Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

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A Constituent Institution of Manipal University

VI SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
MAKE-UP EXAMINATIONS, JUNE 2017

SUBJECT: CONTROL SYSTEM DESIGN [ELE 4013]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 22 June 2017** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Use of MATLAB is permitted.

1A. Design a Lead compensator using root locus method for the unity feedback system with $G(s)=\dfrac{10}{s(s+1)}$ to satisfy the following specifications. The system operates with a damping ratio of ζ=0.5 and the undamped natural frequency of oscillation $\omega_n = 3rad/\sec$ Verify the performance of compensated system. Clearly write the design procedure and relevant design values.

Obtain passive circuit realization for the above designed controller. ***(06)***

1B. Design a lead compensator using frequency domain methods for the unity feedback system with $G(s)=\dfrac{4}{s(s+2)}$ to satisfy the following specifications. Staic velocity error constant to be 20 sec^{-1} , phase margin 50^{o} , gain margin to be 10dB or more. Verify the performance. ***(04)***

2A. For the spring –mass-damper system shown in Fig.2A design a PID controller for obtaining overshoot below 15% and settling time less than 0.5 sec.

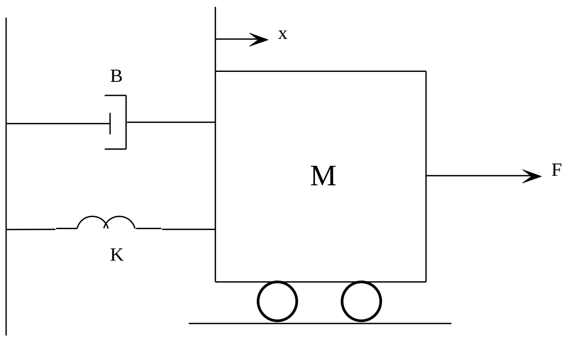

Fig.2A

M=1 kg; B=3N sec / m; k=2N/m; Unit step force applied to the system. Give the results in the form of transfer function of controller and step response of uncompensated and compensated systems. Also obtain the steady state error of compensated systems. ***(05)***

2B. A continuous time system described by $\dot{x} = Ax + Bu$, where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix}$ &

$B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, performance index $J = \int_0^\infty (x^T Qx + u^T Ru)dt$, $R = 0.01$, $Q = \begin{bmatrix} 100 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, solve for i) the positive definite solution matrix 'P' of the Riccati equation ii) the optimal feedback gain matrix 'K' and iii) the eign values of A-BK **(05)**

3A. Design a linear state feedback controller to have the desired closed loop poles at $-1.8 \pm j2.4$ for the system state space model

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 20.6 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \quad and \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix} x$$

Evaluate the steady state error for step input ii) design an observer with desired poles at s=-8, -8, plot the estimated states for zero initial values iii) design an integrator and state feedback controller combination and compare the performance.

Draw the state model of system with integrator and state feedback controller. **(07)**

3B. Explain adaptive control scheme with relevant equations, block diagram and with a suitable example **(03)**

4A. Assess the stability of equilibrium state of a nonlinear system represented by the state equations given below. Use Lyapunov stability criterion. Also state stability theorem.

$$\dot{x}_1 = x_2\ ; \ \dot{x}_2 = -2x_1 - 2x_1^3 - 3x_2$$ **(06)**

4B. For the linear time invariant system represented by the state equation

$\dot{x} = \begin{bmatrix} -1 & 0 \\ 1 & 2 \end{bmatrix} x$, assess the stability of the system, using Lyapunov stability criterion and also derive the corresponding Lyapunov function. **(04)**

5A. Using the describing function analysis, check whether a limit cycle exists for the system shown in Fig.5A , if exists determine the magnitude and frequency of the limit cycle.

The describing function for the non-linear element is

$G_N = \frac{k}{\pi}[2\beta + \sin 2\beta]$ *for* $M \geq 2$ *and* $G_N = k$ *for* $M < 2$, where k is the slope. Input $m(t) = M \sin \omega t$

Assess the stability of limit cycle.

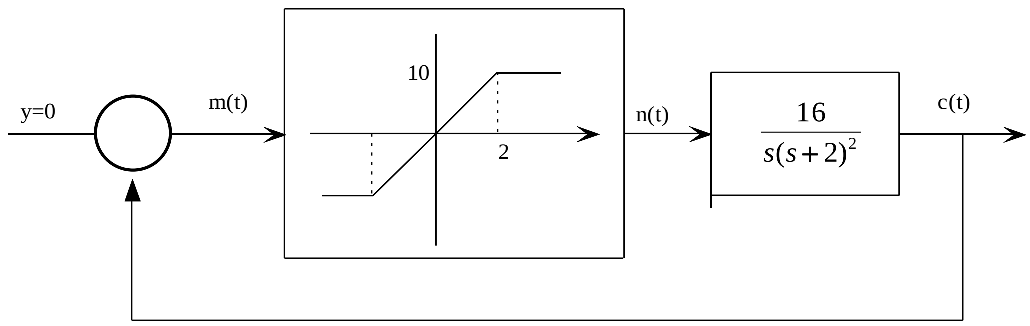

Fig.5A **(07)**

5B. Derive the describing function for a square non- linearity. **(03)**