Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

I SEMESTER M.TECH (EMAL / PESC)

END SEMESTER EXAMINATIONS, NOV/DEC 2015

SUBJECT: CONTROL SYSTEM DESIGN [ELE 501]

REVISED CREDIT SYSTEM

Time: 3 Hours | 01 DECEMBER 2015 | MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitably assumed.
- Use of MATLAB software is allowed

1A. Consider a unity feedback system with open loop transfer function $G(s) = \frac{10(s+1)}{s(s+2)(s+3)}$. Determine i) the finite steady state error ii) plot unit step response and time domain specifications iii) draw root locus and find the range of k for the system to be stable and iv) value of k when the system is critically damped. **(05)**

1B. A unity feedback control system has plant transfer function $G(s) = \frac{k}{s(s+8)}$. Design a lead compensator using root locus method that maintains a peak overshoot of 16.5% but reduces the settling time by a factor of 2. Compare the step responses of uncompensated & compensated system. **(05)**

2A. Consider a unity feedback system with open loop transfer function $G(s) = \frac{k}{s(s+2)(s+3)}$. It is desired that the static velocity error constant be 10/sec, the phase margin be 40° and the gain margin be 10dB or more. Design a lag compensator via bode plot. Compare the step response of compensated system with that of uncompensated system. **(05)**

2B. Discuss the advantages and disadvantages of design of compensators via classical approach. **(02)**

2C. For the transfer function $G(s) = \frac{3s+5}{s(s+1)^2(s+8)}$. Obtain the state space model in controllable canonical form and diagonal canonical form. **(03)**

3A. Consider a state space model shown below. Determine the following i) eigen values and eigen vectors ii) state transition matrix iii) controllability and iv) observability.

$$\dot{x} = \begin{bmatrix} 1 & -1 & 0 \\ 0 & 2 & 0 \\ 7 & 3 & 6 \end{bmatrix} x + \begin{bmatrix} 0 & 1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} u; \; y = \begin{bmatrix} 1 & 2 & 0 \\ 0 & -1 & 1 \end{bmatrix} x$$ **(04)**

3B. Consider an inverted pendulum and the motion of the cart whose state space model is given by

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 4.4537 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ -0.5809 & 0 & 0 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ -0.3947 \\ 0 \\ 0.9211 \end{bmatrix} u;\ y = [0 \quad 0 \quad 1 \quad 0]x$$

Where cart position is the output. Do the following i) design a state feedback controller so as to place the closed loop poles at $-2 \pm j1, -2, -3$ ii) design a full order state observer which acts 10 times faster than the controller iii) obtain the transfer function of the system with controller and observer and iv) plot the response for a step disturbance of 0.2m and comment on the result. **(06)**

4A. Consider a unity feedback system with plant transfer function $G(s) = \frac{k}{s(s+5)}$. Determine i) the closed loop pulse transfer function when discretized with a sampling time T=0.1 ii) draw root locus of the discretized system and find the range of k for which the system remains stable iii) finite steady state error of the discrete time system when damping ratio is 0.5. **(05)**

4B. Consider a UFB system with G$(s) = \frac{1}{(s+1)(s+2)}$. Design a digital lag compensator D(z) using root locus techniquethat meets the following specifications: ζ=0.5 and static error constant Kp≥8. Take T=0.1s. **(05)**

5A. List the differences between a linear system and a nonlinear system. **(02)**

5B. Derive the Matrix Riccati Equation that is used to design an optimal controller which minimizes a performance index J.Consider the problem of attitude control of a rigid satellite whose state space model is given by

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

Design an optimal control law so that **J** =$\int_0^\infty ({x_1}^2 + u^2)dt$is minimized. Compare the step responses of compensated system with uncompensated system. **(08)**

6A. Derive the describing function of on-off relay nonlinearity. A system has G(s)=$\frac{k}{s(s+1)(0.5s+1)}$ cascaded with on-off relay nonlinearity with amplitude M=2. Determine the range of k for which limit cycle is predicted.Predict the stability, amplitude and frequency of the limit cycle when k=10. **(07)**

6B. With the help of block diagram, write a short note on adaptive control systems **(03)**