Seat No.: ________ Enrolment No.______________

# GUJARAT TECHNOLOGICAL UNIVERSITY

**B. E. - SEMESTER – VII • EXAMINATION – WINTER 2012**

**Subject code: 172007** **Date: 28/12/2012**

**Subject Name:** Modern Control System

**Time: 10.30 am - 01.00 pm** **Total Marks: 70**

**Instructions:**

1. **Attempt any five questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

**Q.1** **(a)** Consider a Unity-feedback type-2 system with open loop transfer function. **07**

$$G(s) = \frac{k}{s^2}$$

It is desired to compensate the system so as to meet the following transient response specification

Settling time, $ts \le 4\,\text{sec}$

Peak Overshoot for step input $\le 20\%$

**(b)** Describe the steps required to design the cascade lag compensator for the reshaping of root locus. **07**

**Q.2** **(a)** Consider a type-I unity feedback system with an open-loop transfer function. **07**

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

It is desired to have the velocity error constant $k_v = 10$

Phase Margin of the system be at least $45^\circ$.

Design a suitable cascade Lead compensator the above system.

**(b)** Consider a unity feedback system with plant transfer function is given by **07**

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

It is desired to have the Phase margin $\ge 60^\circ$ and

$K_v \ge 10$.

Design a suitable cascade Lag compensator for the above system.

**OR**

**(b)** Consider a plant with transfer function **07**

$$G(s) = \frac{4}{s(s+0.5)}$$

Design a lead compensator system to meet the following specifications:

Damping ratio, $\zeta = 0.5$

Undamped natural frequency, $\omega n = 5$ rad/sec.

**Q.3** **(a)** Obtain the state transition matrix of the following system **07**

$$\dot{X} = \begin{pmatrix} 0 & 1 \\ -6 & -5 \end{pmatrix} \dot{x} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

And y=[1 0]x

**(b)** Obtain the transfer function of the given state equation. **07**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{pmatrix} 0 & 1 & 0 \\ -1 & -1 & 0 \\ 1 & 0 & 0 \end{pmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} u$$

$$Y=[0\ 0\ 1] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

**OR**

**Q.3** **(a)** Determine the transfer matrix from the data given below: **07**

$$A = \begin{pmatrix} -3 & 1 \\ 0 & -1 \end{pmatrix}, B = \begin{bmatrix} 1 \\ 1 \end{bmatrix},$$

C=[1 1] and D=0

**(b)** A single input single output system is given by **07**

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

Y=[1 0 2] x(t)

Test for controllability and Observability.

**Q.4** **(a)** Define the Properties of z-transform and find the z-transform of the following function. **07**

(i) $f(t) = t$

(ii) $f(t) = \sin wt$

(iii) $f(t) = e^{-at} \cos wt$ .

**(b)** Explain the procedure to find stability of a sampled data control system using jury's stability criterion. **07**

**OR**

**Q.4** **(a)** Explain the stability analysis of sampled Data control system. **07**

**Q.4** **(b)** Find the inverse z-transform of the following function. **07**

(i) $F(z) = \dfrac{0.5z}{(z-1)^2}$

(ii) $F(z) = \dfrac{z}{(z+1)(z+2)}$

**Q.5** **(a)** A regulator system has plant **07**

$$\dot{x} = \begin{pmatrix} 0 & 1 \\ 20.6 & 0 \end{pmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} \text{u}$$

Y=[1 0]x.

Design a control law u= -kx. So that the closed-loop system has eigenvalues at -1.8 $\pm$ j2.4.

**(b)** Explain the pole placement technique using control using state feedback controller. **07**

**OR**

**Q.5** **(a)** Explain the methods used for solution of state equation. **07**

**(b)** Derive the condition for controllability and Observability. **07**

*************