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

V SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
MAKE-UP EXAMINATIONS, DECEMBER 2019
SUBJECT: LINEAR CONTROL THEORY [ELE 3101]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 19 December 2019** **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Semi log graph sheet will be provided

1A. For the rotational mechanical system shown in **Figure Q1A**, determine the transfer function $G(s) = \theta_2(s)/T(s)$ ***(03)***

1B. The block diagram of a system is shown in **Figure. Q1B**. Using suitable block reduction techniques, obtain the final transfer function of the system. ***(03)***

1C. Sketch the root locus for a unity feedback system with open loop transfer function given below and comment on the range of 'K' for system to be stable.

$$G(s) = \frac{K(s+1)}{s(s+4)+13}$$ ***(04)***

2A. For the second order underdamped system $\boldsymbol{G(s)}$ given below, derive suitably the expressions for the following parameters:
- peak time
- maximum peak over shoot

Consider the system to be subjected to a unit step excitation.

$$G(s) = \frac{\omega_n^2}{s^2 + 2\xi w_n s + \omega_n^2}$$ ***(03)***

2B. For the asymptotic bode magnitude plot shown in **Figure. Q 2B**, determine the gain margin (dB) of the system through analytical method. ***(03)***

2C. Determine the phase margin and gain margin of the system with open loop transfer function given below (**Use the semi-log graph sheet to draw the bode plot**):

$$G(s) = \frac{20(s+1)}{s(s+5)(s^2+2s+10)}$$

Also comment on the stability of the system. ***(04)***

3A. A unity feedback system has the open loop transfer function as given below:

$$G(s) = \frac{100K}{(s+1)(s+10)(s+3)}$$

Draw the Nyquist diagram and determine the range of K for which the system remains stable. ***(03)***

3B. For the characteristic equation of a feedback control system $s^4 + 25s^3 + 15s^2 + 20s + k = 0$, determine the range of K for stability. Determine the value of K so the system is marginally stable and the frequency of sustained oscillations. ***(03)***

3C. A unity feedback system has an open loop transfer function given by the following expression is operating with a dominant pole damping ratio of 0.707

$$G_p(s) = \frac{K(s+6)}{(S+2)(S+3)(S+5)}$$

Design a suitable PD controller so as to reduce the settling time by a factor of 2. Also compare the transient and steady state performance of the compensated and uncompensated systems. ***(04)***

4A. Through analytical technique, justify whether the transfer function given below can act as a lag, lead or lag-lead compensator.

$$G_c(s) = \frac{s+1}{s+0.1}$$ ***(03)***

4B. With a neat diagram, realize a lead compensator using an operational amplifier. Also justify its phase lead nature from resultant phase equation. ***(03)***

4C. The open loop transfer function of a unity feedback system is given as:

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

Design a lead compensator to have a static error constant of 20 s^{-1} and prove analytically that a phase margin of at least 50^0 is obtained. ***(04)***

5A. Consider a unity feedback system with the plant transfer function given as:

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

Using root locus approach, design a suitable controller to make steady state error as zero when the system is operating with a closed loop system response that has 15% overshoot. ***(03)***

5B. Determine the state-space representation of the electrical network shown in **Figure Q5B** considering the capacitor voltage $V_0(t)$ to be the output parameter. ***(03)***

5C. For the system shown below, design a state feedback controller such that the compensated system has an overshoot of 10% and settling time of 3secs. Further design an observer which is ten times faster than the designed controller.

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u; \; y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$$ ***(04)***

