

P 529, Syllabus

The tentative syllabus is given. It may be necessary to eliminate some topics.

- Introduction to high energy physics
- Perturbative field theory
 - Lagrangians, propagators, and Feynman rules for real and complex scalars, fermions, and massless and massive vector fields
 - Kinematics
 - Cross section and decay width formulae
 - Tree level examples, scalar and fermion electrodynamics, eP with form factors
 - Loop effects
 - Quantum electrodynamics (QED)
- Lie groups, Lie algebras, and symmetries
 - Basic concepts
 - Global symmetries in field theory
 - $SU(2)$ and $SU(3)$ and their applications
 - Chiral symmetries
 - Explicit and spontaneous breaking; the Goldstone theorem
- Gauge theories
 - Abelian gauge symmetries
 - Structure of non-abelian gauge symmetries

- Feynman rules without spontaneous breaking
- The Higgs mechanism
- The strong interactions and quantum chromodynamics (QCD)
 - The Lagrangian
 - Evidence for QCD
 - Simple QCD processes
 - Running gauge coupling constants
 - Short distance processes
 - . $e^+e^- \rightarrow$ hadrons
 - . Deep inelastic scattering and the parton model
 - Long distance physics
 - . The symmetries of QCD
 - . Chiral $SU(3)_L \times SU(3)_R$ and its breaking
- Collider physics
 - Colliders and detectors
 - Collider kinematics
 - High p_T hadron scattering
- The standard electroweak theory
 - The Fermi theory
 - Discrete symmetries P, C, CP, T
 - Weak processes: μ decay, $\pi_{\ell 2,3}$ decays, strangeness, Cabibbo theory, β decay, the CKM matrix
 - The $SU(2) \times U(1)$ model
 - . Basic structure
 - . The Higgs mechanism
 - . The Lagrangian after spontaneous symmetry breaking
 - Consequences and tests
 - . Gauge interactions of fermions, weak neutral current

- . Gauge bosons and their self-interactions
 - . The Higgs sector
 - . The CKM matrix
 - . K and B physics, penguins, heavy quark expansion, CP violation
- Neutrino mass and implications
 - . Neutrino mass mechanisms
 - . Neutrino oscillations
 - . Neutrinoless double beta decay
 - . The neutrino spectrum
- Beyond the standard model
 - Motivations and general types
 - Supersymmetry
 - Grand unification
 - Strings (qualitative)