National Institute of Technology, Delhi

Name of the Examination: End Semester Examination (Spring Semester 2022)

Branch	**: EEE**	**Semester**	**: 4th**
Title of the Course	**: Control Systems**	**Course Code**	**: EEB 252**

Date of Examination: 10.05.2022 **Time: 3 Hours** **Maximum Marks: 50**

Note: 1. All the 08 questions are compulsory.

2. The symbols used have their usual meaning. Make suitable assumptions wherever necessary.

Section A
(Each question in Section A carries 2 marks).

Q1. (i) Write the transfer function of a PID controller. Write one problem associated with the use of P only controller.

(ii) A system has open-loop transfer function $\frac{1}{s(1+s)}$. The type of the system is _____ and the order of the system is _____.

(iii) Draw the locus of poles of 2nd-order closed-loop system with constant damping ratio.

(iv) What is meant by a slope of 6 dB/octave?

(v) What is the phase angle for the following transfer function at the corner frequency?

$$G(s) = \frac{1}{(1+sT)^3}$$

Section B
(Each question in Section B carries 5 marks).

Q2. Consider a system given by **[2 + 2 + 1 = 5M]**

$$\dot{x}(t) = \begin{bmatrix} -1 & 3 \\ 0 & 2 \end{bmatrix} x(t) + \begin{bmatrix} 5 \\ 6 \end{bmatrix} u(t)$$

$$y(t) = [3 \quad 4]x(t)$$

with $x(0) = \begin{bmatrix} 4 \\ 5 \end{bmatrix}$. Determine the following if the input $u(t)$ is a unit-step input.

(a) Total response of the system.

(b) Transfer function of the system

(c) Impulse response

Q3. Determine the number of roots of the following characteristic polynomial that are in the left-half plane, right-half plane and on the imaginary axis.

$$p(s) = s^5 + 2s^4 + 2s^3 + 4s^2 + s + 2$$

Q4. Consider a unity-feedback system with forward path transfer function given by

$$G(s) = \frac{100}{s(s+6)}$$

Find (i) resonant peak, (ii) resonant frequency, and (iii) bandwidth of the closed-loop system.

Q5. Consider a unity-feedback system with forward path transfer function given by

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

Let the input applied to the system be $1 + 6t$. Determine the value of K so that the steady-state error is less than 0.1.

Section C

(Each question in Section C carries 10 marks).

Q6. Consider the following system equation **[2 + 3 + 5 = 10M]**

$$\dot{x}(t) = \begin{bmatrix} -1 & 1 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -2 & 1 \\ 0 & 0 & 0 & -2 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} u(t)$$

$$y(t) = [1 \quad 1 \quad 1 \quad 0]x(t)$$

(a) Is this system stable?

(b) Draw signal flow graph of the sytem.

(c) Find the transfer function using Mason's gain formula.

Q7. Sketch the root locus for a unity-feedback system with open-loop transfer function given by

$$G(s) = \frac{K(s+0.5)}{s^2(s+4.5)}$$