

Tentative Outline

Here is a tentative outline of some subjects that may be covered throughout the course. The course consists of three primary topics: **Symmetry**, **Gauge Theory**, and **Phenomenology** of the Standard Model.

Introduction - Description of the course structure and goals, workload, and related information.

Overview of the Standard Model - Summary of the Standard Model – Electromagnetic, Weak, and Strong interactions. Basic properties of the fundamental particles – Leptons, Quarks, and Hadrons.

Aspects of QFT - Review of scalar and spinor fields and their quantization. Cross sections and decay rates, the LSZ theorem and the S matrix. Perturbation theory and Feynman rules.

Symmetry I - Introduction to symmetries. Continuous symmetries, Lie groups, and Lie algebras. Basic properties of $U(1)$ and $SU(2)$. Discrete symmetries and interactions – C, P, and T.

Gauge Theory I - Gauge invariance and electromagnetic fields. Quantization of Abelian gauge theory. Quantum Electrodynamics.

Phenomenology I - Elementary processes in QED – Pair production in electron-positron annihilation. Precision tests of QED – The anomalous magnetic moment of leptons.

Symmetry II - Basic properties of $SU(3)$. Representations of $SU(3)$. Flavor $SU(3)$ and the quark model of hadrons – The color hypothesis.

Gauge Theory II - Non-Abelian gauge theories and their quantization. Quantum Chromodynamics. Chiral symmetry breaking, asymptotic freedom, and confinement.

Phenomenology II - Deep inelastic scattering and the structure of the proton – The Parton model. Effective theory of low-energy strong interactions. Electron-positron annihilation and the R ratio.

Symmetry III - Spontaneous symmetry breaking and Goldstone's theorem. Symmetry breaking in gauge theories and the Higgs mechanism.

Gauge Theory III - Electroweak model of leptons. Low-energy effective theory – The four-Fermi interaction. Quarks and the minimal Standard Model. Quark mixing and the CKM matrix.

Phenomenology III - Leptonic and semi-leptonic decays. Neutral meson oscillations and CP violation. Asymmetry observables and Higgs production.

Symmetry IV - Anomalous global symmetries. The $U(1)$ axial anomaly. Anomaly cancellation in the Standard Model. Neutral pion decay. The theta term in QCD.

Beyond the Standard Model - Neutrino masses and oscillations. Dirac and Majorana mass terms for neutrinos. Lepton mixing and the PMNS matrix. Attempts at grand unification.

Tentative Schedule

Week	Date	Topic
1	01/24	Introduction, Overview of the Standard Model
2	01/29, 01/31	Aspects of QFT
3	02/05, 02/07	Symmetry I
4	02/12, 02/14	Gauge Theory I
5	02/19, 02/21	Phenomenology I
6	02/26, 02/28	Symmetry II
7	03/04, 03/06	Gauge Theory II
8	03/11, 03/13	Spring Break (no class)
9	03/18, 03/20	Phenomenology II
10	03/25, 03/27	Symmetry III
11	04/01, 04/03	Gauge Theory III, APS April meeting (no class)
12	04/08, 04/10	Gauge Theory III
13	04/15, 04/17	Phenomenology III
14	04/22, 04/24	Symmetry IV
15	04/29, 05/01	Beyond the Standard Model
16	05/09	Final Exam due at 12:00pm