Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

SECOND SEMESTER M.TECH. (CONTROL SYSTEMS)

END SEMESTER EXAMINATIONS, APRIL - 2018

SUBJECT: NONLINEAR CONTROL SYSTEMS [ICE 5221]

Time: 3 Hours — MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A. Explain the classification of nonlinearities with relevant examples. **2**

1B. Draw the input-output waveform for saturation nonlinearity and derive the describing function. **5**

1C. Consider the undamped simple pendulum equation given below. Find the equilibrium points and linearize the system for small perturbations. Also comment on the stability. **3**

$$\ddot{\theta} + \frac{g}{\ell}\sin\theta = 0$$

2A. A linear second order servo is described by the equation given below. Determine the singular point and construct the phase trajectory using the method of isocline. **5**

$$\ddot{C} + 2\xi\omega_n \dot{C} + \omega_n^2 C = 0, \text{ where, } \xi = 0.15,\ \omega_n = 1 \text{ rad/sec},\ C(0) = 1.5 \text{ and } \dot{C} = 0$$

2B. How do you differentiate stable, unstable and semi stable limit cycles in phase plane? **3**

2C. List the basic assumptions in describing function analysis. **2**

3A. Consider the nonlinear system shown in Fig. Q3A. Determine the largest *K* which preserves the stability of the system. If *K = 2Kmax,* find the amplitude and frequency of the self-sustained oscillation. **5**

3B. Construct a Lyapunov function using variable gradient method for the system with: **3**

$$\begin{cases} \dot{x}_1 = -x_1 + 2x_1^2 x_2 \\ \dot{x}_2 = -x_2 \end{cases}$$

3C. Define local and global invariant set theorem. **2**

4A. Design a back stepping controller for the nonlinear system represented as, **6**

$$\dot{x}_1 = x_1^2 + x_2, \quad \dot{x}_2 = x_3, \quad \dot{x}_3 = u$$

4B. Perform input-output linearization for the system represented as, **4**

$$\dot{x}_1 = -x_1 + \frac{2 + x_3^{\,2}}{1 + x_3^{\,2}} u$$

$$\dot{x}_2 = x_3$$

$$\dot{x}_3 = x_1 x_3 + u$$

$$y = x_2$$

5A. Perform input-state linearization for the field controlled DC motor described by the equations below and show that the designed nonlinear control law cancel the nonlinearities. **6**

$$\dot{x} = f(x) + gu$$

$$f(x) = \begin{bmatrix} -ax_1 \\ -bx_2 + k - cx_1x_3 \\ \theta x_1 x_2 \end{bmatrix}, \quad g = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

5B. Define internal dynamics and explain its significance. **2**

5C. Comment on chattering effects in sliding mode controller. **2**

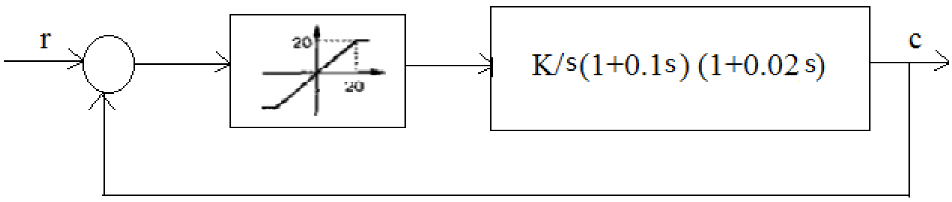

Fig. Q3A

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