3. Attempt any **two** parts of the following :— **(10×2=20)**

(a) Find an unconstrained optimal control $u : [0, t_b] \rightarrow R$, such that the dynamic system

$$\dot{x}_1(t) = x_2(t)$$

$$\dot{x}_2(t) = x_2 + u(t)$$

is transferred from the initial state

$$x_1(0) = 0$$

$$x_2(0) = 0$$

to a final state at the fixed final time t_b satisfying

$$x_1(t_b) \geq s_b > 0$$

$$x_2(t_b) \leq v_b.$$

(b) Give a short note on property of optimal structure.

(c) Derive the Pontryagin's Minimum Principle for optimal control problems with a completely unspecified final state (and no state constraints).

4. Attempt any **two** of the following :— **(10×2=20)**

(a) Give an overview on the concept of variable structure system (VSS).

(b) Discuss the methodology adopted for designing of switching surface.

(c) What is chattering and how it is removed during control of second order system ?

5. Write the short notes on any **two** parts :— **(10×2=20)**

(a) State regulator design through the Lyapunov Equation.

(b) Model reference control.

(c) Hamilton Jacobi-Bellman theory.

(d) Applications of VSS in power system.

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 0925	Roll No.										

B. Tech.

(SEM. VII) ODD SEMESTER THEORY EXAMINATION 2010-11

MODERN CONTROL SYSTEM

Time : 3 Hours *Total Marks : 100*

SECTION—A

Note : Attempt **all** questions. All questions carry equal marks.

1. Attempt any **four** parts of the following :— **(5×4=20)**

(a) Define the concept of controllability and observability and explain the different tests perform to check the both.

(b) Consider the system defined by

$$\dot{\mathbf{x}} = \mathbf{Ax} + \mathbf{Bu}$$

where

$$\mathbf{A} = \begin{bmatrix} 0 & 1 & 1 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}.$$

By using the state feedback control u = – Kx, it is desired to have the closed-loop poles at s = –2 ± j4 and s = –10. Determine the state feedback gain matrix **K**.

(c) Consider a system defined by

$$\dot{\mathbf{x}} = \mathbf{Ax}$$
$$\mathbf{y} = \mathbf{Cx}$$

where

$$\mathbf{A} = \begin{bmatrix} -1 & 1 \\ 1 & 2 \end{bmatrix}, \quad \mathbf{C} = \begin{bmatrix} 1 & 0 \end{bmatrix}.$$

Design a full-order state observer. The desired eigenvalues for the observer matrix are $\mu_1 = -5$, $\mu_2 = -5$.

(d) Consider a system

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

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}.$$

Design a state observer such that the eigenvalues of the observer gain matrix are :

$$\boldsymbol{\mu}_1 = -2 + j2\sqrt{3}, \quad \boldsymbol{\mu}_2 = -2 - j2\sqrt{3}.$$

(e) Define Ackermann's formula and describe with example.

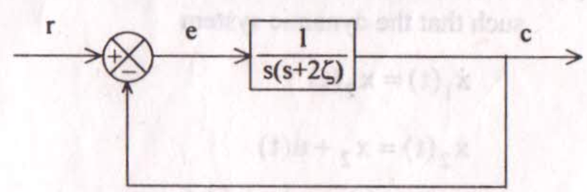
(f) Give an overview of the steady state error design by integral control.

2. Attempt any two parts of the following :— **(10×2=20)**

(a) Determine the value of the damping ratio $\zeta > 0$ so that, In a given figure when the system is subjected to a unit-step $r(t) = 1(t)$, the following performance index is minimized :

$$J = \int_{0+}^{\infty} (e^2 + \mu \dot{e}^2)\,dt \quad (\mu > 0)$$

where e is the error signal and is given by $e = r - c$. The system is assumed to be at rest initially.



(b) Consider the system described by

$$\dot{\mathbf{x}} = \mathbf{Ax}$$

where

$$\mathbf{A} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$$

Determine the stability of the equilibrium state, $x = 0$.

(c) Consider the linear, time-invariant system

$$\dot{\mathbf{x}} = \mathbf{Ax}$$

where

$$A = \begin{bmatrix} 0 & 1 & 0 & 0 & \cdot & \cdot & \cdot & 0 & 0 & 0 \\ -b_n & 0 & 1 & 0 & \cdot & \cdot & \cdot & 0 & 0 & 0 \\ 0 & -b_{n-1} & 0 & 1 & \cdot & \cdot & \cdot & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & & & & & & \cdot \\ \cdot & \cdot & \cdot & \cdot & & & & & & \cdot \\ 0 & 0 & 0 & 0 & & & & -b_3 & 0 & 1 \\ 0 & 0 & 0 & 0 & \cdot & \cdot & \cdot & 0 & -b_2 & -b_1 \end{bmatrix}$$

where $b_1, b_2, \ldots, b_n$ are real quantities. Prove that the origin of the system is asymptotically stable if and only if

$$b_1 > 0, \; b_2 > 0, \; \ldots, \; b_n > 0.$$