PHY 557 Elementary Particle Physics Spring 2025

Instructor:

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  Office hrs: Tuesday 11:30-12:30 in the office or by appointment

Place and Time:

- Monday and Wednesday 11:00-12:20 in YITP common room (Math 6-125).
- First Lecture: Monday Jan 27th, 2025
- This homepage: http://insti.physics.sunysb.edu/~concha/PHY557/S25/phy557_S25.html

Objectives:

Phy557 is an introduction to Modern Elementary Particle Physics. The course is an overview of the field. The course will start with the basic particle physics taxonomy. The role of conservation rules and symmetries will be discussed. The three well established gauge theories: QED, QCD and electroweak interactions will be introduced and the basic techniques to evaluate cross sections and decay rates for some processes at first order will be given (although the course does not require field theory).

Texts:

These are the text books mostly being used to prepare the lectures.

- F. Halzen and A. Martin, Quark and Leptons. Wiley 1984
- D. Griffiths, Introduction to Elementary Particles, Wiley 1987

The particle data listings will be useful. It can be accessed online by the students at Particle Data Group

Program (Temptative):

Chapter 1 ``Basics'': Overview; Basic concepts of quantum physics for particles; the particle contens of the Standard Model, Natural Units;

Chapter 2 ``Relativistic Kinematics'': Lorentz transformation; Implications; Four-vector notation; Energy-momentum four-vector; Examples. (Chapter 2 Griffiths)

Chapter 3 ``Symmetries in Particle Physics'': Symmetry groups and conservations laws; Space-time

symmetries: Translations and energy-momentum conservation, and rotations and angular momentum conservation; Spin angular momentum and representations of SU(2); Finite symmetries: C,P,T and CPT;

Chapter 4 ``Relativistic Wave Equations'': Schrodinger equation and its probabilistic interpretation; Klein-Gordon equation and its problems; Dirac Equation: Derivation, Solutions; Electromagnetic wave equations: photons; Procca Equation for massive spin 1 particle; (Halzen and Martin (3-3 to 3-5, 5, and 6.9), Griffiths(7.1 to 7.4)

Chapter 5 ``QED I: Feynman amplitudes and Feynman diagrams'': Non-relativistic perturbation theory; Interaction of electron with electromagnetic field; e- mu- --> e- mu- scattering amplitude; Feymman rules for QED; Lagrangian formalism; QED as an abelian gauge theory; (Halzen and Martin (3.6, 6.1, 6.4, 6.17, 4.8, 6.10, brief summary of chapter 7, check also chapter 4)

Chapter 6 ``QED II: QED processes in lowest order'': Definition of scattering cross section; cross section in terms of Feynman amplitude; cross section for e- mu- --> e- mu- : techniques, trace theorems, Mandelstam variables, data; helicity conservation at high energies; cross section for e-e- --> e- e- (Moller scattering) and crossed processes; e- gamma --> e- gamma (Compton scattering); e+ e- --> gamma gamma (pair annihilation, homework); e- mu- --> e- mu- in Lab frame. (Halzen and Martin 4.3, Chapter 6,Griffiths 6.1, 6.2, 7.6,7.7) (Lectures 10/14/03, 10/17/03, 10/21/03)

Chapter 7 ``QED and the structure of hadrons'': Concept of form factors; e-p -->e-p elastic scattering: proton form factors; e-p -->e-p elastic inelastic scattering; Bjorken scaling and quarks; quark distribution functions; the gluons. (Halzen and Martin 8.1-8.4, Chapter 9; Griffiths 8.3-8.6)

Chapter 8 ``Strong Interactions: Quantum Chromodynamics'': Representations of SU(N); Evidence of 3 colours: e+e---> hadrons; Lagrangian and Feynman rules for QCD; q qbar interactions: colour singlet and colour octet configurations; Tests of perturbative QCD: Drell-Yan, e+e--> 2 jets and the spin of the quark; e+e- --> 3 jets and the spin of the gluon ; Internal symmetries and classification of bound states of strong interactions (hadrons): SU(2) isospin flavour and SU(3) flavour.

Chapter 9 ``Weak Interactions'': Weak decays and parity violation: V-A weak charged currents; W boson as mediator of weak charged currents; Low energy tests: Weak neutral currents: Z0 and the GIM mechanism; CP violation.

Chapter 10 ``Electroweak Unification'': Weinberg-Salam Model of Electroweak Interactions; Spontaneous symmetry breaking; The Higgs Boson;

Problem Sets and Grading:

Problem sets will be assigned in class and are due on the date shown. You are expected to solve them on your own and the final calculations handed in must be your own work **and must be written CLEARLY by hand** . Late homework will not be accepted. The final grade will be based on the homeworks (40%) a midterm exam (30%) and a final work/presentation (30%).

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