CBCS SCHEME

USN

17EC43

Fourth Semester B.E. Degree Examination, Feb./Mar. 2022
Control Systems

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Module-1

1 a. Define open loop and closed loop system and list the difference between these two. **(05 Marks)**

b. For the mechanical system shown in Fig Q1(b).
   i) Draw the equivalent mechanical system
   ii) Write the differential equations of performance
   iii) Draw the electrical network based on torque current analogy.

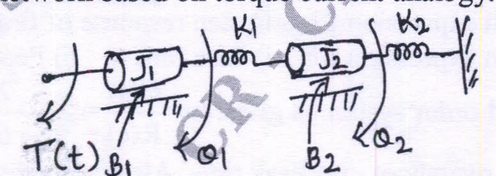

Fig Q1(b) **(08 Marks)**

c. Show that the two systems shown in Fig Q1(c) are analogous systems by comparing their transfer function.

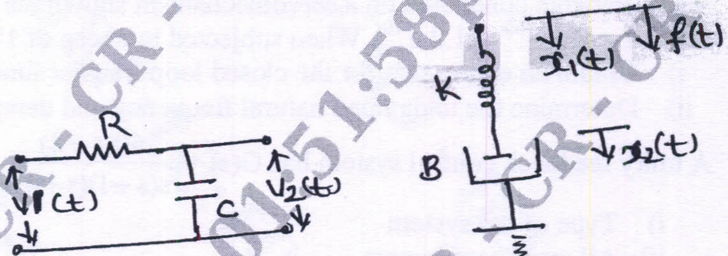

Fig Q1(c) **(07 Marks)**

OR

2 a. Define the following terms with respect signal flow graph.
i) Node ii) Forward path gain iii) Self loop iv) Non-touching loops. **(04 Marks)**

b. For the block diagram shown in Fig Q2(b), determine the transfer function $\frac{C(s)}{R(s)}$ using block diagram reduction technique.

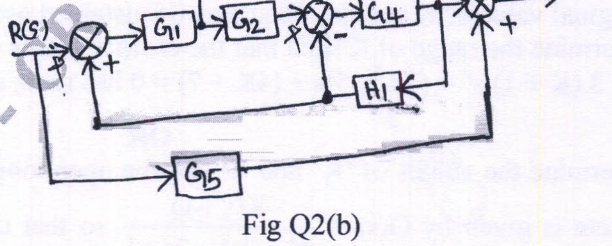

Fig Q2(b) **(08 Marks)**

c. Using Mason's gain formula, find the transfer function $\frac{C(s)}{R(s)}$ for the signal flow graph shown in Fig Q2(c).

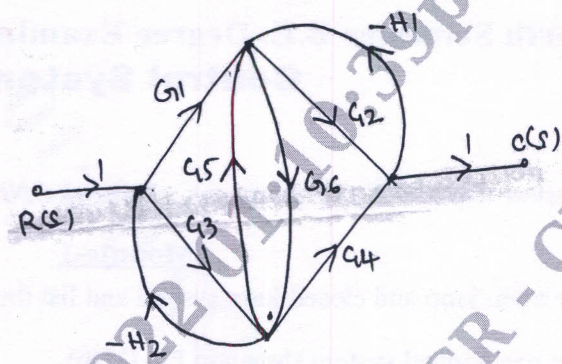

Fig Q2(c) **(08 Marks)**

Module-2

3 a. Derive an expression for unit step response of first order system. **(04 Marks)**

b. Derive an expression for i) Rise time t_r ii) Peak time t_p iii) Peak over shoot m_p **(09 Marks)**

c. A second order system is given by $\frac{C(s)}{R(s)} = \frac{25}{s^2 + 6s + 25}$. Find i) rise time ii) settling time iii) Peak overshoot iv) Peak time. Also calculate expression for its output response. **(07 Marks)**

OR

4 a. Measurements conducted on a servomechanism shown the system response to be $c(t) = 1 + 0.2\,e^{-60t} - 1.2\,e^{-10t}$. When subjected to a step of 1V.

