PHY315: Quantum Physics II (Spring 2015)

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Instructor:	Dr Oliver Beckstein
Lecture:	Mon/Wed/Fri 12 noon–12:50 pm
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Office hours:	Mon/Wed 1 pm–2 pm
Grader:	TBD
Course page:	see Blackboard
Web page:	http://becksteinlab.physics.asu.edu/learning/45/phy315-quantum-physics-ii

Contents

1 Course description

PHY 315 is the second semester of the quantum physics sequence for physics majors. The prerequisites are PHY 302 (Mathematical Methods in Physics II), PHY 314 (Quantum Physics I). The course consists of lectures together with written home work assignments.

The goal of the course is to give you a quantitative understanding of the quantum mechanical behavior of a single particle and of many particles at the atomic scale. Together with an introduction to the theory of special relativity you will acquire core ideas and concepts of modern physics that offer a fundamentally different view of the world than classical physics.

1.1 Content

The course continues from the end of PHY 314 by reviewing quantum mechanics of a single particle in three spatial dimensions, moves on to quantum effects in many-body systems, introduces approximate solutions for problems that cannot be solved exactly, and concludes with an introduction to the theory of special relativity.

Three-Dimensional Quantum Mechanics with spin

- Review of the concepts and formalism of quantum mechanics
- Orbital angular momentum
- Solving the 3-D Schrödinger equation in centro-symmetric potentials
- Examples: Free particle, harmonic oscillator
- The hydrogen atom
- Spin; interaction with magnetic fields
- Addition of angular momenta

Many-body quantum mechanics: Identical Particles

- Two-particle and many particle systems
- Bosons and fermions; the Pauli exclusion principle; exchange forces
- Atoms and the periodic table
- Fermi gases; energy band structure
- Introduction to quantum statistical mechanics

Approximate solutions

Time-independent Perturbation Theory

- Non-degenerate case, 1st and 2nd order
- Degenerate case
- Examples: Relativistic and spin-orbit effects in hydrogen; the Zeeman effect; hyperfine splitting

The Variational Principle

- Basic theory
- Examples: He and H_2^+

Special Relativity

- Frames of reference; Galilean relativity

- Einstein's postulates
- Lorentz transformations, length contraction, time dilation
- Velocity addition, Doppler shifts
- Space-time and Minkowski diagrams
- Energy and momentum
- Four-vectors and the Minkowski metric

1.2 Learning outcomes

Upon successful completion of the course:

- You will be familiar with key ideas and concepts in quantum mechanics and special relativity that form the foundation of modern physics.
- You will deepen your understanding for how our current view of the the nature of reality radically differs from the classical view shaped by our every-day experience.
- You will be able to use the mathematical tools and the formalism of quantum mechanics to quantitatively describe the behavior of simple one- and many-particle systems, either exactly or using approximate methods.
- You will be able to solve kinematic and simple dynamic problems for objects near the speed of light.

1.3 Reading materials

The following texts are required:

1. Introduction to Quantum Mechanics by *David J. Griffiths*, Prentice Hall, ISBN: 9780131118928
2. Quantum Mechanics by *Nouredine Zettili*, Wiley, ISBN: 9780470026793
3. Special Relativity by *A.P. French*, Norton, ISBN: 9780393097931

Books are intended as a support and complement to the lectures. The lectures will follow a given textbook in their general structure, but close correspondence in content should not be expected.

1.4 Grading and assignments

1.4.1 Grading policy

- **Home work** will constitute **33%** of your grade while **67%** will come from **exams**.
- Two midterm exams and one final exam will be given.
- **The exam with the lowest score will be dropped** and the exam grade will thus be calculated from two exams, equally weighted.
- Not handing in home work or absence from an exam will be equivalent to a null score on the particular assignment.
- The full grade scale[1] from A+ down to E is used for the final course letter grade.
- Final conversion from percentages to a letter grade will be carried out with a scale that will be published near the end of the semester.

[1] See https://students.asu.edu/grades for the meaning of the grades.

1.4.2 Home work

Typically, there will be one home work assignment per week. Home work will be due one week after it has been assigned, as specified on the assignment. It will be graded and returned. The home work is an integral part of the course as it provides the opportunity to learn the application of the mathematical tools to physical problems and to deepen the understanding of new physical concepts.

- No credit will be given for late or unexcused homework.
- In case of documented medical or family emergencies you may be allowed to submit home work for credit after the due date. Contact the instructor within 48 hours after the due date of the home work to apply for an extension and provide documentation for the emergency.
- You may discuss home work problems with your peers but you must write and submit *your own work*.
- You may submit home work on paper or electronically (PDF format). If you scanned your solutions make sure that they are legible; solutions that are difficult to read might be returned un-graded with 0 points.
- You may use computer tools as an aid in your home work but software-generated results should be used exclusively to substantiate, illustrate, and supplement the result of your own reasoning. They cannot be accepted as proof of facts that are not explained otherwise.

