

2022

PHYSICS

Paper : PHY 523

(Nonlinear Dynamics)

Full Marks : 50

*The figures in the margin indicate full marks.**Candidates are required to give their answers in their own words as far as practicable.*Answer *any five* questions.

1. (a) Make a schematic plot of the potential $V(x)$ for the one-dimensional system $\dot{x} = x - x^3$. Identify all the equilibrium point(s). Plot the phase trajectories close to the equilibrium point(s).
(b) Show that the initial value problem $\dot{x} = x^{1/3}$ with $x(0) = 0$ does not have a unique solution. What happens if the initial value is $x(0) = x_0 \neq 0$? (2+2+2)+(3+1)
2. (a) Consider the system given by $\dot{x} = r + x^2$. Show that the system undergoes a bifurcation as the parameter r is varied from $r > 0$, $r = 0$ and $r < 0$. Classify the nature of the fixed points for $r < 0$ and discuss what happens when $r \rightarrow 0$. Draw the bifurcation diagram.
(b) Consider the system $\dot{x} = rx + x^3 - x^5$.
(i) Obtain algebraic expressions for all the fixed points as the parameter r takes different values from negative to positive, through zero.
(ii) For different r values, sketch the vector fields. Clearly indicate all the fixed points and their stability. (1+1+1)+(4+3)
3. (a) Enumerate the important features of a limit cycle. Discuss how it differs from the regular closed orbits which may occur in a linear system.
(b) Consider the system $\dot{r} = r(1-r^2) + \mu r \cos \theta$, $\dot{\theta} = 1$. Identify a trapping region and hence, using Poincare-Bendixon theorem, show that a limit cycle exists for positive but sufficiently small μ . (3+2)+5
4. (a) Consider the dynamics of a point (x, y) described by the equations

$$\frac{dx}{dt} = -y \quad \frac{dy}{dt} = x + ay,$$

where a is a real parameter. Find the stability of the fixed point for $0 < a < 2$.

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