B. E. ELECTRICAL ENGINEERING EXAMINATION, 2022

(THIRD YEAR, Second Semester)

Nonlinear and Optimal Control

Part-I

Full Marks 100

Time: Three hours **(√50 marks for each part)**

Use a separate Answer-Script for each part

Q1a) Considering all the viewpoints, distinguish between autonomous and non-autonomous systems. Justify your answer. (CO1) **6**

Q1b) Consider the following scalar differential equation.

$$\dot{x} = f(x) = x^2$$

Show the direction of the vector field. Ascertain the stability of the equilibrium point. (CO1) **4**

Q2) Derive the describing function of the element whose input-output characteristic is shown in figure P-2. Show that the required describing function equals the sum of the describing functions of relay with dead-zone and amplifier with dead-zone. (CO2) **14**

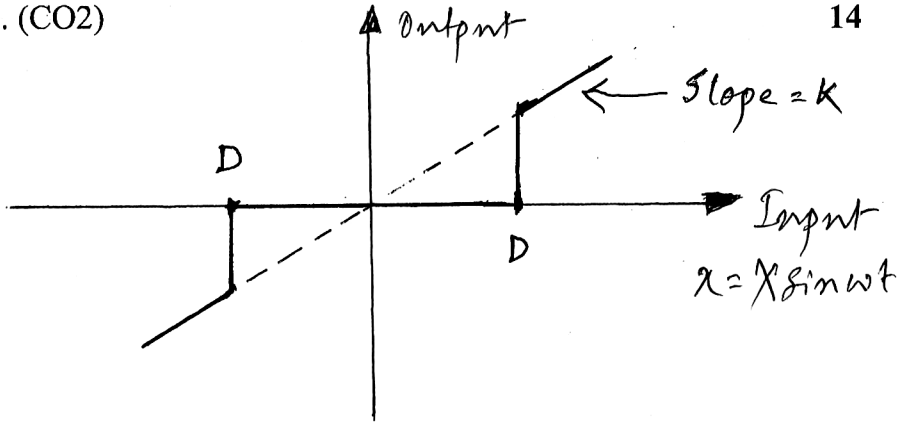

Fig. P-2: Input-Output Characteristic of the Nonlinear Element

OR

Q2) Consider the nonlinear differential equation (CO2)

$$\ddot{y} - (0.1 - \frac{10}{3}\dot{y}^2)\dot{y} + y + y^2 = 0$$

i) Find all the singular points of the system.
ii) Classify the singular points.
iii) Sketch the phase portrait in the neighbourhood of the singular points.

14

Q3) Write short notes on any two **8+8**

i) Lyapunov's Indirect Method (CO3)
ii) Jump Resonance (CO1)
iii) Minimum Time trajectory (CO2)

Q4) Determine the stability of the system described by the following equation using Lyapunov's Direct Method. (CO3) **10**

$$\dot{x} = Ax$$

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$$

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B.E. ELECTRICAL ENGINEERING THIRD YEAR SECOND SEMESTER – 2022

NONLINEAR AND OPTIMAL CONTROL (HONS.)

(50 Marks for this part)

Part-II

Answer any THREE questions.

Different parts of the same question should be answered together. Two marks will be given for neat and well organized answer.

1. a) State the advantages and disadvantages of optimal control.

c) Explain how selection of the mathematical model may influence the design of the optimal control law.

[6+10=16]

2. a) Explain the following with proper diagram:

(i) Control history, (ii) State trajectory, (iii) Admissible control, (iv) Admissible trajectory

b) Formulate a suitable optimal control problem for a second order underdamped servo system with a given tolerance for steady state error of ±1% and percent overshoot of 5% from the steady state value for unit step input.

[6+10=16]

3.a) What is performance measure and what is its role in optimal control problem?

b) Describe the classification of optimal control problems based on various performance measures.

[2+2+12=16]

4. a) Explain the following with example:

(i) Closeness of Functions, (ii) Increment of Functional (iii) Variation of a Functional

b) Let x be a continuous scalar function defined for t ϵ [0, 1]. Find the variation of the functional:

$$J(x) = \int_0^1 [x^2(t) + 4x(t)]dt$$

[3x3+7=16]