PHYSICS 137A (QUANTUM MECHANICS), Summer 2015, C. Wohl

General Info—Please read this page carefully!

Lecturer—Charles Wohl (cgwohl@lbl.gov, 486-4730). My office hours are in the "Reading Room," 251 Le Conte (I don't have an office on campus). I'll announce office hours in class. In order to minimize conflicts with your schedules, they will be mainly close to the lunch hour.

GSI—David Gee (ddgee@berkeley.edu).

Student Services Advisor—Kathy Lee (kathyl@berkeley.edu), 368 Le Conte. See Kathy for administrative problems.

What we cover—References to chapters, homework problems, etc., are always to MY notes. See the contents, which are already posted and can serve as an outline of the course. We shall cover up through Chapter 10 or 11. If you already have a text, hang on to it. Here are some good books. They are on reserve in the Physics Library. It is worthwhile to spend an hour browsing the shelf of quantum-mechanics books in the Library.

R.P. Feynman, *The Feynman Lectures on Physics, Vol. III.*
D.J. Griffiths, *Introduction to Quantum Mechanics.*
R. Shankar, *Principles of Quantum Mechanics.*

Website—Chapters, homework assignments, solutions, announcements, etc., will be posted on the course site as we go along.

First assignments—Read Chapter 1 and get a start on Chapter 2. There are homework turn-in boxes marked Monday, Tuesday, ... Friday in 251 Le Conte. Put Thursday's HW in the Thursday box, etc. HW's are due ON TIME. Turn in whatever you've got done, even if it is only part of the assignment.

HW #1, due Tuesday at 5 PM: Chapter 1, Problem 5.
HW #2, due Wednesday at 5 PM: Chapter 1, Problem 6 (use a ruler!).
HW #3, due Thursday at 5 PM: Chapter 2, Problems 1 & 2.
HW #4, due Friday at 5 PM: Chapter 2, Problems 3 & 4.

The probable list for next week (but I don't yet know in what order) is Chapter 2, Problems 8, 10, 12, 15(a), 16, 18, and 19.

Exams, grades—There will be in-class exams Thursdays of weeks 4, 6, and 8. There may also be an occasional quiz. Exams will count 75 to 80 percent of the grade and HW's the rest. The approximate ratios of grades is supposed to be A:B:C = 35:40:25.

SOME ADVICE

- You have just read a few pages and realize you understand very little of what you have read. Don't despair—that's normal. Learning new physics is like learning to play a new piece of music—for a while there isn't music. Read a few pages, take a break, read the pages again, read a few more pages, try a problem, . . .
- Read the problems early on. They tell you what you are expected to be able to do with what you are learning. With the problems in mind, you'll be able to snag relevant information from the reading and lectures. And you'll sometimes find that you've worked on the problems subconsciously.
- Unless you think you see all the way through a problem, start out on scrap paper. Then when you've found your way to the solution, clean it up. Where did you go wrong? Do you now see how you could have gone more directly from start to finish? Write *that* up.
- As best you can, do your own homework. Give yourself an hour per problem before you go looking for help. How else are you going to get better? But also find someone to talk with about the physics. Verbalizing forces you to try to have complete thoughts, and often will clarify matters all by itself.
- Do lots of problems. And write out a lot of the equations. You can't learn to do physics simply by reading and listening any more than you could learn to play music simply by reading a score and listening to a recording. You learn up your arm as well as through your eyes and ears. If you don't get it up your arm, it won't come down your arm on exams.
- The best way to see if you understand something is to try to recreate it away from the books, maybe on paper napkins over a cup of coffee. And talk things through to yourself. The person muttering over in the corner of the cafe might be deranged, or might just be a physicist.
- Try to see the physics from the math. The usual process is: formulation of a physical problem; a swim in mathematical waters (often a near-drowning experience); and emergence with a solution to be interpreted physically. There is nothing especially quantum mechanical about the mathematics—most of it was developed in the nineteenth century to solve classical problems. (And once in a while stop to marvel that all those mathematical manipulations have anything to do with the physical world.)
- Don't fight the math. That's like a carpenter fighting his tools. Try to get good at it. If you're more interested in equipment or data analysis, fine, but the math is indispensable.

MATH

- You need a reference for integrals, properties of functions, special polynomials, ... Good and cheap ($15 online) is the *Mathematical Handbook of Formulas and Tables* by M.R. Spiegel, S. Lipschutz, and J. Liu (3rd ed., Schaum's Outline Series). If you don't have it, or something similar (perhaps online), get it now!
- The most powerful technique for doing integrals is to look them up. When looking up an integral over some standard range, such as 0 to ∞ or 0 to $\pi/2$, look in the table of *definite* integrals.
- Do not give numerical answers to more decimal places than is warranted by the precision of the input numbers. Your calculator gives 6.911503838 cm as the circumference of a circle of diameter 2.2 cm (if you use the built-in value of π) because your calculator can't think. For most work, set your calculator to display three or four places and extend its battery life.
- Know how to graph simple functions such as x^2, x^3, e^x, $\ln x$, $\sin\theta$, $\cos\theta$, $\tan\theta$, etc. What is the value of the function at the origin? What is its slope there? Does the function have zeros? Infinities? Never graph a function with a calculator or computer until you have tried to sketch the function yourself.
- Polar coordinates are r and θ, where $0 \le r \le \infty$ and $0 \le \theta \le 2\pi$. Note that r is never negative. Spherical coordinates are r, θ, and ϕ, where $0 \le r \le \infty$, $0 \le \theta \le \pi$, and $0 \le \phi \le 2\pi$. Know θ from ϕ; and r is never negative. (Math books switch θ and ϕ. Dont you!) What, in polar and in spherical coordinates, are the coordinates of the point diametrically opposite to (r, θ) and to (r, θ, ϕ)?
- You need to have some basic relations memorized. Here is a small sample:

$$\sin(\theta \pm \phi) = \sin\theta\cos\phi \pm \cos\theta\sin\phi, \quad \text{and so} \quad \sin 2\theta = 2\sin\theta\cos\theta$$
$$\cos(\theta \pm \phi) = \cos\theta\cos\phi \mp \sin\theta\sin\phi, \quad \text{and so} \quad \cos 2\theta = \cos^2\theta - \sin^2\theta$$

$$e^{\pm i\theta} = \cos\theta \pm i\sin\theta, \quad \text{and so} \quad \cos\theta = \frac{1}{2}(e^{i\theta} + e^{-i\theta}), \quad \sin\theta = \frac{1}{2i}(e^{i\theta} - e^{-i\theta})$$

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots, \quad \text{and so (with } x \to i\theta\text{, and } \theta \text{ in radians)}$$

$$\cos\theta = 1 - \frac{\theta^2}{2!} + \frac{\theta^4}{4!} + \cdots, \quad \text{and} \quad \sin\theta = \theta - \frac{\theta^3}{3!} + \cdots$$

$$\text{When } \epsilon \ll 1, \; (1+\epsilon)^\alpha \approx 1 + \alpha\epsilon + \frac{\alpha(\alpha-1)}{2!}\,\epsilon^2 + \frac{\alpha(\alpha-1)(\alpha-2)}{3!}\,\epsilon^3 + \cdots$$

  Thus for $\epsilon \ll 1$,

$$(1+\epsilon)^{1/2} \approx 1 + \epsilon/2, \quad (1+\epsilon)^{-1/2} \approx 1 - \epsilon/2, \quad (1+\epsilon)^{-1} \approx 1 - \epsilon, \quad \text{etc.}$$

- Add to this list. Maybe keep a small notebook of useful math. When you find yourself using a relation repeatedly, commit it to memory.