

# National Institute of Technology, Delhi

Name of the Examination: B. Tech.

Branch : EEE

Semester : 5<sup>th</sup>

Title of the Course : Control Systems

Course Code : EE 301

Time: 2 Hours

Maximum Marks: 30

Note : 1. All the 5 questions are compulsory. The marks for each question are indicated against it.

2. All the symbols have their usual meaning. Make suitable assumptions wherever required.

Q1. A system is described by the following transfer function: (2+2+2 = 6 Marks)

$$\frac{Y(s)}{R(s)} = \frac{8(s+5)}{s^3 + 12s^2 + 44s + 48}$$

- a) Obtain the state-space model for the above system.
- b) Determine the state transition matrix.
- c) Draw the signal flow graph for the model obtained in part (a) above.

Q2. a) What part of the output response is responsible for determining the stability of a linear system?

b) A system has a transfer function  $T(s) = \frac{1}{s}$ . Is this system BIBO stable?

c) A system has a characteristic equation

$$s^3 + 2s^2 + (K + 1)s + 8 = 0$$

Find the range of K for the system to be stable.

(1+1+4= 6 Marks)

Q3. a) Derive the expression for the maximum percent overshoot for a second order underdamped system subjected to a unit-step input. 2 Marks

b) For the system shown in Fig. 1, find the values of  $K_1$  and  $K_2$  to yield a peak time of 1.5 seconds and a settling time of 3.2 seconds (2 % criterion) for the closed loop system's unit step response. 4 Marks

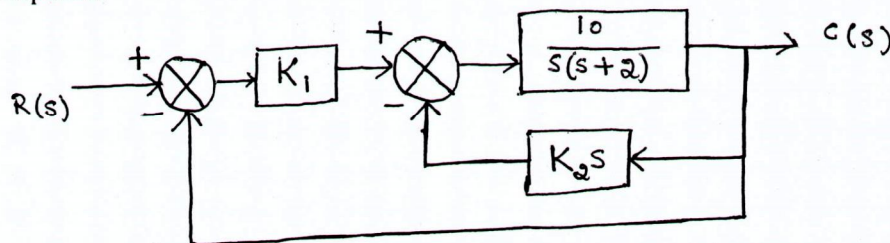


Fig. 1

P.T.O.

- Q4. a) Obtain the transfer functions  $\frac{X_1(s)}{U(s)}$  and  $\frac{X_2(s)}{U(s)}$  of the mechanical system shown in Fig. 2.

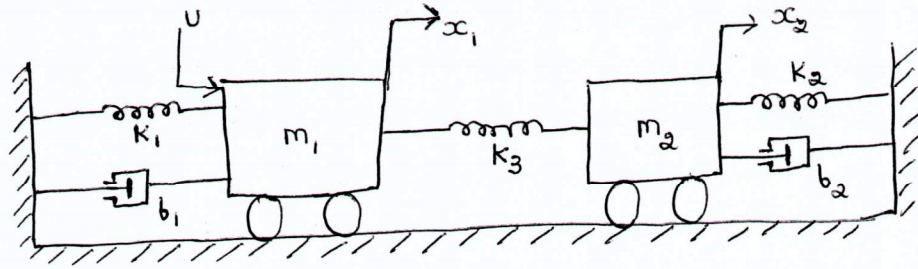


Fig. 2

4 Marks

- b) Obtain the transfer function  $\frac{E_o(s)}{E_i(s)}$  of the electrical system shown in Fig. 3.

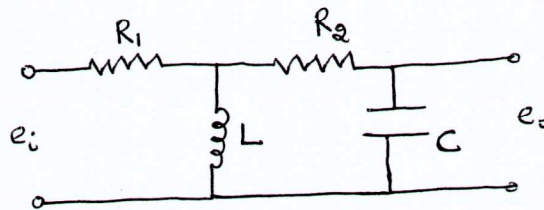


Fig. 3

2 Marks

- Q5. a) Obtain the transfer functions  $\frac{C(s)}{R(s)}$  and  $\frac{C(s)}{D(s)}$  of the system shown in Fig. 4.

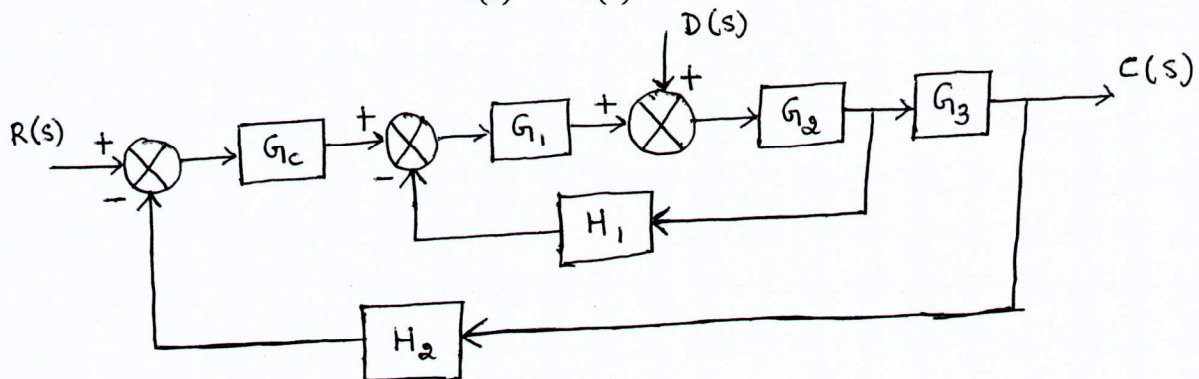


Fig. 4

4 Marks

- b) A thermometer requires 1 min to indicate 98% of the response to a unit-step input. Assuming the thermometer to be a first-order system, find the time constant. If the thermometer is placed in a bath, the temperature of which is changing linearly at a rate of  $10^\circ/\text{min}$ , how much error does the thermometer show?

2 Marks