Physics 125 – Quantum Mechanics – Fall 2017

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Office hours: T 10-11, F 12-1, and by appointment
Classroom: Gal 112, TTh 11:30-1:05

> *I think I can safely say that nobody understands quantum mechanics.*
> – Richard Feynman

It is well known that on the microscopic level, particles behave in ways that defy our intuition. We find ourselves saying that an object is both a wave and a particle, it has traversed an impenetrable barrier, or it is in two places at once. Words fail. Even if each of these statements bears a certain truth, we need mathematics to express precisely the nature and behaviors of the quantum world. Its dynamical possibilities are much richer than those afforded to us large, lumbering beings. As mysterious and magical as they may seem, they constitute the true logic of physics. The real mystery is why we've been left out.

Course Outline

We will begin by studying the intrinsic spin of the electron. With a minimum of mathematical complication, this allows us entry to the phenomena that define the quantum world – superposition and interference, Schrödinger dynamics, and entanglement – and by mapping to similar two-state systems, entry to applications such as magnetic resonance and the ammonia maser. These systems are inherently quantum in nature and represent a break from anything you will have studied previously in physics. In parallel with this conceptual groundwork, we will develop the algebraic formalism of states, operators, and measurement.

Midway through the course we will introduce the spatial wavefunction to describe particle dynamics in one and then three spatial dimensions. These systems live in infinite dimensional Hilbert space and require for their description tools of functional analysis. We will study simple bound-state and scattering-state systems, with particular focus on the harmonic oscillator. As an end goal, we will seek to understand the hydrogen atom in detail and something of the structure of helium and the periodic table. This plan amounts to Chapters 1-7 and 9 of Townsend and selected topics from later in the book.

Learning Objectives

In this course we redo physics from scratch, and there is really one objective: to understand quantum mechanics. To put down a few specific sign posts, you should grow in your ability:

1. To articulate the meaning and give working examples of quantum superposition, as distinct from a classical probabilistic mixture;
2. To solve for and numerically simulate quantum dynamics;
3. To explain the structure of the periodic table of elements;
4. To see the meta-structure of physical theory, as expressed in states, observables, and dynamics;
5. To integrate in problem solving increasingly sophisticated mathematical tools of linear algebra and functional analysis.

Outposts on the internet

Our course web page is linked from the department webpage, physics.stmarys-ca.edu. Assignments will be posted there. Grades will be posted on Moodle.

Texts

The required text is John S. Townsend, *A Modern Approach to Quantum Mechanics*, 2nd edition.

Though more comprehensive and polished, Townsend's approach is very much inspired by Feynman, Volume III of *The Feynman Lectures on Physics*. It's always good to hear Feynman explain it.

Of the more traditional textbooks, my go-to is Bransden and Joachain, *Introduction to Quantum Mechanics*.

Expectations, for students and instructor

- Engagement. This means really working to understand the subtleties of the quantum world, generating questions, and refusing to be satisfied with half answers.
- Honesty in communication and in written work.
- Courtesy and kindness. Good life practice.

So that we all can stay focused on physics, I ask that you do not use cell phones or computers in class.

Assessment

Course grades will be based on:

- Weekly assigments - 25%
- Midterms - 25%
- Final exam - 50%

I do not give extensions on homework, but I will drop one assignment from your final course grade to give you a measure of flexibility. Please plan accordingly. That said, if a major family or health emergency arises, please let me know and we will adjust as needed.

Student Disability Services

The College strives to make all learning experiences as accessible as possible. Students who anticipate or experience academic barriers based on a disability are encouraged to contact Student Disability Services (SDS), a department of the Student Success Office, to set up a confidential appointment to discuss available services and options. The Student Disability Services office can be reached by emailing sds@stmarys-ca.edu; calling 925-631-4358; or visiting the office located in Filippi Academic Hall FAH190.

Stem Center

Saint Marys has a new STEM Center on the second floor of Assumption Hall for students studying Science, Technology, Engineering, and Mathematics. The STEM Center will provide several useful services, including:

- Math and physics tutoring: Monday-Thursday 12-2 PM and 4-9 PM; Sunday 6-8 PM
- Chemistry tutoring: Sunday-Thursday 6-8PM and Wednesday 1-2PM.
- "Pathways to Science" speakers series featuring world-class scientists
- Social events with free food
- Study space and computer workstations

If you have any questions, please contact Dr. Ameer Thompson at athompson@stmarys-ca.edu or (925) 631-6282.