IDC601: DYNAMICAL SYSTEMS AND CHAOS

Instructor: Sagar Chakraborty (Department of Physics, IITK).
Units: 3-0-0-0-9 [3 lectures, 9 credits]. **Pre-requisite**: None.
Who can take the course: Ph. D., M. Sc., and advanced UG students.

Course contents:

Dynamical systems (map, flow, boolean, automata): Finite vs. infinite dimensional systems, Conservative vs. dissipative systems, Phase space, Fixed points, Linear stability analysis, Poincaré section, Numerical solution of maps and flows.
(**4 lectures**)

Maps: Circle map, Logistic map and conjugate Tent map, Chaos, Lyapunov exponents, Period doubling route to chaos, Intermittency route to chaos, Crisis, Quasi-periodic route to chaos.
(**9 lectures**)

Autonomous flows: Hartman-Grobman theorem (proof optional), Poincaré-Bendixon theorem (proof optional), Limit cycles, Hopf bifurcation theorem (proof optional), Flow on n-torus and quasi-periodicity, Lorenz equation, Chaotic attractor, Lyapunov exponents, Routes to chaos.
(**9 lectures**)

Non-Autonomous flows: Floquet theory, Duffing oscillator, Chaos.
(**5 lectures**)

Introduction to bifurcation theory and normal forms.
(**7 lectures**)

Fractals, Topological dimension, Similarity dimension, Box dimension, Correlation dimension, Generalized dimensions, Lyapunov dimension.
(**3 lectures**)

Some research topics: e.g., Synchronization, Phase space reconstruction, etc.
(**3 lectures**)

Primary Textbooks and References:

(1) S. H. Strogatz, *Nonlinear Dynamics And Chaos: With Applications to Physics, Biology, Chemistry, And Engineering,* Westview Press (2001).
(2) R. C. Hilborn, *Chaos and Nonlinear Dynamics*, Oxford University Press (2001).
(3) J. Argyris, G. Faust, M. Haase, & R. Friedrich, *An Exploration of Dynamical Systems and Chaos*, Springer (2015).
(4) H. G. Schuster & W. Just, *Deterministic Chaos: An Introduction*, Wiley-VCH (2005).
(5) D. Jordan & P. Smith, *Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers,* Oxford University Press, 4th edition (2007).
(6) J. Guckenheimer and P. Holmes, *Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields*, Springer (1983).