Question Paper

Exam Date & Time: 26-May-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

FOURTH SEMESTER B.TECH (E&I) END SEMESTER EXAMINATIONS, MAY-JUNE 2023

LINEAR CONTROL THEORY [ICE 2253]

Marks: 50 **Duration: 180 mins.**

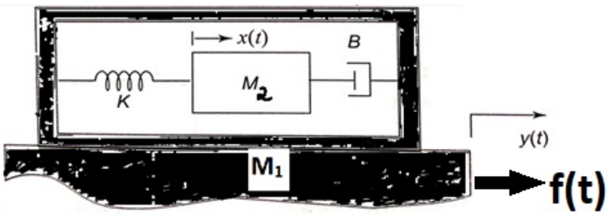
A

Answer all the questions.

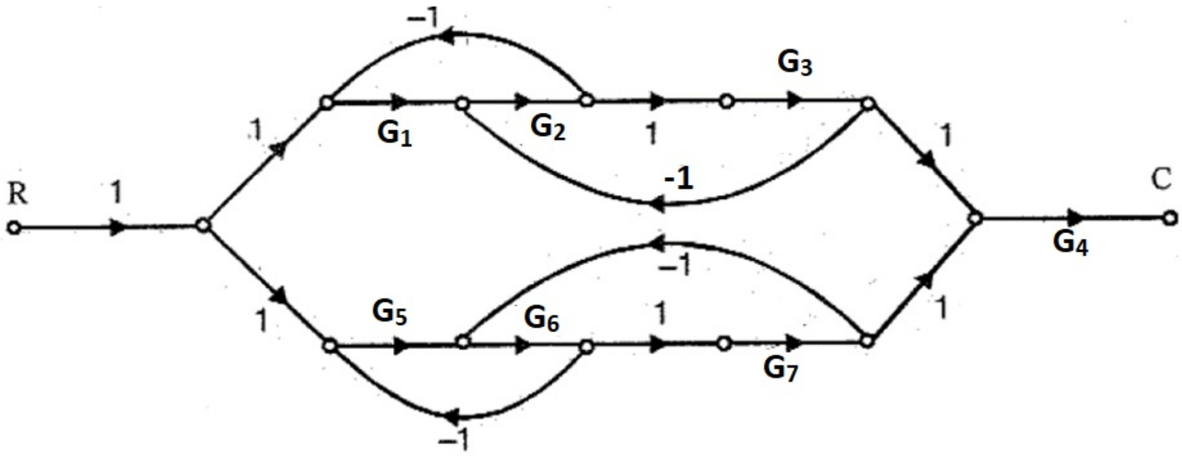
Instructions to Candidates:
Answer ALL questions Missing data may be suitably assumed

1) Obtain the transfer function X(s)/F(s) from the model of the moving train coach given below. The entire 'blackened' portion shown in the given figure is a single mechanical frame of a mass 'M1', which has no connection with the mass of 'M2'. [CO 1, PO 1-6,9,10,12, BL3] (4)

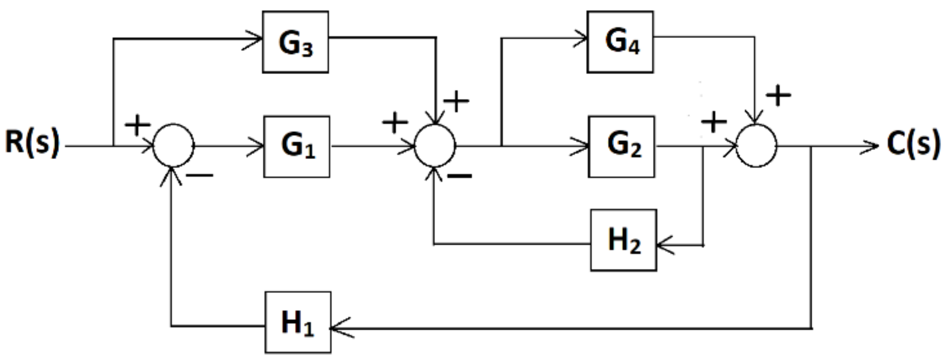
A)



B) Obtain the overall transfer function C(s)/R(s) for the following system, represented as a Signal Flow Graph (shown in the figure below). [CO 1, PO 1-6,9,10,12, BL3] (3)



C) A system is represented below by the following block diagram. Determine the overall transfer function C(s)/R(s) using block diagram reduction method. [CO 1, PO 1-6,9,10,12, BL4] (3)



2) Consider the unit step response of an integral process with unity negative feedback whose open-loop transfer function is: [CO 2, PO 1-6,9,10,12, BL5] (2)

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

Obtain:

i. Rise time

ii. Peak time

iii. Maximum Overshoot

iv. Settling time (2% criterion)

B) A certain unity negative feedback control system has the following forward path transfer function.[CO 2, PO 1-6,9,10,12, BL5] (3)

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

Determine the generalized error coefficients and hence the steady state error if the input to the system is described as:

$r(t) = 3 + t^2 + 2t^3$

C) Given that the open loop transfer function of an integrating level process model with unity negative feedback is:[CO4, PO 1-6,9,10,12, BL5] (5)

$$G(s)H(s) = \frac{5}{s(s+1)(s+2)}$$

Draw the Nyquist plot and examine whether the system is stable is not.

3) A negative unity feedback integral system is characterized by an open-loop transfer function[CO 2, PO 1-6,9,10,12, BL5] (2)

A)

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

.

Determine the gain K and the undamped natural frequency, so that the closed-loop system has a damping ratio of 0.6.

B) Compute the final expressions of i) Peak time ii) Rise time for a second-order underdamped system.[CO 2, PO 1-6,9,10,12, BL2] (4)

C) Answer the following:[CO3, PO 1-6,9,10,12, BL4] (4)

(i) Using Routh Hurwitz stability criterion comment on the stability of the nozzle of a spacecraft, whose characteristic equation is given by:

$$s^5 + 2s^4 + 6s^3 + 12s^2 + 8s + 16 = 0$$

(ii) For the given characteristic equation, evaluate the value of K and comment on the stability of the system:

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

4) Construct the Root Locus for the transfer function of a satellite attitude path is given by:[CO 3, PO 1-6,9,10,12, BL4] (5)

A)

$$G(s) = \frac{K(s+9)}{\ldots}$$

$$s(s^2+4s+11)$$

Also, determine the range of K for which the system remains stable.

B) For the evaluation of stability based on the frequency domain, construct the Bode plot for the system with the transfer function of a missile is given by: (5)

$$G(s) = \frac{10}{s(1+0.5s)(1+0.1s)}$$

.

Find the following: [CO 4, PO 1-6,9,10,12, BL4]

i. Gain crossover frequency
ii. Phase crossover frequency
iii. Gain margin
iv. Phase margin

5) With necessary diagrams, derive the design procedure of Lag-Lead compensator transfer function using frequency-domain specifications. [CO 5, PO 1-6,9,10,12, BL2] (5)

A)

B) Using the Bode plot for the following system, (5)

$$G(s) = \frac{10}{s(1+0.5s)(1+0.1s)}$$

design a Lag Compensator satisfying the following requirements:

- Phase margin is 50 Deg.,
- Gain margin to be (>10dB) and
- Desired velocity error constant as Kv=20 sec^{1}. [CO 5, PO 1-6,9,10,12, BL3]

-----End-----