

PHY 625: Mathematical Methods 2
2025-26, semester - 2, Instructor - Apratim Kaviraj

Instructor: Apratim Kaviraj

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Office: 104, Block A, First floor, Sustainable energy centre (near New Media Labs)

Number of lectures per week: Per Week Lectures: 03 (L), Tutorial: 01(T)

Credits: 3-1-0-0(11),

Class schedule: Tuesdays, Thursdays, Fridays 8:00-9:00, Tutorial: Wednesday: 11:00- 12:00.

Course content: This course covers various essential topics in Group theory, for the first part of this course, with the goal to understand representation theory using various theorems and tools. The second half of this course focuses on solving partial differential equations using mainly Greens function techniques.

Broad topic	Topics	Number of lectures
Group theory	Introduction to symmetries and basics of group theory	2
	Finite groups and their representations.	3
	Lie groups and Lie algebras	3
	Roots and weights	3
	Examples: SU(N) and SO(N)	3
	Young tableaux	2
	Application in Quantum Mechanics	3
	Special topics : Haar measure / Weyl Character formula / Conformal group	3
Partial differential equations	Introducing PDEs through examples : the wave, diffusion and Laplace equations.	3
	Classification of PDEs	2
	Separation of variables method, Eigenfunction expansions approach	4
	Greens function methods, use of integral transforms	4
	Properties of Greens functions : analyticity and causality	3
	Introduction to symmetries and basics of group theory	2
	Special topics : Non-linear PDEs : KdV equation / Nonlinear Schrodinger equation / solitons	40

Books:

1. Lie algebras in particle physics, H Georgi.
2. Group Theory in a Nutshell, A. Zee
3. Mathematical Methods of Physics, J. Mathews and R. J. Walker
4. Mathematical methods, Arfken and Weber
5. Mathematical Methods, Byron and Fuller

Course evaluation:

Homework (30%)

Midsem exam (30%)

Endsem exam (35%)

Class performance (5%)*

(* will depend on participation in questions/answers and solving problems during class hours.)

First class: 6th January