Physics 412-3 – Graduate Quantum Mechanics III

SPRING 2020

Instructor: Dr. Andrew Geraci

Office: Tech F135, Email: andrew.geraci@northwestern.edu

Class Time/location: Tu/Th 9:30-10:50 Tech L170 (Or by remote lectures on Zoom until further notice!) , Zoom Meeting ID: 225 302 123, Password: Phys412-3 (will update/change as needed)

Office Hours: On zoom class meeting site, Thursdays 11:00-12, or by appointment

TA/grader: Thomas Myers, Email: thomasmyers2021@u.northwestern.edu

Discussion section: Tuesdays 12-2pm on alternate weeks (when a problem set is due Friday).

Textbooks:

Recommended: J. Sakurai, *Modern Quantum Mechanics*

Recommended: C. Cohen-Tannoudji, B. Diu, and F. Laloe, *Quantum Mechanics* (Vols. I&II).

Course description: This is the third of a three-quarter sequence of a graduate-level course on quantum mechanics and its applications to the microphysical world. Topics may include: quasi-classical limit; Feynman path integral; EM fields & one-electron systems; identical particles and spin; the occupation number representation; variational methods; many-electron atoms; Thomas-Fermi method & density functional theory; diatomic molecules; polyatomic molecules; elastic scattering; inelastic scattering; quantization of the free electromagnetic field; interaction of one-electron atom & quantized radiation field; Klein-Gordon equation; Dirac equation.

Homework and Exams:

There will be a total of 5 homework assignments for this course, distributed approximately every 2 weeks. Homework will be due approximately 1.5 weeks after it is assigned, typically due on Fridays at 5pm. Working in groups (using remote meetings on e.g. Zoom or Skype) is highly encouraged! However please write up your solutions individually. Homework is to be turned in electronically (PDF) on **Canvas**, or else as a backup method by email to the course TA at: thomasmeyers2021@u.northwestern.edu. Please include your last name in the file name. Please use Canvas if possible to help with administrative activities for the course.

There will be a take-home **final exam,** date TBD.

Grading Scheme:

Homework: 60%

Final Exam: 40% *Date/Time TBD*

General Outline of Course Topics:

1: Approximation Methods (Variational method, WKB approximation) (~1 week)

2: Scattering Theory (~3 weeks)

3: Identical Particles, exchange degeneracy, Helium Atom and other examples (~2 weeks)

4: Gauge invariance, Path Integral formulation of Quantum Mechanics, Aharonov-Bohm effect (~ 2 weeks)

5: Quantum Entanglement and Quantum Information Science (~ 1 week)

Student Learning Outcomes

Upon completion of this course, students will be able to:

1. Apply the WKB method and the variational method to problems in quantum theory.
2. Compute scattering amplitudes and cross sections for elastic scattering processes using the methods of partial wave expansion and the first-Born approximation.
3. Understand exchange degeneracy, Fermi-dirac statistics, Bose-Einstein statistics, and explain how symmetry or anti-symmetry under particle exchange can affect the energy spectrum of a quantum mechanical system.
4. Describe the Feynman Path integral formulation of Quantum Mechanics

Statement on Disability Accommodation:

Northwestern is committed to providing an accessible, supportive, and challenging environment for all students who attend the University. Any student requesting accommodations related to a disability or other condition is required to register with AccessibleNU (accessiblenu@northwestern.edu; 847-467-5530) and provide professors with an accommodation notification from AccessibleNU, preferably within the first two weeks of class. All information will remain confidential.

Statement on Academic Integrity:

Suspected violations of academic integrity will be reported to the Dean's Office. For more information on Northwestern’s academic integrity policies, see http://www.weinberg.northwestern.edu/undergraduate/courses-registration-grades/integrity/