Professor: Dr. Wei Li

Office: Herman Brown Hall 229A
Contact Info: x3948, wl33@rice.edu
Course Meets: Tu-Th 13:00-14h15, Herman Brown Hall 223

Required Text: *Quarks & Leptons: An Introductory Course in Modern Particle Physics* by Halzen and Martin

If you have a documented disability that will impact your work in this class, please contact me to discuss your needs. Additionally, you will need to register with the Disability Support Services Office in the Allen Center.

Structure & Grading

The course will consist of two 75-minute meetings per week.

Discussion in class is strongly encouraged, and for each meeting a student is asked to explain the assigned material. In other words, for each meeting you are expected to have prepared your notes such that you can stand in front of the class and explain the assigned chapter or sections thereof to your fellow students.

In addition, weekly homework assignments are handed out. Discussing the problem sets with each other is again encouraged. However, you may not copy solutions from another student: the problem set that you submit must be entirely your own work. Homework needs to be returned the week following the assignment.

By the end of the semester, you will be required to write a research paper on a topic of your choice. The purpose is to establish in-depth understanding of a subject in the forefront of particle and nuclear physics. Possible topics will be discussed in the second half of the semester. The paper should include (but not limited to) theoretical background and motivation, experimental techniques and latest results, future outlook and perspectives. Each student will give a presentation on your research paper during the last week of the semester.

There will be no exams in this course. The overall grading is based on

- homework (40%)
- recitation of the text material (40%)
- research paper and presentation (20%)

Course Outline

This is a brief outline of the topics that will be covered in this course but subjects to be updated as the semester progresses.

Symmetries: SU(2) isospin, SU(3) color, SU(3) isospin x strangeness

Quarks: Mesons, baryons, magnetic moments, heavy quarks

Antiparticles: Klein-Gordon equation, perturbation theory, Feynman approach

Electrodynamics of spinless particles: Cross sections, decay rates, invariants

Dirac equation: Review of Dirac algebra in covariant form

Electrodynamics of spin-1/2 particles: electron-electron, electron-positron, helicity conservation, propegators, parton model kinematics, Feynman rules for QED

Renormalization: brief discussion

Hadron structure: Partons, Bjorken scaling in deep inelastic scattering, structure functions of quarks and gluons

Electron-positron annihilation and quantum chromodynamics: Fragmentation, three jet events, perturbative QCD

Weak Interactions: Parity violation, beta decay, muon and pion decays, neutrino scattering, neutral currents, weak mixing angles, CKM matrix

Electroweak Interaction: Electron-positron annihilation at the Z Mass, electroweak interference

Gauge Invariance: Abelian and non-Abelian, massive bosons, broken gauge symmetry, spontaneously broken symmetry, Higgs mechanism

Standard Model: The Lagrangian: Higgs Field, renormalizability, unification with QCD? higher symmetries?

Other References

Text books

- *Introduction to Elementary Particles* (2nd revised edition), D. Griffiths, recommended; nice alternative to H&M
- *QCD and Collider Physics*, R. K. Ellis, W. J. Stirling and B. R. Webber, dedicated to QCD
- *Collider Physics,* V. D. Barger, R. J. N. Phillips
- *Particle Physics (*3rd edition), B. R. Martin and G. Shaw, mostly undergraduate level
- *Introduction to High Energy Physics* (4th edition), D. Perkins, mostly undergraduate level
- *Fundamental Forces of Nature - The Story of Gauge Fields*, K. Huang, interesting read on gauge theory without invoking too many equations

Reference books

- The Experimental Foundations of Particle Physics (2nd edition), R. Cahn and G. Goldhaber