Physics 7143 Syllabus

Group theory and quantum mechanics

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(Last updated August 25th, 2026)

1. General Information

- Course objectives: To deliver the subset of group theory known to have important applications in physics. Formal proofs will be minimized, emphasized only when straightforward or essential to understanding.
- Pre-requisites: Students must be comfortable with quantum mechanics.
- Class time & location
    - Tuesday & Thursday 14:00-15:15, Howey S106.
    - Office hours. 15:00-16:00 on the following days:
        - September 10th;
        - October 8th;
        - November 5th;
        - December 3rd.
- TA: None

2. Course requirements, grading, and guidelines

- Grading: 100 points in total
    - Biweekly homework, 50 points
    - In-class exercises, 25 points
    - Final oral exam, 25 points
- Letter grading: Final score will be rounded to the next integer.
    - A: 90 points or more
    - B: 80-89 points
    - C: 70-79 points
    - D: 60-69 points
    - F: 59 or less

- Homework: A couple of problems in each set.
    - 10 points each. Submit on canvas. Typically due two weeks after the homework is announced.
    - Students can skip one set of homework of their choice. It's recommended to save this for sickness or emergencies etc. If all 6 sets of homeworks are completed, the 5 sets with the highest scores will be kept.
    - Recommended: First think independently; then discuss with human/robotic friends if needed. However, after discussions, students are expected to write down their own solutions independently.
    - Copying solutions from any source without understanding them is plagiarism. If discovered, the whole homework set will receive zero points and the academic misconduct will be reported.
    - Penalty for late submissions: 1 points within one day, 2 points between 1-2 days, 3 points between 2 days and 1 week, 5 points between 1-2 weeks, 10 points afterwards.
- Oral exam
    - 20-minute in-private oral exam which will happen during the week of December 10th - 17th.
    - Closed-book, no electronics.
    - During the exam, each student will answer 4-5 questions regarding the materials in lecture notes and/or homeworks.
- In-class exercises
    - Each class will include solving 1-2 in-class exercises – open book, but no AI.
    - You can choose to work independently, or as a group with 1-3 friends (4 students max in a group).
    - You submit your solution to the exercise problem. It can be group work, but you need to write your own solution.
    - Solutions will be graded largely by efforts.
    - If you choose to show your solution on the board in front of the class, you automatically get full credits.
    - You can skip 4 submissions of in-class exercises. If you submit more than required, only the highest scores will be recorded.
    - No makeup submissions please.

- Academic integrity: https://catalog.gatech.edu/rules/18/
- Students with disabilities: Contact me and the office of disability services as soon as possible https://disabilityservices.gatech.edu/
- AI policy: https://oit.gatech.edu/ai/guidance

3. Course content and materials

- Lecture notes and other supplementary readings: Will be posted on canvas after each class.
- Textbook: Not required, as lecture notes will be self-contained. But in case students are interested, here are some recommendations:
    - Group theory in physics: an introduction, by J. F. Cornwell.
    - Group theory in a nutshell for physicists, by A. Zee.
    - Group theory and quantum mechanics, by M. Tinkham.
    - Lie algebras in particle physics - from isospin to unified theories, by H. Georgi.
    - Applications of finite groups, by J. S. Lomont.
    - Group theory, by P. Cvitanović.
    - Physics 220: Symmetries in Physics, by J. McGreevy.
    - Lecture notes on Group theory in physics, by D. Arovas.
    - Introduction to group theory for physicists, by M. von Steinkirch.
- Plan of the course (subject to changes)
    - **Why** group theory?
    - **Basic framework**: Definition and examples, presentations, homomorphism and isomorphism, subgroup, class, invariant subgroup, cosets, factor groups, (semi)-direct product.
    - **Discrete groups**: Lagrange's theorem, multiplication table, re-arrangement theorem. Permutation group, dihedral group, quaternionic group.
    - **Representation theory**: Definition, examples, equivalent, unitary, irreducible representations, Schur's lemma, orthogonality theorem, character, character table, projectors, direct product representation, representations of direct product groups, induced representations.
    - **Lie groups**: Coordinate transformations and Lie's idea, Lie algebra, structure constants, tensor methods, SO(N), SU(N), Sp(2N), Casmirs, Cartan-Weyl method,

Dykin diagrams, simple lie algebras, regular subalgebras, spinor representations, Clebsch-Gordan coefficients, Wigner Eckard theorem.

- **Applications in quantum mechanics**: Schrodinger's equation revisited, degeneracy, transition probabilities and selection rules, time-independent perturbations,
- **Crystals**: point groups and irrepns, Bloch's theorem, Brillouin zones, space groups, crystal-field splitting of atomic energy levels
- **Selected important symmetries**: CPT, Lorentz group, Poincaré group, conformal group, isometry of AdS, grand unification.
- **Beyond** group theory

Enjoy groups!