# Physics 731 Course Outline

**Instructor:** Prof. Tao Zhou, taozhou@njit.edu, Tel: 973-642-4931, Room: T478

**Reference books:**
*Quantum Mechanics with basic field theory*, B.R. Desai, Cambridge University Press, 2010.
*Quantum Field Theory for the gifted amateur,* T. Lancaster and S. J. Blundell, Oxford University Press, 2014
*Introduction to elementary particles*, D. Griffiths, Wiley, 2014

**Pre-requisite**: Physics 631, Quantum Mechanics I.

**Office Hour**: Monday 2:30 to 4 pm, and Wednesday 11:30 am to 1 pm.

**Grade Decomposition**

Class participation and quiz 30%
Home work: 40%
Final term project: 30%

**Learning Objective:** Students are expected to learn the particle version of relativistic quantum mechanics, have a detailed understanding of Klein-Gordon equation, Dirac equation, their consequences and shortcomings. Students are then expected to get familiar with the second quantization method, its application on quantizing different Fermion and Boson fields, and the general notion of quantum electrodynamics (QED). Finally students are expected to have some basic knowledge of spontaneous symmetry breaking and the standard model.

**Learning Outcome Evaluation Metrics:** Through in-class quiz and discussion, instructor can evaluate students' understanding of basic physical concepts. Through homework, instructor can evaluate students' problem solving capability. The final project will test students' capability of literature search and basic research skill.

At the end of the semester, students are expected to be able to:

- Solve the Dirac equation for free electron.
- Solve the Dirac equation for electron under a central force, i.e. the single particle relativistic hydrogen atomic model.
- Solve the Dirac equation for electrons under external electromagnetic field.
- Understand second quantization and the canonical quantization methods.
- Understand the classical Lagrangian expression of fields
- Using the Green's function method to solve scattering processes.
- Understanding the equivalence between Green's function method and Feynman diagram method.
- Extend these methods to solve relativistic scattering processes, including the radiative correction, electron self energy, anomalous magnetic moment, and Lamb's shift.

**Topics:**

| **Date and Lecture Topic** | **Text Assignment** |
|---|---|
| **Week 1: Special Relativity and quantum mechanics : An Introduction** | **Chap. 31 (B.R.D)** |
| **Week 2: Klein-Gordon Equation** | **Chap. 32 (B.R.D)** |
| **Week 3: The Dirac Equation I** | **Chap. 33 (B.R.D)** |
| **Week 4: The Dirac equation II** | **Chap 34 -36 (B.R.D)** |
| **Week 5: Harmonic oscillators and second quantization** | **Part I (T.L. & S.J.B)** |
| **Week 6: The need for quantum field** | **Part III (T.L. & S.J.B)** |
| **Week 7: Progator and perturbation** | **Part IV (T.L. & S.J.B)** |
| **Week 8: Feynman diagrams** | **Part IV (T.L. & S.J.B)** |
| **Week 9: Scattering theory** | **Part IV (T.L. & S.J.B)** |
| **Week 10: Quantum Electrodynamics** | **Part IX (T.L. & S.J.B)** |
| **Week 11: Renormalization of QED** | **Part IX (T.L. & S.J.B)** |
| **Week 12: Spontaneous Symmetry Breaking** | **Part X (T.L. & S.J.B)** |
| **Week 13: Weinberg-Salam Model** | **Part XI (T.L. & S.J.B)** |
| **Final Project** | |