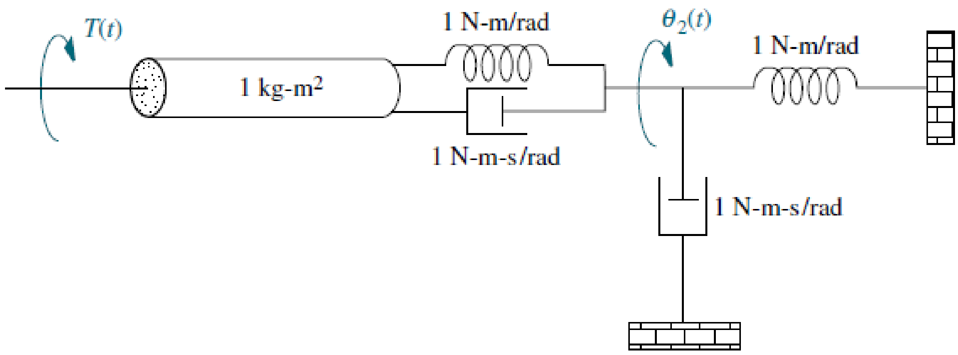

Figure. Q1A

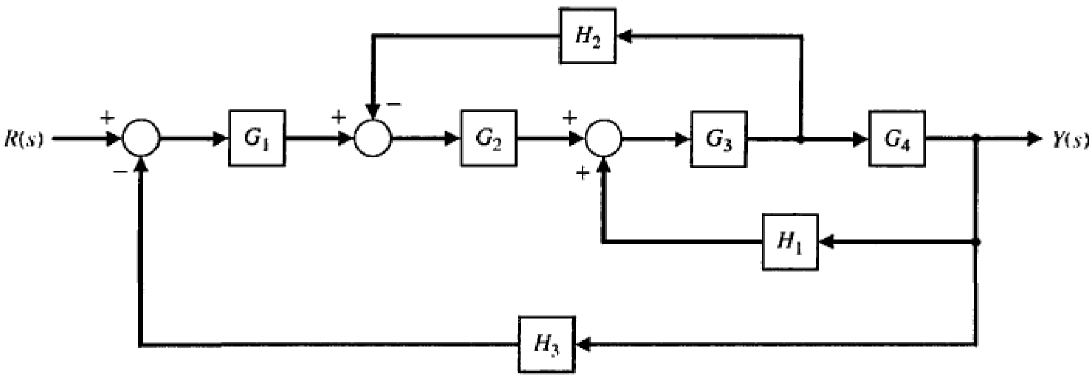

Figure. Q1B

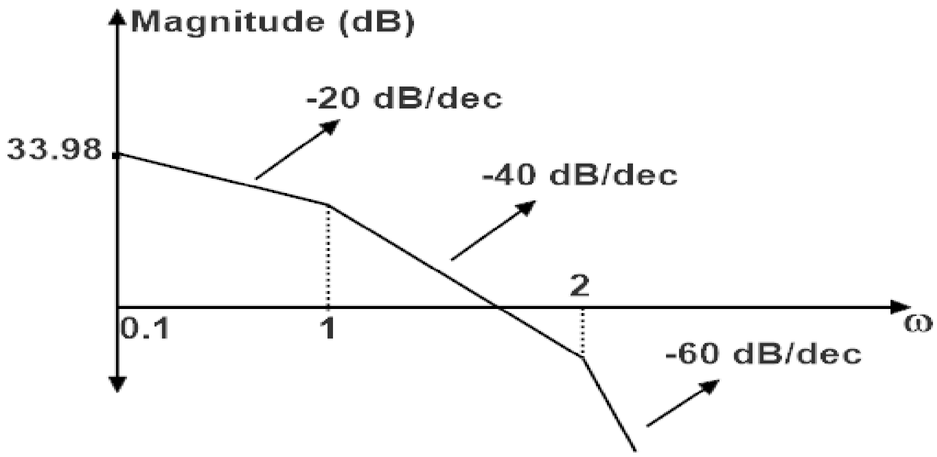

Figure. Q2B

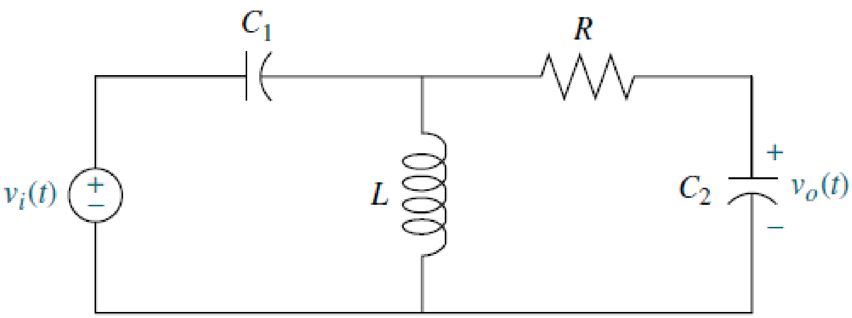

Figure. Q5B