PHYS 4410
Quantum Mechanics 2
Spring 2023

OVERVIEW

This is the second semester of undergraduate quantum mechanics. The class will explain how the theory of symmetry, and approximation methods, help us understand real-world quantum mechanics problems.

Lectures: MWF 11:15 AM -12:05 PM in Duane G125.

Instructor: Andrew Lucas (`andrew.j.lucas@colorado.edu`); Duane F629.
Office hours are on Zoom (Tuesday 8-9 PM) and in person (Wednesday 2:30-3:30 PM)

Canvas: `https://canvas.colorado.edu/courses/88944`

Books and References: Not required. Can be used for background reading.

- D. H. McIntyre. *Quantum Mechanics* (Pearson, 2012).
- D. Tong. *Lectures on Applications of Quantum Mechanics* (online notes).

Recommended prerequisites: PHYS 3320, or similar.

COURSE OUTLINE

- quantum harmonic oscillator; multiple dimensions ($\approx$ 5 lectures)
- quantum theory of symmetries; parity; bosons and fermions ($\approx$ 6 lectures)
- translation symmetry; metals and insulators ($\approx$ 3 lectures)
- rotational symmetry and angular momentum; hydrogen atom ($\approx$ 7 lectures)
- the variational principle ($\approx$ 4 lectures)
- perturbation theory ($\approx$ 9 lectures)
- the semiclassical limit; tunneling and metastable quantum states ($\approx$ 4 lectures)

COURSE POLICIES

- All documents are found by clicking appropriate links on the homepage of Canvas.
- Suggested reading is optional, and is posted next to each lecture on the Canvas homepage.
- You are free to choose whether to attend class in person or remotely via Zoom. Zoom links will appear via the Canvas Zoom plug-in. Zoom will be used to record lectures.
- There are no participation or clicker grades. I encourage participation both by asking questions during class, and by participating in regular short problem-solving exercises during class, during which you are encouraged to work/talk with others.
- Standard university policies regarding appropriate conduct on campus also apply to this class, and can be found in writing on the course website.

GRADES

- **40% homework:** Homework can be found on the course website, and on Canvas. Homework is **due at or before 11:59 PM on the due date**. Solutions will be posted on Canvas on the third day after the due date. You must upload every homework assignment electronically into Canvas. I anticipate 10-12 homework assignments in this class.

  Late/drop policies: Every student starts with 3 extensions, which can be tracked in the ungraded "Extensions Left" assignment in Canvas. Extensions can be used as follows:

  - To receive a no penalty 48 hour extension on the due date for a homework assignment.
  - To drop a homework which was not turned in, *or* a homework which was turned in late but is (at the end of the class) below your average homework score.
  - To drop a low score. (Remaining extensions will be used this way at the end of the class.)

  Assuming no apocalypse, I will not give more extensions or push back deadlines. I apply these rules automatically, in the order above, so you do not need to ask for permission to use these extensions.

  You can work together on homework, but you must write up your own solutions. Solutions which do not appear original could be given no credit at the discretion of course staff.

- **60% exams:** We will have 3 **timed, 2 hour, in-person, open book/notes exams**:

  - **Exam 1:** 7:30 PM - 9:30 PM, Thursday, February 16.
  - **Exam 2:** 7:30 PM - 9:30 PM, Thursday, March 23.
  - **Exam 3:** 7:30 PM - 9:30 PM, Sunday, May 7 (predicted time, but fixed by registrar).

  Your total exam percentage E is calculated, given your scores on exams 1, 2 and 3 ($E_{1,2,3}$), as:

  $$E = \frac{2E_1 + 2E_2 + 2E_3 - \min(E_1, E_2, E_3)}{5}.$$

  In the Canvas gradebook, this policy will be implemented in the "Top 2 Scores" exam grade.

  I can arrange an alternative time if you have a conflict you tell me about quickly. For last minute issues (e.g. illness), students may take *one* exam remotely, sychronously with the class.

Grade cutoffs will be chosen to avoid students being just below a cutoff, and will not be announced until after final grades have been assigned. Guiding principles are:

grade:	A /A–	B+/B/B–	C+/C/C–
curve will not be harsher than:	90%	75%	60%
% of class that should receive at least a...:	$\geq 30\%$	$\geq 60\%$	all?

The holistic grading method for this class can be found on the course website. Partial credit is assigned on the basis of the entire (sub)problem taken together, and is primarily given based on demonstrated conceptual understanding. Note that you can get full credit with minor (math) mistakes.

Each homework/exam will be graded out of 100 points. The numbers besides each (sub)problem denote the number of points it is worth. If a (sub)problem is worth $5k$ points, you'll receive 0, k, $2k$, $3k$, $4k$ or $5k$ points according to the holistic grading scheme. **There will always be more than 100 points that can be earned. Scores over 100 are possible.**

Consequences for cheating will, at minimum, include receiving a 0 on the assignment(s) in question and a university-required referral to the Honor Code board. Further consequences may occur, at the discretion of the course instructor and graders.

PHILOSOPHY OF THE CLASS

Good physicists are skilled and versatile problem-solvers; they get that way through deliberate and sustained practice. My primary goal in this class is to teach you this subject by providing you with sustained practice solving problems and utilizing material from lectures to solve "real world" problems. Along the way, these assigned problems will showcase the incredible diversity of applications of the subject; I hope that most of you will find something that makes you want to read more about it!

Homework in this class is not merely a series of "skill drills". Problems are chosen to make you think increasingly deeply about physics, and I do *not* expect you to solve everything. In general, I expect broad grade distributions on both homework and exams. You should study the solutions, and keep in mind that you'll often learn more from the problems you didn't solve correctly, than the ones you did. Many students find my classes to be difficult compared to other classes in the physics department.

The final grade distribution will be chosen generously, with the guidelines above serving as the expected "worst case". Students who put in effort (don't give up, ask for help, turn in assignments, take exams) have never failed one of my classes, as of today. If you come close to the 60% benchmark in your final grade, you will pass. If you are determined to get an A, you may need to put in more effort than you're used to – the A cutoff may be $\approx 95\%$.