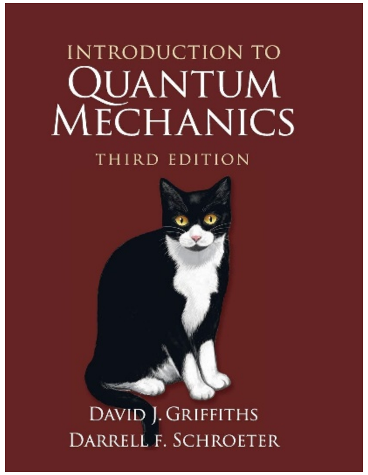
Course Information, Fall Semester 2022
Physics 411: Introduction to Quantum Mechanics

Meeting Time, Location, etc.: Tuesdays and Thursdays, 11:20 am – 12:35 pm, room Nielsen 304, one floor down from the main entrance floor of the Physics Bldg. Please arrive on time. Football game problems coming week??

Instructor: **Prof. Elbio Dagotto**, joint faculty UT-ORNL. **Office:** 3th floor South College building.
edagotto@utk.edu ← email will be the best means of communication this fall. Second best, texting.

Textbook: *Introduction to Quantum Mechanics,* 3rd edition, D.J. Griffiths (brown cover). There will be a total of 28 lectures, including 2 days for midterm exams, and ½ days preparation for those exams.



The lectures in PDF format will appear in the web page
http://sces.phys.utk.edu/~dagotto/QuantumMechanics/index2022.htm
shortly after being delivered. The afternoon before class, I will try to send you the .pptx file if you wish to glance in advance, or to take notes during lecture in that file via a tablet.
Taking your own notes in class is encouraged.
Asking questions, particularly "trivial" ones, also!

This class will be **in person**. Not sure about mask policies yet. 6-feet policy with teacher ☺

First class: Thursday, Aug 25, 11:20 am – 12:35 pm
Last class: Tuesday, Dec 6, 11:20 am – 12:35 pm
Final exam: to be decided by UTK, sometime Dec 9-15
No class on Oct 6, Thursday (Fall Break) and Nov. 24, Thursday (Thanksgiving).

Office Hours: Previous experience shows that students asking questions as the issues arise, as opposed to "at a fixed-time office hours", works better in practice. Thus, email Prof. Dagotto for short questions at any time. You can send me a specific question or photographs of calculations that are causing trouble and I will do my best to help fast.

Whatsapp audio communication works well for many: text me a question (I will provide my phone number first class) and if the answer requires more than a couple of lines of typing, I can record my response and/or send you photographs of sketches or calculations by hand as illustration. Plus, Whatsapp audio can be heard many times and photos can be saved.

If this fails, we can talk by phone or zoom, being careful not to be disruptive to those around us.

After class is also a great time to ask questions

Prerequisites: P411 requires the quantum portion of Modern Physics and a good mathematical foundation. *Confidence with **simple** derivatives, integrals, differential equations, linear algebra (matrices, eigenvalues, eigenvectors), and, **especially**, elementary operations of complex numbers (addition, multiplication, complex conjugate, $e^{ix} = \cos x + i \sin x$ Euler's formula, etc.), are essential in this course.*

From previous experience I know your main obstacle in this class will not be QM or the teacher, but will be your background in math.

Good news is that you will NOT be asked to solve complicated integrals or complicated differential equations, only simple ones. Any complicated integral etc. needed to solve a problem will be provided.

Physics 411 is the first semester of a two semester sequence (with 412) and is mandatory for all physics majors pursuing the Academic Physics Concentration. P411 will deal with the foundations of quantum mechanics. P411 will approx cover most of Chs. 1-4 of Griffiths and will follow the text *closely*, but with several extra comments and illustrations. Not all sections of those chapters will be addressed. Topics:

- The wave function and the uncertainty principle.
- The time-independent Schrödinger Equation.
- One-dimensional potentials, such as the square well and harmonic oscillator.
- Introduction to linear algebra, Hilbert Space, Hermitian operators.
- Schrödinger Eq. in 3-Dimensions, hydrogen atom (the highlight of the semester!), angular momentum, spin.

Course Information: Lecture notes, problem assignments, and exams will be located in the same web page http://sces.phys.utk.edu/~dagotto/QuantumMechanics/index2022.htm
Professor will try to send HW problem assignments by email. But it is the student's responsibility to remain current with posted information. Shortly after your deadline I will send my solutions.

