Standard Model of Elementary Particles (PHZ6358): SYLLABUS

0. Introduction: Quarks, Leptons, Vector Bosons and Their Interactions (QFT Notes, chapter 16)

1. Feynman Diagrams and Rules.(QFT notes, Chapter 17; S, Sections 58, 61),
   - Propagators for spins 0, 1/2, 1
   - Vertices and rules for spinor and scalar QED
   - Ultraviolet divergences of Feynman diagrams: Degree of divergence.

2. Scattering Amplitudes in Quantum Field Theory (QFT Notes 18; S, 59)
   - Reduction Formalism
   - Examples

3. Quantum Electrodynamics: 1 Loop Corrections (QFT Notes Chapter 19,20)
   - Higher order Processes (S 62-65)
     - Ultraviolet divergences
     - Ward identities (S 67–68)
   - Mass and Charge Renormalization
   - Anomalous Magnetic Moment; Lamb shift
   - Positronium and Quarkonium
   - Infrared Divergences; Soft Photon Bremsstrahlung; Gauge Invariance (QFT Notes, 14.)

4. Non abelian Gauge Field Theories (S, 69-72)
   - Review path Integral for Gauge Theories
   - Some gauge groups
   - Gauge-fixing—Fadeev-Popov prescription
   - BRST symmetry
   - Renormalization
   - Quantum Field Theory of the Standard Model: Chiral Asymmetry

5. Systematics of Renormalization
• Renormalized Perturbation Theory
• Two loop examples
• Renormalization Group and Callan-Symanzik Equation

6. Renormalization and the Short Distance Properties of QCD
• Asymptotic Freedom
• Renormalization Group
• Background Field Methods
• Operator Product Expansion

7. Spontaneous Breaking of Global Symmetry: Chiral Dynamics
• Effective Action and Potential
• Goldstone Bosons and Soft Pion Theorems
• Adler-Weisberger and Other Sum Rules
• Effective Chiral Lagrangians

8. Gauge Invariance and Anomalies (QFT Notes 21)
• Gauge Invariance and Ultraviolet Divergences
• Axial current anomalies
• \( \pi_0 \rightarrow 2\gamma \) decay
• Consequences of Anomalies for the Standard Model

9. Spontaneous Breaking of Gauge Symmetry; The Higgs Mechanism
• Scalar Fields: Global Symmetries, Goldstone Bosons
• Gauge Symmetries, the Abelian Case
• Gauge Symmetries, the Non-abelian case
• Perturbation theory with spontaneous symmetry breaking

10. Leptons and their Electro-weak Interactions
• Electron, QED processes
• Muon
• Tau
• Neutrinos