. 3(c)

Determine the transfer function, characteristic equation of the system, ω_n, ζ, ω_d, t_p, and M_p (in %) for given unity feedback control system.

End