1.4.3 Exams

You will be assessed in **two midterm** and one **final exam**. The midterm exams will take place during class hours, roughly after 1/3 and 2/3 of the course, while the final will be on the date assigned by the university. All exams will be similar in scope and length.

Allowed materials For your exam you will be allowed a single letter-size sheet of paper with your own notes. No computers, phones or smart phones, PDAs, programmable calculators, nor any other internet-capable device will be allowed. (You may use a standard scientific calculator although you are probably not going to need it.)

Make-up exams There will be no make-up exams for unexcused absences from exams. Approval to be excused from an exam is rare and will only be granted in cases of extreme personal emergency with written documentation. Note that the vast majority of cases of missing an exam is supposed to be covered by the fact that one out of three exams is dropped from the grade.

- If you miss a scheduled **midterm** exam due to an emergency, you must apply to the instructor within 48 hours of the end of the exam, in which case you may be allowed to take a make-up exam.
- There will be no make-up exam for the final exam.

2 Conduct

2.1 Attendance and class disruption

Students are expected to attend every scheduled class period and to be punctual. You are responsible for all material covered in class, even in your absence! If you are absent, obtain class notes and handouts from your fellow students.

Use of cell phones, beepers, smart phones, tablets, and other electronic devices *is prohibited in class* unless used for taking lecture notes. Devices must be silenced before entering.

2.2 Lectures and lecture material

In general, no lecture slides or handouts will be posted and you are expected to **take your own notes**.

Recording of lectures or taking pictures during lectures is prohibited unless explicit and specific written permission has been granted by the instructor.

All *lecture materials* including slides, assignments, and solutions are copyrighted by the instructor and may contain material licensed only for instructional use. It cannot be distributed in any form without obtaining prior written approval from the instructor (and any other copyright holders).

2.3 Blackboard

Each student has access to the *PHY 315* course page. You are expected to check this site on a daily or near-daily basis. Important announcements, course documents (syllabus and general information), presentations and other course materials will be posted here throughout the semester. You will also find **home work assignments** here.

2.4 Communication

You can see your instructor during office hours or send an e-mail[2]. E-mails will generally be answered within two business days. Although effort will be made to also respond sooner to urgent e-mails, no guarantee can be given that e-mails will be answered in time e.g. on the night before an exam or home work due date—make sure that you ask well in advance of any critical dates.

2.5 Academic dishonesty

Academic honesty is expected of all students in all examinations, papers, laboratory work, academic transactions and records. The possible sanctions include, but are not limited to, appropriate grade penalties, course failure (indicated on the transcript as a grade of E), course failure due to academic dishonesty (indicated on the transcript as a grade of XE), loss of registration privileges, disqualification and dismissal. For more information, see http://provost.asu.edu/academicintegrity.[3]

[2] E-mails are expected to be written in a professional tone. See *Scientific Communication: E-mail* at http://www.nature.com/scitable/topicpage/e-mail-13953985 for what this means. Start your subject with "*PHY315: ...*".

[3] This paragraph is required by ASU and outlines the *minimum* university-wide policy.

Academic dishonesty will not be tolerated in this course. There are severe sanctions for cheating, plagiarizing and any other form of dishonesty, including a permanent XE in the student record. In the *Student Academic Integrity Policy manual*, ASU defines "*plagiarism* [as] using another's words, ideas, materials or work without properly acknowledging and documenting the source. **Students are responsible for knowing the rules governing the use of another's work or materials and for acknowledging and documenting the source appropriately.**"

All students are expected to visit http://graduate.asu.edu/beintheknow in order to educate themselves on academic integrity.

3 Withdrawal policy

The withdrawal policy is established by the university.

4 Disability policy

Disability Accommodations Qualified students with disabilities who will require disability accommodations in this class are encouraged to make their requests to the instructor at the beginning of the semester either during office hours or by appointment. **Note:** Prior to receiving disability accommodations, verification of eligibility from the Disability Resource Center (DRC) is required. Disability information is confidential.

Establishing Eligibility for Disability Accommodations Students who feel they will need disability accommodations in this class but have not registered with the Disability Resource Center (DRC) should contact DRC immediately. Their office is located on the first floor of the Matthews Center Building. DRC staff can also be reached at: 480-965-1234 (V), 480-965-9000 (TTY). For additional information, visit http://www.asu.edu/studentaffairs/ed/drc. Their hours are 8:00am to 5:00pm, Monday through Friday.

A History of changes to this document

Amendments to the original initial version of this Syllabus are recorded here. See also the date at the top of this document.

December 15, 2014 initial version