Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent Institution of MAHE, Manipal)

VII SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

MAKE UP EXAMINATIONS, MAY 2018

SUBJECT: ADVANCED CONTROL SYSTEMS [ELE 431]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 05 MAY 2018** **Max. Marks: 50**

Instructions to Candidates:

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

1A. Explain the following: i) Saturation nonlinearity ii) Jump resonance and iii) Asynchronous quenching ***(06)***

1B. Linearize the non-linear equation $z = 4\sin\theta$ around $\theta = \pi/5$. ***(04)***

2. Derive the describing function of on-off relay nonlinearity. A unity feedback system has G(s)=k/s(s+1)(0.5s+1) cascaded with on-off relay nonlinearity with M=1. Determine the range of gain k for which limit cycle is predicted. Also determine the stability, amplitude and frequency of the limit cycle when gain of the linear system is k=10. ***(10)***

3A. Draw the phase trajectory for the equation given below with initial conditions $(x, \dot{x})$= (0,1) using isocline method (2 quadrants with minimum six isoclines) $\ddot{x} + 0.8\dot{x} + 3x = 0$. ***(05)***

3B. Find the optimal control vector using Dynamic programming which minimizes the performance index $\mathbf{J} = \int_0^\infty \boldsymbol{u^2 dt}$ for the system described by $\dot{x} = x + u$. ***(05)***

4A. Using Pontryagin's minimum principle, obtain the optimal control signal u*(t) for the system given by $\dot{x} = -x + u$, $x(0)=1$, $x(2)=0$ which minimizes $\mathbf{J} = \int_0^2 (-\boldsymbol{x} + \boldsymbol{u})^2 \boldsymbol{dt}$ with u(t) unrestricted. ***(05)***

4B. Determine the stability region of the equilibrium point(s) of a system given below using **lyapunov's** method. $\ddot{\boldsymbol{x}} - (\mathbf{1} - \boldsymbol{x^2})\dot{\boldsymbol{x}} + \boldsymbol{x} = \mathbf{0}$. ***(05)***

5. Consider a satellite attitude control system whose state space model is given by

$$\dot{\boldsymbol{x}} = \begin{bmatrix} \mathbf{0} & \mathbf{1} \\ \mathbf{0} & \mathbf{0} \end{bmatrix} \boldsymbol{x} + \begin{bmatrix} \mathbf{0} \\ \mathbf{2} \end{bmatrix} \boldsymbol{u} + \begin{bmatrix} \mathbf{0} \\ \mathbf{1} \end{bmatrix} \boldsymbol{w}; \quad \boldsymbol{y} = [\mathbf{1} \quad \mathbf{0}]\boldsymbol{x};$$

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

ii. Design an optimal control law given by $u=-kx_1-kx_2$ using Lyapunov's method to minimize the above performance index taking the initial condition as x(0)=[1 0]. ***(10)***

6A. With a neat block diagram, explain any one type of adaptive control system. ***(03)***

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

$$\dot{\boldsymbol{x}} = \begin{bmatrix} \mathbf{0} & \mathbf{1} \\ \mathbf{0} & \mathbf{0} \end{bmatrix} \boldsymbol{x} + \begin{bmatrix} \mathbf{0} \\ \mathbf{10} \end{bmatrix} \boldsymbol{u} + \begin{bmatrix} \mathbf{0} \\ \mathbf{1} \end{bmatrix} \boldsymbol{w}; \; \boldsymbol{y} = [\mathbf{1} \quad \mathbf{0}]\boldsymbol{x} + \boldsymbol{v};$$

Design a Kalman Filter for the above system, when the noise co-variance Q_N=0.6 and R_N=1. Also draw the block diagram of the system with Kalman filter. ***(07)***