Roll No.:......................

National Institute of Technology, Delhi

Name of the Examination: B. Tech.

Branch	**: EEE**	**Semester**	**: 5th**
Title of the Course	**: Control Systems**	**Course Code**	**: EE 301**

Time: 3 Hours **Maximum Marks: 50**

Note : 1. This question paper has 3 sections: A, B and C. All the sections are compulsory. **Section A** carries only one question (Q1) having 10 parts of 01 mark each and all the parts are compulsory. **Section B** contains five questions (Q2 to Q6) of 5 marks each and any four are to be answered. **Section C** contains three questions (Q7 to Q9) of 10 marks each and any two are to be answered.

Section A

Q1. a) Define corner frequency.

b) Give two examples of open loop control system.

c) Define the transfer function.

d) If a pole is moved along a radial line extending from the origin, what will the responses have in common?

e) Define state variables.

f) An 8th order system would be represented in state space with how many state equations?

g) What does the performance specification for a first-order system tell us?

h) Which form of the state-space representation leads to a diagonal matrix?

i) Write the Mason's gain formula used for finding the transfer function of a system.

j) Define system type.

Section B

Q2. a) Define observability. Write the condition for observability in terms of observability matrix.

b) Determine whether the following system is controllable: **(2+3) Marks**

$$\dot{x} = \begin{bmatrix} -1 & 1 & 2 \\ 0 & -1 & 5 \\ 0 & 3 & -4 \end{bmatrix} x + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u$$

Q3. Explain the effect of proportional, integral and derivative control actions on system performance.

Q4. a) Explain the concept of absolute stability and relative stability. **(2+3) Marks**

b) Find the range of K for stability for a unity feedback system with forward path transfer function:

$$G(s) = \frac{K(s+20)}{s(s+2)(s+3)}$$

Q5. A unity feedback system has the following forward transfer function:

$$G(s) = \frac{1000(s+8)}{(s+7)(s+9)}$$

a) Evaluate system type K_p, K_v and K_a. **(3+2) Marks**

b) Find the steady state errors to the standard step and parabolic inputs.

Q6. Find damping ratio, natural frequency, settling time, peak time, rise time and maximum percent overshoot for a system whose transfer function is given by

$$G(s) = \frac{361}{s^2+16s+361}$$

Section C

Q7. Given a unity feedback system that has the following transfer function

$$G(s) = \frac{K(s+2)}{s^2-4s+13}$$

a) Sketch the root locus.

b) Find the imaginary axis crossing and the corresponding gain K.

c) Find the break-in point.

d) Find the angle of departure from complex poles. **(5+2+1+2) Marks**

Q8. Consider the state space representation of a system as follows:

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

$$y(t) = \begin{bmatrix} 2 & 1 \end{bmatrix} x(t)$$

$$x(0) = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

(4+4+2 = 10 Marks)

a) Find the state-transition matrix.

b) Solve for the state vector $x(t)$.

c) Find the output $y(t)$.

Q9. Consider the state space representation of a system as follows:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -25 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Obtain the sinusoidal transfer functions: $\frac{Y_1(j\omega)}{U_1(j\omega)}, \frac{Y_2(j\omega)}{U_1(j\omega)}, \frac{Y_1(j\omega)}{U_2(j\omega)}, \frac{Y_2(j\omega)}{U_2(j\omega)}$.