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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent Institution of MAHE, Manipal)

V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
MAKE-UP SEMESTER EXAMINATIONS, DECEMBER 2018
SUBJECT: LINEAR CONTROL THEORY [ELE 3101]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 21, December 2018** **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Semilog Graph sheet may be provided.
- Missing data may be suitably assumed.

1A. Find the transfer function $G(s)=\frac{\theta_L(s)}{E_a(s)}$ for the armature controlled D.C motor and the load shown in **Fig. Q1A**, the torque-speed curve is given by $T_m=-8\omega_m+200$ when the input voltage is 100volts. ***(03)***

1B. A signal flow graph for the system is shown in the **Fig. Q1B**, determine the overall gain using the Mason's Gain formula ***(03)***

1C. The block schematic of a system is shown in **Fig. Q1C.** Using suitable block reduction techniques, obtain the final transfer function of the system. ***(04)***

2A. Justify appropriately whether, the transfer function $G_c(s)={(s+2)}\Big/{(s+4)}$ can indeed function as a lead compensator. Further, determine the frequency at which the phase of $G_c(s)$ is maximum. ***(03)***

2B. A control system with a PI controller is shown in **Fig Q2B**. Select the appropriate controller gains so that the overshoot to a unit step input is equal to 5% and the velocity constant K_v is equal to 5. ***(03)***

2C. Assuming positive value for the gain "K", sketch the root locus of the system shown below and comment on its stability. Further, determine the values of "K" for which the system will be
i) Underdamped
ii) Overdamped.

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

(04)

3A. In a unity feedback control system, the plant transfer function in the forward path is given as:

$$G_p(s)=\frac{K}{s(s+10)}$$

Determine the value of the proportional gain $'K'$ which results in the overall system having a damping ratio of 0.25. ***(03)***

3B. Consider a unity feedback system with open loop transfer function

$$G(s)=\frac{20}{s(s+2)(s+4)}$$

Design a PD controller so that the closed loop has a damping ratio of 0.8 and natural frequency of oscillation as 2 rad/sec. ***(03)***

3C. Consider a unity feedback system with the plant transfer function given as:

$$G(s) = \frac{K}{s(s+7)}$$

Design as well as realize (through active circuit components) a suitable controller that ensures zero steady state error after the closed loop system endures an initial overshoot of 15%. ***(04)***

4A. The open loop transfer function of a unity feedback system is

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

Design a lead compensator to have a static error constant of 20 s^{-1} and phase margin of at least 50^{0}. (**use the provided semi-log graph sheet**) ***(03)***

4B. From the fundamentals, derive the transfer function of the active network shown in **Fig Q4B**. Also determine the conditions for which the considered network behaves as:

a) Phase lead compensator

b) Phase lag compensator ***(03)***

4C. A unity feedback system has the open loop transfer function is given below:

$$G(s)H(s) = \frac{K(s+6)}{s(s+1)(s+4)}$$

Draw the Nyquist diagram and determine the range of K for which the system remains stable. ***(04)***

5A. A system matrix for a linear time invariant system *is* $A = \begin{bmatrix} 0 & 2 \\ -3 & -5 \end{bmatrix}$. Determine the state transition matrix and show that $\Phi(0) = I$ *and* $\dot{\Phi}(0) = A$ ***(03)***

5B. Represent the electrical network shown in **Fig. Q 5B**, in state space physical variable form if the output is current through the resistor. Convert the state space to represent the same electrical network in transfer function form ***(03)***

5C. For the system shown below, design a state space observer such that estimation error goes to zero in two Seconds.

$\dot{x} = \begin{bmatrix} -5 & 1 \\ -1 & 2 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u\ ;\ y = [1 \quad 0]x$ ***(04)***

