Department of Physics
Indian Institute of Technology Kanpur

Course Title: Advanced Statistical Mechanics

Course Number: PHY613

Course Units: 3-0-0-0 (9)

Course Instructor: Adhip Agarwala (adhip@iitk.ac.in)

Course Timings: Wed, Fri (9.00 am-10:15 am)

Prerequisites: Statistical Mechanics (PHY413)

First Lecture: 31st July, 2026

Tutor: TBA

Course Objective:

This is a second course on statistical mechanics and will discuss advanced concepts such as symmetry breaking and universality in critical phenomena. Defining ideas of modern physics such as scaling and renormalization group theory will be discussed. Then related themes in both classical and quantum many body systems will be introduced.

Syllabus:

Lectures	Topics
14	Phenomenology of Phases and Phase Transitions (2), Order and Order Parameters (2), Aspects of Ising model, XY models, Heinsenberg and Pott's Models (5), Symmetry breaking, Goldstone Modes, Landau theory (5)
16	Finite Size Scaling, Scaling Theory (2), Idea of Renormalization group (1), Kadanoff Construction and Real Space RG (5), Momentum Shell RG (8)
6	Introduction to Hydrodynamics (2), Spin systems, Fluids and Nucleation (4)
4	Introduction to Quantum Phase Transition (1), Transverse Field Ising Model, d - (d+1) duality (2), Introduction to Statistical field theory (1), Hopfield Model, Neural Networks (Time Permitting)

References: [No Textbook]

(i) Mehran Kardar: Statistical theory of fields (Part 2), (ii) Principles of Condensed Matter Physics by Chaikin and Lubensky (iii) Statistical Mechanics of Phase Transitions by J. M. Yeomans (iv) Lectures on Phase Transitions and Renormalization Group by Nigel Goldenfeld

Grading scheme:
Quiz (20%), Mid-Sem Examination (20%),
Final Examination (30%), Assignments (20%),
Readings and discussions (10%).
Grading will be relative.

Assignment Submission Policy:

We will be using HelloIITK to share lecture notes and assignments. Please maintain an account and keep a watch. Submissions will be in hard-copy. Please respect deadlines.

Assignment/Exam Policy:
In Assignments: Participants are welcome to discuss among each other and refer to literature. Due credit should be provided in terms of references/people discussed with, when submitting the assignment.

Copying an assignment from a colleague – will be penalized. Students may be asked to present their answers to assignment questions to the rest of the class, therefore please ensure you stand by your submitted scripts.

In exams, any kind of mal-practice will be severely penalized. Present examiner's discretion will be final in such Instances.

Regarding Course:
This is a graduate level course. Which implies every lecture may have heavy assignments which will include state of the art numerics and analytics. If one is taking this course, it is advised people shouldn't take multiple other courses. The material discussed and presented will require significant time and effort from the side of the participants to suitably digest.

Attendance policy:
An attendance record will be maintained. Exams/surprise quizzes (if any) will not be repeated for absentees. Frequent casual absences/vegetative participation may be penalized, and/or sustained attendance with active participation may be rewarded. Instructor discretion will be final.

Absence due to medical/emergencies will be duly considered, even for re-examination, if informed with necessary documents and in time.