Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

VII SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, DECEMBER 2018

SUBJECT: ADVANCED CONTROL SYSTEMS [ELE 431]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 01 December 2018** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitably assumed.
- Use of graph sheets may be allowed.

1A.	Differentiate between a linear system and a nonlinear system. (at least five points)	**03**
1B.	Find the equilibrium point(s) and linearize the system about the equilibrium point(s). Comment on the stability of the equilibrium point(s) for the following system $dx_1/dt= 2x_1-x_1x_2$; $dx_2/dt= 2x_1^2-x_2$.	**05**
1C.	Explain any two types of nonlinearities present in the systems.	**02**
2.	Derive the describing function of relay with hysteresis. Consider a linear system whose transfer function is given by $G(s) = 4/s(s+1)^2$. This system is connected in cascade with a relay with hysteresis nonlinearity. Take h= 0.1 & M=1. Using describing technique, predict i) the existence of the limit cycle ii) if yes, the stability of limit cycle and iii) the amplitude and frequency of the limit cycle.	**10**
3A.	Draw the phase trajectory for the equation given below with initial conditions $(x, \dot{x})$= (0,1) using delta method (three quadrants) $$\ddot{x} + (1 + x)\dot{x} - 2x + 0.5x^3 = 0$$	**05**
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 method.	**05**
4A.	What are the advantages and disadvantages of dynamic programming? Using Dynamic programming, obtain the optimal control policy u*(t) that minimizes the input u(t) given to an RC series circuit with R=1Ω and C=1F. $\mathbf{J = 0.5\int_0^\infty u^2 dt}$	**06**
4B.	Using Pontryagin's minimum principle, obtain the optimal control signal u*(t) for the system given by $\dot{x} = -x + u$, $x(0)=2$, $x(2)=0.5$ which minimizes $\mathbf{J = 0.5\int_0^2 \dot{x}^2 dt}$ with u(t) unrestricted.	**04**
5.	Derive the algebraic (or Matrix) Riccati equation for optimal controller design. Consider a satellite attitude control system whose state space model is given by $$\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} x + \begin{bmatrix} 0 \\ 20 \end{bmatrix} u \quad \boldsymbol{y} = [\mathbf{1} \quad \mathbf{0}]\boldsymbol{x};$$ Design an optimal control law using Matrix Riccati equation in order to minimize $\mathbf{J=\int_0^\infty (x^2 + u^2) dt}$.	**10**

6A. For the satellite attitude control system given in Q5, design an optimal control law $u = -k(x_1+x_2)$ using Lyapunov's method to minimize $\mathbf{J}=\int_0^{\infty}(x^2 + u^2)dt$. Take $x(0)=[1\ 0]^T$ **06**

6B. What is the purpose of using Kalman filter? Why is it called an optimal filter? Explain the design procedure of a Kalman filter. **04**