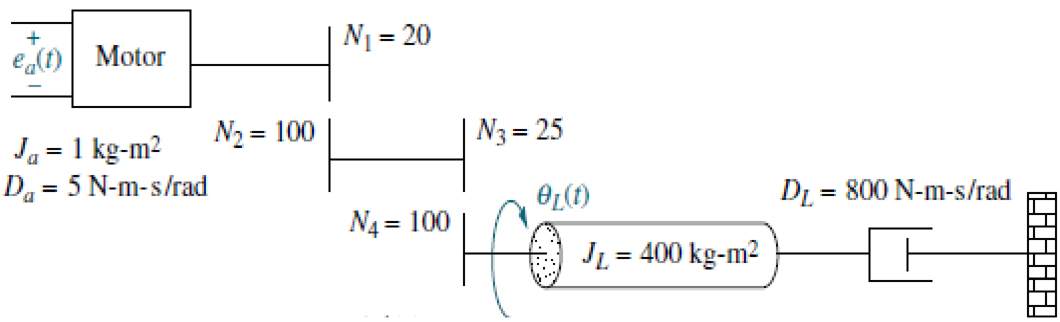

Fig. Q1A

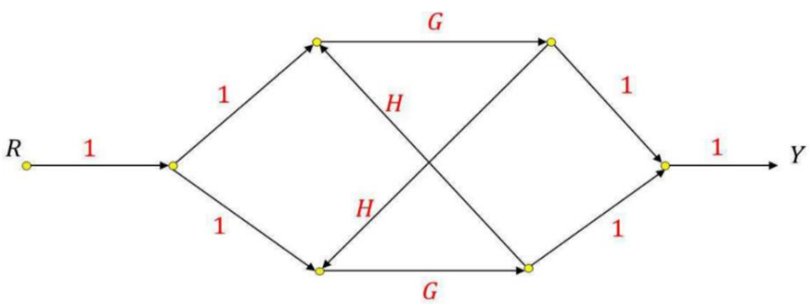

Fig. Q1B

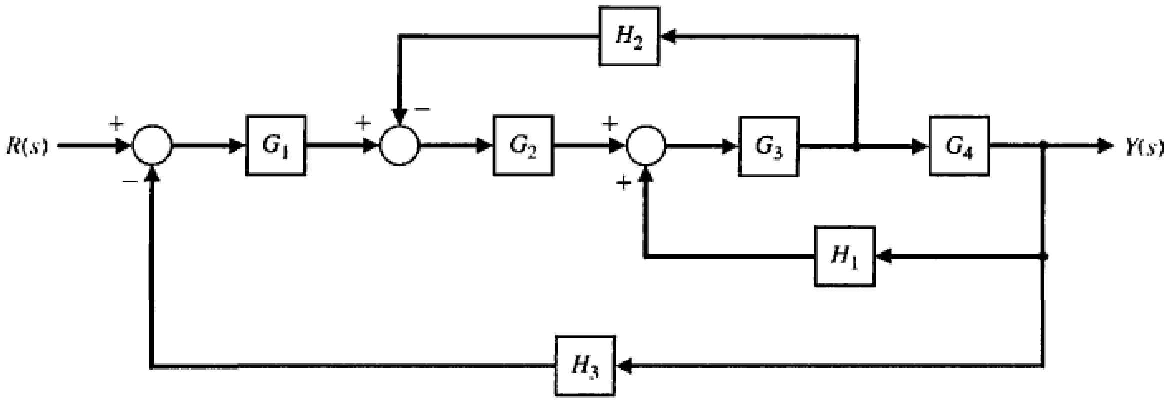

Fig. Q1C

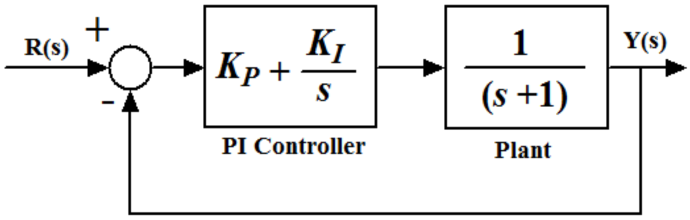

Fig. Q2B

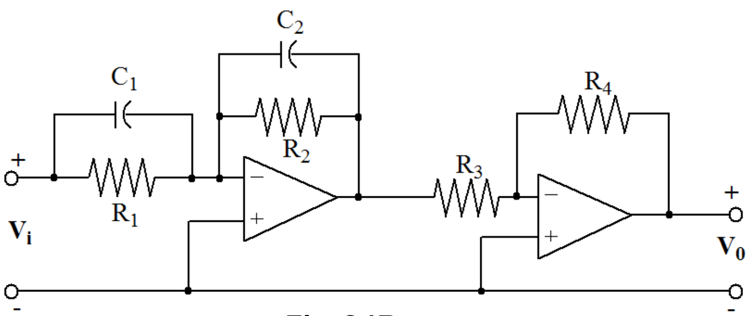

Fig. Q4B

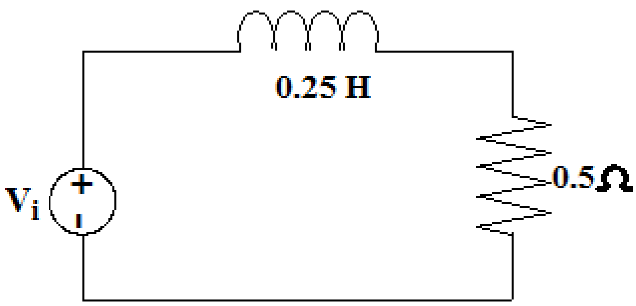

Fig. Q5B