ACADEMIC YEAR: 2025-2026; 1st SEMESTER

Department of Physics, Indian Institute of Technology Kanpur

PHY615: Non-Equilibrium Statistical Mechanics

Instructor-in-charge: Sagar Chakraborty

(Prerequisite: PHY412 or equivalent)

Course Content:

Langevin equation: Application to free Brownian particle.

Fokker- Planck equation: Application to Diffusion, Mapping onto Schrödinger equation and application to Brownian particle subjected to harmonic potential, Kramers' theory of activated barrier crossing and decay of metastable states.

Markov processes, Classifications of states, Application to random walk and birth-death processes, Master equation for interacting systems, Kinetic Ising model: exact solution in one-dimension and mean-field approximation in higher dimensions, Critical slowing down.

Random excursions, Backward master equation and distribution of first-passage times, Stochastic calculus and calculus of variations, Path Integrals, Info-theoretic and path-based stochastic thermodynamics, Fluctuation theorems.

Chaos in non-equilibrium statistical mechanics, Linear response and transport phenomena, Surface growth, Turbulence, Pattern formation.

Reference Books:

1. *"Non-equilibrium Statistical Physics: A Modern Perspective", by Livi and Politi (Cambridge University Press, 2017).*
2. *"Simple Brownian Diffusion", by Gillespie and Seitaridou (Oxford University Press, 2013).*
3. *"A Kinetic View of Statistical Physics", by Krapivsky, Redner and Ben-Naim (Cambridge University Press, 2010).*
4. *"An introduction to chaos in non-equilibrium statistical mechanics", by Dorfman (Cambridge University Press, 2009).*
5. *"Stochastic Processes in Physics and Chemistry", by van Kampen (Elsevier, 2007).*
6. *"Stochastic Methods", by Gardiner (Spinger, 2009).*
7. *"The Fokker—Planck equation", by Risken (Spinger, 1989).*
8. *"Non-equilibrium Statistical Mechanics", by Zwanzig (Oxford university Press, 2001).*

Brief Course Policy (tentative):

Mandatory attendance. Two quizzes (20%), one mid-sem exam (30%) and one end-sem exam (50%).