PHYS 611: Advanced Quantum Mechanics and Quantum Field Theory
Fall Semester, 2020
Professor: Anthony Mezzacappa, 206 South College, 4-2621, mezz@utk.edu
Grader: Shashi Pandey, spandey3@vols.utk.edu

Class Times: TTh, 11:30 AM – 12:45 PM
Class Location: Buehler 415, and through synchronous Zoom

Course Syllabus

1. Motivation and Need for Quantum Field Theory
2. Review of Canonical Formalism and Quantization for Particles
3. Review of the Harmonic Oscillator in Quantum Field Theoretic Language
4. Connecting Particle and Field Mechanics: The Classical Linear Chain
5. The Quantum Linear Chain
6. Brief Review of Tensors and Functional Calculus
7. Classical Field Theory, Real Scalar Field
8. Noether's Theorem, Symmetries, and Conservation
9. Quantization of a Free Real Scalar Field
10. Classical and Quantum Free Complex Scalar Fields, Antiparticles
11. Causality, the Feynman Propagator for Scalar Fields, Propagators as Green's Functions
12. Non-Relativistic Many-Body Quantum Mechanics: Second Quantization, with Applications to Condensed Matter and Nuclear Physics
13. Building Field Theories for Particles of a Definite Spin: The Lagrangian for Massive, Spin 1 Particles, the Classical Equations of Motion, and their Solutions
14. Building Field Theories for Particles of a Definite Spin: The Lagrangian for Massless, Spin 1 Particles, the Classical Equations of Motion, and their Solutions
15. Quantization of the Spin 1 Field
16. Quantum Fields: Unitary Representations of the Poincare' Group, the Little Group, the Method of Induced Representations
17. Spinor Representations of the Lorentz Group
18. Building Field Theories for Particles of a Definite Spin: The Lagrangian for Spin 1/2 Particles, the Dirac Equation, and its Solutions
19. Quantization of the Dirac Field
20. Coupling to the Photon, Gauge Invariance, Antiparticles
21. The Non-Relativistic Limit of the Dirac Equation
22. Charge Conjugation, Parity, Time Reversal, and the CPT Theorem
23. Interacting Fields: Dyson's Formula, the S-Matrix
24. The LSZ Reduction Formula
25. Constructing Initial and Final States
26. An Example Interacting Quantum Field Theory: Scalar Yukawa Theory. Particle Decays and Scattering, Wick's Theorem, Feynman Diagrams, Mandelstam Variables, Cross Sections and Decay Rates
27. The Photon Propagator
28. Scalar Quantum Electrodynamics
29. Spin and Statistics: Lorentz Invariance, Causality, Stability, and the Propagator for Spin 1/2 Particles
30. Quantum Electrodynamics
31. Renormalization of Quantum Electrodynamics
32. Weak Interactions at Low Energy

Course Texts

My lectures will draw primarily from the following texts (in order of importance):

1. Schwartz, Quantum Field Theory and the Standard Model
2. Strickland, Relativistic Quantum Field Theory, Volume I: Canonical Formalism
3. Maggiore, A Modern Introduction to Quantum Field Theory
4. Fetter and Walecka, Quantum Theory of Many Particle Systems
5. Lancaster and Blundell, Quantum Field Theory for the Gifted Amateur

Other texts I consulted and from which I drew some supporting material (but please don't rush out to buy them):

6. Baym, Lectures on Quantum Mechanics
7. Bethe, Intermediate Quantum Mechanics
8. Bjorken and Drell, Relativistic Quantum Mechanics
9. Bjorken and Drell, Relativistic Quantum Fields
10. Georgi, Lie Algebras in Particle Physics
11. Itzykson and Zuber, Quantum Field Theory
12. Mandl and Shaw, Quantum Field Theory
13. Martin and Rothen, Many Body Problems and Quantum Field Theory, An Introduction
14. Peskin and Schroeder, An Introduction to Quantum Field Theory
15. Ryder, Quantum Field Theory
16. Schweber, Relativistic Quantum Field Theory
17. Tung, Group Theory in Physics
18. Weinberg, Quantum Field Theory I
19. Zee, Quantum Field Theory in a Nutshell

Grades

Grades will be based on: (1) graded homework assignments, (2) a midterm exam, and (3) a final exam. All three will be equally weighted. The midterm and final exams will be closed-book, take-home exams. Shashi Pandey will grade the homework assignments. I will grade the midterm and final exams.

Office Hours

TTh, 4:00 PM – 5:00 PM, via Zoom

SOCIAL DISTANCING & COVID-19 PROCEDURES

Students are required to wear face masks at all times and maintain social distancing (6 feet between individuals in traditional classrooms, or, in instructional laboratories and similar settings, only a few minutes in closer proximity when absolutely necessary to achieve learning objectives). Students who are feeling ill or experiencing symptoms such as sneezing, coughing, or a higher than normal temperature will be excused from class and should stay at home.

Instructors have the right to ask those who are not complying with these requirements to leave class in the interest of everyone's health and safety. In the event that a student refuses to comply with these requirements, the instructor has the right to cancel class.

Additionally, following other simple practices will promote good health in and out of the classroom, such as frequent and thorough hand washing, wiping down desks and seats with disinfectant wipes whenever possible, not sharing personal items such as pens and cell phones, and avoiding crowded hallways and other enclosed spaces.

The Volunteer Creed reminds us that we bear the torch in order to give light to others. As Volunteers, we commit to caring for one another and for the members of the communities in which we live, work, and learn. This semester, the University asks that we all demonstrate the Volunteer spirit by following these and other health guidelines and requirements.