DHIRUBHAI AMBANI INSTITUTE OF INFORMATION AND COMMUNICATION TECHNOLOGY
Gandhinagar 382007, Gujarat, India

Introduction to Nonlinear Dynamics (SC401)

Mid-Semester Examination Syllabus – Autumn Semester, 2022

Course covered in the class notes:

1. Introduction to the course and its overview.
2. Basic principles of differential equations (ordinary and partial). Orders of differential equations.
3. First order linear systems of one variable. Rate $\propto$ state. Transformation of variables, separation of variables, rescaling into dimensionless forms.
4. Scales, approximations and basic plotting techniques ($\dot{x} = a \pm bx$). Stokes's law of terminal velocity.
5. Atomic waste disposal. Viscoelastic deformation of rocks.
6. The Duckworth-Lewis method in cricket. Radioactivity. Radioactive series.
7. Detecting art forgery. Radio-carbon dating.
8. Q-R-C circuit. Flows on the line. Phase plots, fixed points (equilibrium points), attractors and repellers. Practice plotting of second-degree equations.
9. Plotting of a polynomial series and transcendental equation. Linear stability analysis and small perturbations.
10. Half-stable fixed points and power-law convergence.
11. The p-n diode. Plotting cubic polynomials. The logistic equation. Rescaling of variables. Integral solution.
12. Plotting of the logistic equation. Higher orders on nonlinearity. The Fermi-Dirac form of equation.
13. Modifications of the logistic equation. Nonlinear non-autonomous systems. Power laws and Zipf's law.
14. Population dynamics. Malthusian law of population growth. Logistic modelling of global demographics.
15. Country-wise examples of population growth and policy implications. Criticisms of the logistic equation.
16. The laws of social dynamics. Example of sharks and salmon. Critical population growth of New York city.
17. Turbulence. Free fall of a parachutist.
18. Item response theory. Sigmoid functions in neuron activity and positive cooperativity in haemoglobin. Spread of agricultural innovations.
19. Spread of industrial innovations. Growth of free living dividing cells. Gompertz law of tumour growth.
20. Bacteria versus toxin. Autocatalysis. The Allee effect.

Books:

1. *Nonlinear Dynamics and Chaos: Steven Strogatz* – Chapter 1: Sections 1.0, 1.1, 1.2, 1.3 (general reading). Chapter 2: Sections 2.0, 2.1, 2.2, 2.3, 2.4, 2.5 and 2.6.
2. *Differential Equations and Their Applications: Martin Braun* – Chapter 1: Sections 1.3 (at the end of the section go through the brief note on C-14 dating that follows Question 6, and the problems in Questions 7 & 8), 1.5 (also Questions 7 & 8 at the end of the section), 1.6, 1.7 and 1.8.