Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. 1ST Semester Remedial Examination –July- 2011

Subject code: 710301

Subject Name: CONTROL ENGINEERING

Date:07/07/2011 **Time: 10:30 am – 01:00 pm**

Total Marks: 70

Instructions:

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

Q.1 **(a)** For given characteristic equations, find stability using Routh criteria, **07**

1) $3\lambda^4 + 10\lambda^3 + 5\lambda^2 + 5\lambda + 2 = 0$

2) $\lambda^6 + 2\lambda^5 + 8\lambda^4 + 12\lambda^3 + 20\lambda^2 + 16\lambda + 6 = 0$

(b) Derive the equation of co-state vector, state vector and control equation using Hamiltonion method for the optimal control problem. **07**

Q.2 **(a)** Write a short note on Full Order Observers. **07**

(b) Consider the linear autonomous system **07**

$X(k+1) = \begin{bmatrix} 0.5 & 1 \\ -1 & -1 \end{bmatrix} x(k)$

Using direct method of Lyapunov, determine stability of the equilibrium state.

OR

(b) Prove that the state equation, $\dot{x}(t) = Ax(t) + Bu(t)$ is asymptotically stable if and only if all the eigen values of matrix A have negative real parts. **07**

Q.3 **(a)** Explain the Pole placement controller strategy in detail. Design a state feedback control law for a given system such that the closed loop system has poles at -1, -2, -3. **12**

$A = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 2 & 0 \\ 1 & 1 & 1 \end{bmatrix}$; $B = \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}$; $C = \begin{bmatrix} 1 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

(b) What do you mean by Reduced Order Observers? **02**

OR

Q.3 **(a)** State and prove the sufficient condition of stability for the autonomous system, $x^{\cdot}(t) = f(x); f(0) = 0$ using Lyapunov's Stability theorem. **07**

(b) Design a deadbeat state feedback controller for the mixing tank system given in discrete time model as, **07**

X(k+1) = Fx(k) + Gu(k)

Where,

F = $\begin{bmatrix} 0.9512 & 0 \\ 0 & 0.9048 \end{bmatrix}$; G = $\begin{bmatrix} 4.88 & 4.88 \\ -0.019 & 0.0095 \end{bmatrix}$

Q.4 **(a)** Find the extremals for the functional, J(x)= $\int_0^{\pi/4}(x^2 - \dot{x}^2)\,dt$; **07**

x(0) = 0, x(π/4) is free.

(b) Explain the Principle of Causality and Principle of Invarient Imbedding for the Optimal control problem. **07**

OR

Q.4 **(a)** Show that the extremal for the functional, **J**(x)= $\int_0^{\pi/2}(\dot{x}^2 - x^2)dt$ **07**

Which satisfies the boundry conditions x(0) = 0 ; x(π/2) =1 is

$x^*(t) = \sin t$.

(b) A first order system $\dot{x} = -x + u$ is to be controlled to minimize J = $\frac{1}{2}\int_0^1(x^2 + u^2)dt$. Find the optimal control law. Draw the structure of controller for this system. **07**

Q.5 **(a)** A first order system is described by the differential equation $\dot{x}(t) = 2x(t) + u(t)$. **07**

It is desired to find the control law that minimize the performance index J = $\frac{1}{2}\int_0^{\infty}(3x^2 + \frac{1}{4}u^2)dt$. Also draw the structure of controller for given system.

(b) Write short note on Optimal estimation for linear continuous time system. **07**

OR

Q.5 **(a)** What are the characteristics of Stochastic process? Give the response of linear discrete time system to white noise. **07**

(b) Derive the equations of Optimal control law, Feedback gain algorithm and Optimal performance index for Discrete-time Linear State Regulator problem. **07**

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