Grading: In addition to lectures, the course will include problem sets, two midterm exams, and a final (which will be like a third midterm exam in practice). Final grade will be determined by a weighted average of:

(1) Problem Sets weight 40% (here a grader designated by the department will grade, with the exception of the first set that the professor will handle)
(2) Test 1, weight 20% ← covering first third of semester; tentative 9/27 or 9/29.
(3) Test 2, weight 20% ← covering second third of semester; tentative 11/1 or 11/3.
(4) Final (aka Test 3), weight 20% ← "final exam" will cover the last third of semester.

Midterms and final exam will be graded by professor.

HWs graded by grader (PhD Grad Student Leandro Chinellato, email lchinell@vols.utk.edu).

HW1 will be graded by professor. HW2 and beyond will be graded by grader Leandro, and you will leave the HW directly in his mailbox by the deadline.

We will coordinate later where to pick up the graded HW.

Homework (HW) Policy: The solving of problems is an essential part of this course. It is allowed for students to work together on the HW sets. Interactions of this kind are encouraged. However, **solutions to HW problem sets must be submitted in each student's own hand.**

The given HW sets will include the deadline (day and time) clearly written (typically you will have one week to complete). This deadline is strict. Shortly after deadline, solutions will be sent to all students by email. Graded HW will be returned within a week or earlier. It is crucial that you present the solutions in a well-organized manner, with framed results, showing your work. **We are more interested in your "thinking" to solve a problem, more than the final result.** Make sketches by hand if needed to explain better your solutions. No need to save paper. **Partial credit will be generous. Take advantage of the possibility of collecting close to 40% of the grade via HW.** Plus you will be well prepared for exams by understanding the HW problems.

Tests Schedule

The dates of the tests will be announced in class, by email, and they will be posted in the class web page. Tentatively they are: **Test 1, Sept 27 or 29, Test 2 Nov 1 or 3.** The date of the final (Test 3) will be made available on the University Academic Calendar and it is fixed by UT. It is the student's responsibility to remain current on these dates. **For all the tests, the lecture before will be, partially or fully, for students to ask questions. Do not be shy. You will not be graded or judged based on the type of questions you formulate.**

No "curve", but generous grade scale:
90-100 A 85-90 A-
80-85 B+ 75-80 B 70-75 B-
65-70 C+ 60-65 C 55-60 C-
Less 55 D,F range

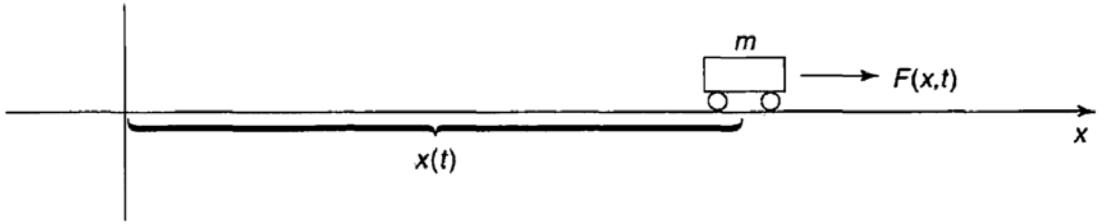
Note: Read in Skills Employers Look for in College Graduates the top ten things employers look for in new college graduates. Among them is problem-solving skills, critical thinkers, good written communication abilities, etc. The class of Quantum Mechanics will help to develop these abilities!

University Disability Statement
The University of Tennessee, Knoxville, is committed to providing an inclusive learning environment for all students. If you anticipate or experience a barrier in this course due to a chronic health condition, a learning, hearing, neurological, mental health, vision, physical, or other kind of disability, or a temporary injury, you are encouraged to contact Student Disability Services (SDS) at 865-974-6087 or sds@utk.edu. An SDS Coordinator will meet with you to develop a plan to ensure you have equitable access to this course. If you are already registered with SDS, please contact your instructor to discuss implementing accommodations included in your course access letter.

Introduction

In non-relativistic classical mechanics, Newton's law says

$$ma = F$$



It is a second order differential equation. Assuming the force is conservative (arises from a potential energy function *V(x)*, unlike friction) in 1D (for simplicity) it becomes:

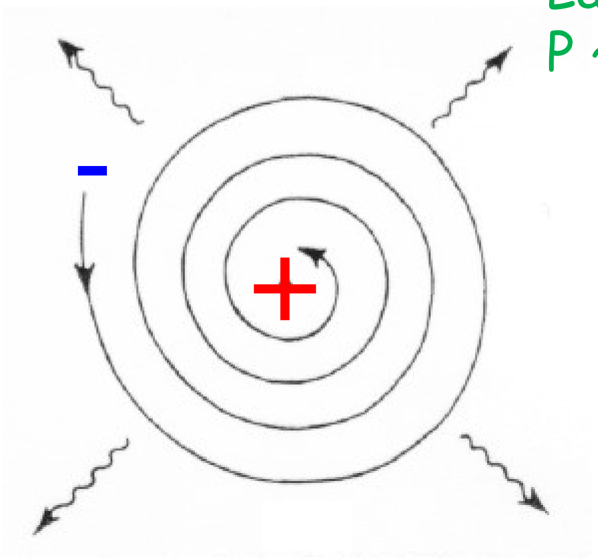
$$m\, d^2x/dt^2 = -\partial V/\partial x$$

