CBCS SCHEME

USN

21EE52

Fifth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025

Control Systems

Time: 3 hrs. Max. Marks: 100

Note: *1. Answer any FIVE full questions, choosing ONE full question from each module.*
2. Semilog graph sheet required.

Module-1

1 a. Define control system. Distinguish the types of control system with example. **(08 Marks)**

b. For the mechanical system shown in Fig.Q1(b). Write the differential equations describing its behavior. Write the analogous electrical equations based on force-voltage analogy, and force–current analogy, and draw the corresponding networks. Also draw the mechanical network and obtain the transfer function : $\frac{Y_1(s)}{F(s)}$.

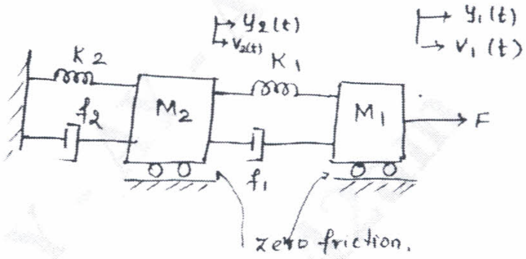

Fig.Q1(b) **(12 Marks)**

OR

2 a. Obtain the governing equation for the given electrical network and derive its transfer function shown in Fig.Q2(b).

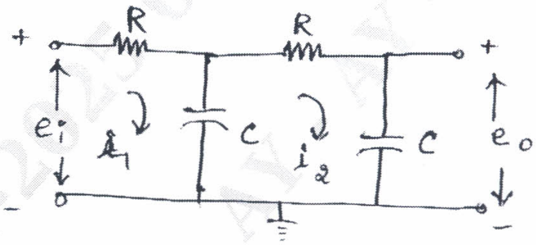

Fig.Q2(b) **(10 Marks)**

b. Discuss about : i) Synchros ii) Gear trains. **(10 Marks)**

Module-2

3 a. Give the list of block diagram reduction rules. **(08 Marks)**

b. Obtain the transfer function of the feedback control system shown in Fig.Q3(b) by block diagram reduction technique.

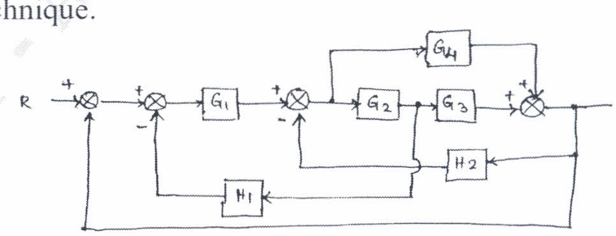

Fig.Q3(b) **(12 Marks)**

OR

4 a. Explain the construction of signal flow graph with its properties. **(08 Marks)**

b. Obtain the transfer function of the control system represented by the block diagram shown in Fig.Q4(b) by signal flow graph method.

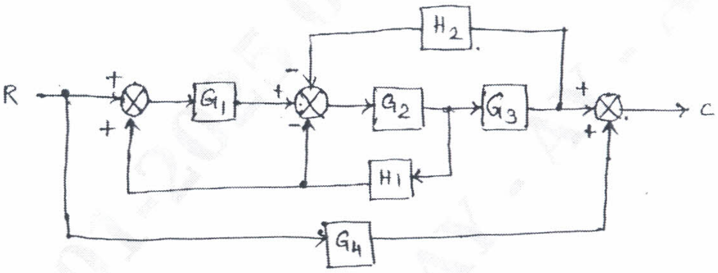

Fig.Q4(b) **(12 Marks)**

Module-3

5 a. A unity feedback system is characterized by an openl-loop transfer function :

$G(s) = \frac{k}{s(s+10)}$. Determine the gain K so that the system will have a damping ratio of 0.5.

For this value of K, determine the setting time, peak overshoot and time to peak overshoot for a unit-step input. **(10 Marks)**

b. The characteristic equation of a feedback control system is given by :

$s^4 + 20s^3 + 15x^2 + 2s + K = 0$

i) Determine the range of K for the system to be stable

ii) Can the system be marginally stable? If so, find the required value of K and the frequency of sustained oscillations. **(10 Marks)**

OR

6 a. The open-loop transfer function of a servo system with unity feedback is

$G(s) = \frac{10}{s(0.1s+1)}$

Evaluate the static error coefficients (K_p, K_V, K_a) for the system obtain the steady-state error of the system when subjected to an input given by the polynomial $r(t) = a_0 + a_1 t + \frac{a_2}{2} t^2$.

Also evaluate the dynamic error using dynamic error coefficients. **(12 Marks)**

b. Using the Routh criterion, cheek whether the system represented by the following characteristic equation is stable or not. Comment on the location of the roots. Determine the frequency of sustained oscillations if any, $s^4 + 2s^3 + 6s^2 + 8s + 8 = 0$. **(08 Marks)**

Module-4

7 a. Give the list of rules for the construction of the root locus. **(08 Marks)**

b. Sketch the root locus of the open-loop transfer function given below :

$G(s)H(s) = \frac{K}{s(s+2)(S^2 + 2s + 5)}$. **(12 Marks)**

OR

8 a. A unit-step response test conducted on a second-order system yielded peak overshoot $M_p = 0.12$, and peak time $t_p = 0.2s$. Obtain the corresponding frequency response indices (M_r, W_r, W_b) for the system. **(08 Marks)**

b. Sketch the bode plot for the following transfer function and determine the system gain K for the gain cross over frequency $w_g = 10$ rad/s.

$$G(s)H(s) = \frac{Ks^2}{(1+0.25s)(1+0.025s)}.$$ **(12 Marks)**

Module-5

9 a. Define principle of argument. Discuss in detail about Nyquist stability criterion. **(10 Marks)**

b. Design a lead compensator for a unity feedback system with an open-loop transfer function :

$$G_f(s) = \frac{k}{s(s+1)}$$

For the specifications of $K_v = 10s^{-1}$ and $\varphi_m = 35^o$. **(10 Marks)**

OR

10 a. Draw the Nyquist plot and assess the stability of the closed loop system whose open loop transfer function is :

$$G(s)H(s) = \frac{(s+4)}{(s+1)(s-1)}.$$ **(10 Marks)**

b. Consider a unity feedback system with open loop transfer function :

$$G(s) = \frac{5}{s(s+0.5)(s+1)}$$

Design a PD controller so that the phase margin of the system is 30° at a frequency of 1.2 rad/sec. **(10 Marks)**

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