i) Obtain an expression for the closed loop transfer function
ii) Determine the undamped natural frequency and damping ratio of the system. **(07 Marks)**

b. A unity feedback control system has $G(s) = \frac{40(s+2)}{s(s+1)(s+4)}$. Determine :

i) Type of the system
ii) All error coefficients
iii) Error for the ramp input with magnitude 4. **(07 Marks)**

c. With a neat block diagram explain the Proportional Integral and Derivative (PID) controller. **(06 Marks)**

Module-3

5 a. State and explain Routh's stability criterion for determining the stability of the system and mention its limitations. **(06 Marks)**

b. The open loop transfer function of a unity feedback system is given by $G(s) = \frac{K}{s(1+0.4s)(1+0.25s)}$. Using RH criterion find the range of values of K for stability, marginal value of K and the frequency of sustained oscillation. **(08 Marks)**

c. Determine the range of K such that the characteristics equation $s^3 + 3(K+1)s^2 + (7K+5)s + (4K+7) = 0$ has roots more negative than s = -1. **(06 Marks)**

OR

6 a. Determine the values of 'K' and 'P' for the open loop transfer function of a unity feedback system is given by $G(s) = \frac{K(s+1)}{s^3 + Ps^2 + 2s + 1}$ so that the system oscillates at a frequency of 2 rad/sec. **(06 Marks)**

b. The open loop transfer function of a control system is given by $G(s)\,H(s) = \dfrac{K}{s(s+2)(s+4)}$.
Find whether $s = -0.75$ and $s = -1 + j4$ is on the root locus or not using angle condition. **(04 Marks)**

c. Sketch the root locus plot for the unity feedback system whose open loop transfer function is given by $G(s)\ \dfrac{K}{s(s+2)(s+6)}$
   i) Find the range of 'K' for stability of the system
   ii) Find the value of 'K' for marginal stability. **(10 Marks)**

Module-4

7 a. Define the following terms with respect to Bode plots.
   i) Gain cross over frequency ii) Phase cross over frequency
   iii) Gain margin iv) Phase margin **(04 Marks)**

b. With a neat circuit and relevant expressions, explain the lead compensator. **(06 Marks)**

c. A unity feedback control system has $G(s) = \dfrac{100(0.1s+1)}{s(s+1)^2(0.01s+1)}$. Draw the Bode plot. Determine Gain margin and phase margin. Comment on the stability. **(10 Marks)**

OR

8 a. Using Nyquist stability criterion, determine the stability of a negative feedback control system whose open loop transfer function is given by
$G(s)\,H(s) = \dfrac{100}{(s+1)(s+2)(s+3)}$. **(10 Marks)**

b. A unity feedback control system has $G(s) = \dfrac{4}{(0.1s+1)^2(0.01s+1)}$. Draw the Bodeplot, comment of the stability. **(10 Marks)**

Module-5

9 a. With a neat schematic and relevant waveforms explain signal reconstruction with respect to digital control system. **(06 Marks)**

b. State the advantages of state variable analysis. **(04 Marks)**

c. Obtain the state model of the electrical network shown in Fig Q9(c)

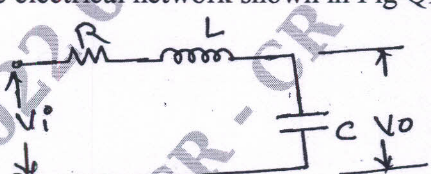

Fig Q9(c) **(10 Marks)**

OR

10 a. Obtain the state model for a system characterized by differential equation
$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = u$$ **(06 Marks)**

b. The transfer function of a control system is given by
$\dfrac{Y(s)}{U(s)} = \dfrac{6s^3 + 4s^2 + 3s + 10}{s^3 + 8s^2 + 4s + 20}$. Obtain the state model. **(06 Marks)**

c. Obtain the transfer function of the system whose state output equations are given by
$$\dot{x}_1 = -9x_1 - x_2 + 5u$$
$$\dot{x}_2 = 15x_1 - x_2 + 2u$$
$$y = 2x_1 + x_2$$ **(08 Marks)**