BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: M.Tech **SEMESTER : II**
BRANCH: EEE **SESSION : SP/19**

SUBJECT: **EE553 NONLINEAR CONTROL SYSTEM**

TIME: 3.00 Hrs. **FULL MARKS: 50**

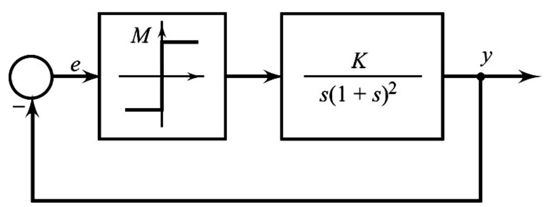
INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) State the theorem of Poincare-Bendixson related to existence of limit cycles in a 2nd order autonomous system. [5]

Q.1(b) Define phase plane, phase trajectory. Graph the phase portrait for the linear system $\dot{x} = Ax$, where $A = \begin{bmatrix} a & 0 \\ 0 & -1 \end{bmatrix}$ and a varies from $-\infty$ to $+\infty$ with $a < -1; a = -1; -1 < a < 0; a = 0; a > 0$ [5]

Q.2(a) What do you understand by hard nonlinearities and soft nonlinearities? Give examples of each. What is the concept in describing function? What are the basic assumptions for considering the DF method of analysis? Justify. Mention the limitations. [5]

Q.2(b) Consider the system shown in the figure. Apply describing-function analysis to show that a stable limit cycle exists for all values of K>0. Find the amplitude and frequency of the limit cycle when K=4, and plot y(t) versus t. [5]



Q.3(a) Give the concepts: asymptotic stability, stable in the sense of Lyapunov, and exponential stability. Apply Lyapunov based concept to design a nonlinear control law for the following nonlinear system such that the origin is globally asymptotically stable. System is $\dot{x}_1 = -3x_1 + 2x_1x_2^2 + u$ and $\dot{x}_2 = -x_2^3 - x_2$. [5]

Q.3(b) Apply Krasovskii method to construct the Lyapunov function for the following nonlinear system with P as identity matrix. Investigate the stability and obtain the region of asymptotic stability. $\dot{x}_1 = -3x_1 + x_2$ and $\dot{x}_2 = x_1 - x_2 - x_2^3$ [5]

Q.4(a) What classes of nonlinear systems can be transformed into linear systems? Arrange the steps those are required to design the control law based on input-output linearization. [3]

Q.4(b) Perform the input-output linearization for the following system and evaluate the control law. Label the concept of relative degree. Examine the stability of the internal dynamics of the system to justify the design. $\dot{x}_1 = x_2$; $\dot{x}_2 = x_3$; $\dot{x}_3 = -a_0x_1 - a_1x_2 - a_2x_3 + u$ and $y = b_0x_1 + b_1x_2$ [7]

Q.5(a) Compare robust control and adaptive control methods. Explain the concept of sliding mode control. Illustrate chattering effect. [5]

Q.5(b) List the condition required for I/P state linearization. Design the control law for input-state linearization for stabilizing the origin of the pendulum given by $\dot{x}_1 = x_2$; $\dot{x}_2 = -a[Sin(x_1 + \delta) - Sin\delta] - bx_2 + cu$. [5]