Then, typically we solve this 2nd order differential eq. with initial conditions at $t=0$, namely $x(0)$ and $dx/dt\ (t=0)$, and find $x(t)$.

From $x(t)$ we get position, velocity, acceleration, kinetic energy, etc.

In addition, we have Maxwell's equations for electrodynamics. All seems very nice and clear, right?

<u>However, at the atomic level classical physics does not work</u>

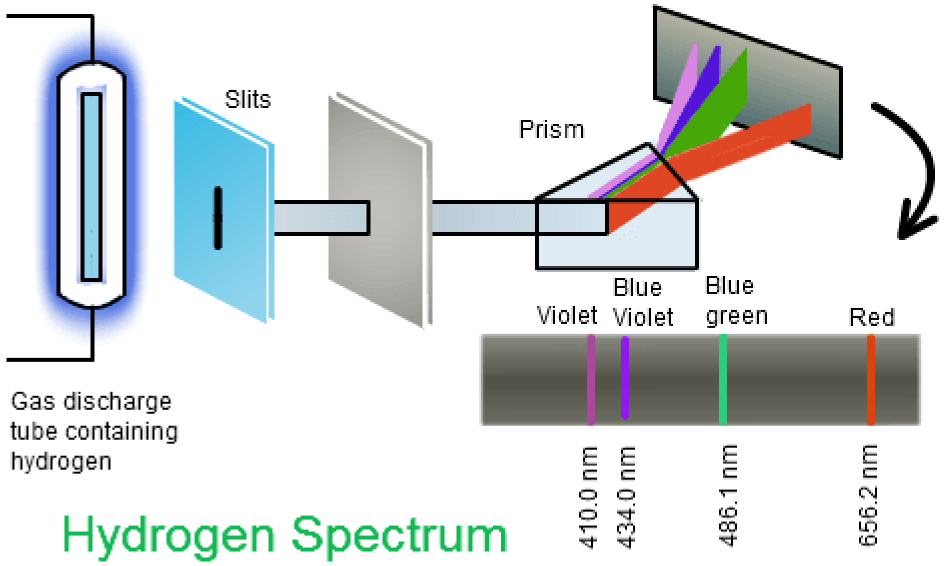


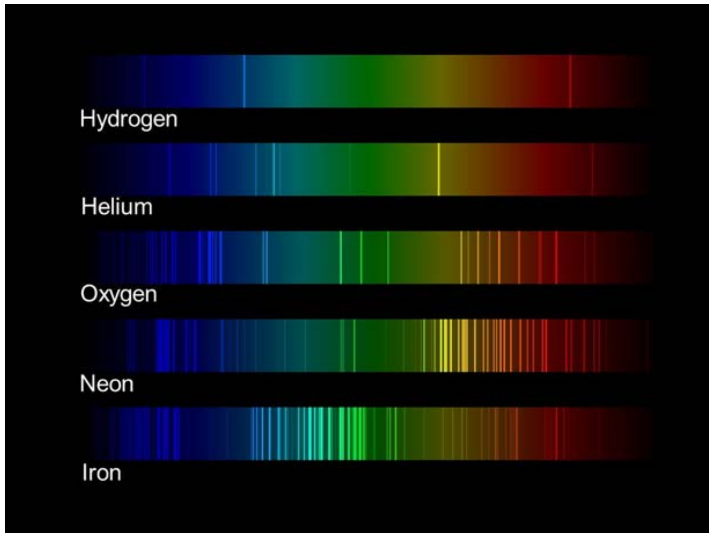
Larmor radiation
$P \sim a^2$

The classical view of an atom as a miniature "solar system" does not work because electron and proton are charged, unlike planets around the Sun.

Within classical electromagnetism (Maxwell eqs) charged particles in a circular orbit loose energy because they emit Larmor radiation. Lifetime estimated to be 10^{-10} seconds. Atoms would be unstable!

In addition, when hydrogen atoms inside a tube absorb energy, and then return the energy as light, the spectrum is found to be discrete, with just a few lines (Modern Physics class).





Classical physics has no explanation for this result at all.

We need a new physics **drastically** different from classical …