Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

VII SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

MAKEUP EXAMINATIONS, DEC 2016 - JAN 2017

SUBJECT: ADVANCED CONTROL SYSTEMS [ELE 431]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 02 January 2017** **MAX. MARKS: 50**

Instructions to Candidates:

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitably assumed.

1A. With the help of input-output characteristics, discuss four types of nonlinearities present in physical systems. ***03***

1B. Linearize the following equation $\ddot{x} + (1 + x)\dot{x} - 2x + 0.5x^3 = 0$ around $(x, \dot{x})$=(0,0). Also find the Eigen values of the linearized system and predict the nature of phase trajectory. ***04***

1C. What are singular points? How are they classified for a second order linear time invariant system? ***03***

2. Explain Describing function theory highlighting the assumptions made. With neat sketches, Derive the describing function for dead-zone nonlinearity. A single loop system has $G(s) = \frac{10}{(s+2)^3}$ cascaded to dead-zone nonlinearity. Determine the stability, amplitude and frequency of the limit cycle when Δ=0.1 and K=1. ***10***

3A. Draw the phase trajectory for the system given below with initial conditions $(x, \dot{x})$= (0,1) using isocline method (2 quadrants) $\ddot{x} + 0.6\dot{x} + 3x = 0$ ***03***

3B. Show that the origin of $\dot{x}_1 = x_2;\ \dot{x}_2 = -x_1^3 - x_2^3$ is globally asymptotically stable using Lyapunov's direct method. ***04***

3C. Explain Krasovskii's method of constructing Lyapunov function for a nonlinear system described by $\dot{x} = f(x)$. ***03***

4A. Consider the system $\dot{x} = -x + u$ which is to be transferred from x(0)= 3 to x(1)=0 such that **J= 0.5**$\int_0^1 \boldsymbol{u^2 dt}$ is minimized**.** Find the optimal control u*(t) using Pontryagin principle**.** ***04***

4B. The discrete approximation of a CT system is given by $\boldsymbol{x[k+1] = 0.5x[k] + u[k]}$**.** The performance index to be minimized is $J = \sum_{k=0}^{2} |x(k)|$. The admissible states and control are constrained as follows 0 ≤ x(k) ≤ 0.2, and -0.1 ≤ u(k) ≤ 0.1. Quantize the state and control in steps of 0.05. i)Use dynamic programming to determine optimal law and also find ii) the optimal control sequence, if the initial state is at x(0)=0.2. ***06***

5A. The system is described by $\dot{x}_1 = x_2;\ \dot{x}_2 = u$. Design the optimal state regulator whose control law is given by u=–k(x_1+x_2) using Lyapunov's method to minimize the performance index **J** =$\int_0^\infty (\boldsymbol{x^T Q x + u^T R u)dt}$**.** Take x(0)=[1 0]. ***06***

5B. A unity feedback control system has the forward path transfer function $\boldsymbol{G(s) = \frac{2}{s(s+a)}}$.
The reference input is a unit step input and is initially at rest. Determine the value of '**a**' which minimizes Integral Square Error. Find J_{min}. ***04***

6. Consider a system given by the following state space model

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u;\ y = [1 \quad 0]x;$$

i) Design an optimal control law using Algebraic Riccati equation so that $\mathbf{J} = \int_0^\infty (x^2 + u^2)dt$ is minimized.

ii) Derive the expression for Kalman estimator highlighting the assumptions made. ***10***