Code No: **RT42022A** **R13** **Set No. 1**

IV B.Tech II Semester Regular/Supplementary Examinations, April - 2018

ADVANCED CONTROL SYSTEMS

(Electrical and Electronics Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B

Answer ALL sub questions from Part-A

Answer any THREE questions from Part-B

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PART–A *(22 Marks)*

1. a) State the significance of state transition matrix. [4]
   b) What do you mean by principle of duality? [4]
   c) Explain the effect of inherent nonlinearities on static accuracy. [4]
   d) What are the different types of stability? [3]
   e) State the fundamental theorem of the calculus of variations. [4]
   f) What is the difference between the LQR and LQG? [3]

PART–B *(3x16 = 48 Marks)*

2. a) Explain the concept of state? Write the observable canonical form? [6]
   b) The following facts are known about the linear system $\dot{x}(t) = Ax(t)$

   If $x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$, then $x(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$

   If $x(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$, then $x(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ Find e^{At} and hence A [10]

3. a) Describe the controllability tests for continuous time systems. [6]
   b) Convert the following state model into the Jordan canonical form and there from comment on controllability and observability.

   $$\dot{x}(t) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -4 & -3 \end{bmatrix} x(t) + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -1 & 1 \end{bmatrix} u(t), \quad y(t) = \begin{bmatrix} 0 & 1 & -1 \\ 1 & 2 & 1 \end{bmatrix} x(t)$$ [10]

4. a) Draw a phase plane portrait of the following system, $\ddot{\theta} + \dot{\theta} + sin\theta = 0$. [8]
   b) Determine the describing function for the nonlinear element described by $y = x^3$ where x=input to the nonlinear element (Sinusoidal signal) y=output of the nonlinear element. [8]

5. a) State and explain the Lyapunovs instability theorem. [7]
   b) Find a Lyapunovs function for the following system

   $$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ 2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$ [9]

6. a) With suitable diagrams illustrate the one point is fixed end, terminal time t_1 is specified and $x(t_1)$ free end problem and derive the necessary conditions of variational calculus. [8]
   b) Find the extremals for the functional

   $J(x) = \int_0^1 [x^2(t) + \dot{x}^2(t)]dt;\ x(0) = 0, x(1) = 1$ [8]

7. How LQG frame work can be used to design optimal controller? Explain with mathematical equations. [16]