Physics of Complex Systems – Introduction & Methods

Course Instructor: Janaki Balakrishnan

Targeted audience: The course is expected to be of interest to students across various disciplines in physical sciences, engineering and the life sciences.

4-credit course, 4 contact hours per week; LTP structure: 3-1-0.

Course details:

Order & disorder phenomena – typical examples.

Dynamical systems, nonlinear systems, equilibrium points & trajectories in phase space, stability, limit cycles, bifurcations, dissipative systems & their attractors, Lorenz model, unpredictable dynamics, instability hierarchies & routes to chaos, intermittency.

Self-similar patterns, fractal dimensions, self-organization & the role of fluctuations,

Random processes, information entropy, Brownian motion, Markov processes, Chapman-Kolmogorov equation, path integrals, Gaussian processes, Master equation, detailed balance, fluctuations, Langevin equation, Fokker-Planck equation, stationary solutions, phase transition analogy.

Cooperative effects in physical, chemical and biological systems: Elastic stability, Gunn instability, laser equations, brief discussion of some fluid dynamics instabilities, Brusselator model
Application to biological systems: models in ecology & population dynamics -- predator-prey equations, models for competition, co-existence & symbiosis, simple dynamical neuron models, model for morphogenesis.

Suggested books:

1. Synergetics: an Introduction by H. Haken
2. Nonlinear dynamics & Chaos by Steven Strogatz