



PHY404: ORDER AND CHAOS

I/C: Sagar Chakraborty, Department of Physics, IITK

Lectures: 1035–1150 hrs on Wednesdays and Fridays

Target audience: 3rd year and 4th year BS students, and MSc/MS students.

Prerequisites: It will be assumed that the takers of the course know how to find eigenvectors of matrices and how to solve simple ordinary differential equations.

Course Content: This is a curiosity-driven course where emphasis will be on developing mathematical and physical understanding of the concepts and formalisms pertaining to chaos and fractals while going through the general introduction to the highly interdisciplinary topic of nonlinear dynamics:

S. no.	Broad Topics	Detailed topics	No. of Lectures
1	Maps	1D and 2D autonomous Maps, Conservative vs. dissipative dynamics, Phase space, Cobweb diagram, Stability analysis, Bifurcations (transcritical, flip, Neimark-Sacker etc.), Periodicity, Chaos, Strange attractor, Lyapunov exponents, Routes to chaos, Period doubling, Quasiperiodicity, Intermittency, Feigenbaum's constants: universality and renormalization.	15
2	Flows	1D, 2D, and 3D autonomous flows, Conservative vs. Dissipative systems, Poincare section, Bifurcations (saddle-node, transcritical, pitchfork, Hopf, etc.), Lyapunov function, Limit cycles, Perturbation techniques (Lindstedt-Poincare, multiple time scale, renormalization group, and equivalent linearization), Chaos.	14
3	Fractals	Fractals, Fat fractals, Multifractal, Fractal Dimensions, Fractal basin boundary, Riddled basins.	7
4	Misc.	Synchronization, Spatiotemporal chaos, Examples of chaos and fractal from physical sciences, engineering and biology.	3
Total number of lectures:			39

References:

1. S. Strogatz; *Nonlinear Dynamics and Chaos*, Westview Press (2014).
2. J. Banks, V. Dragan, and A. Jones; *Chaos: A Mathematical Introduction*, Cambridge University Press (2003).
3. K. T. Alligood, T. D. Sauer, and J. A. Yorke; *Chaos: An Introduction to Dynamical Systems*, Springer-Verlag New York Inc. (1996).
4. E. Ott; *Chaos in Dynamical Systems*, Cambridge University Press (2002).
5. J. H. Argyris, G. Faust, M. Haase, and R. Friedrich; *An Exploration of Dynamical Systems and Chaos*, Springer (2016).
6. R. C. Hilborn; *Chaos and Nonlinear Dynamics*, Oxford University Press (2000).
7. H. G. Schuster and W. Just; *Deterministic Chaos*, Wiley VCH (2005).