1. **September 29th 2026**

   Introduction to the course.

2. **Octoberber 6th 2026**

   Reminders of Group Theory.

   Representations. Definition of Representation of a group. Reducible and completely reducible representations. Lie Groups and Lie Algebras. Jacobi identity. Classification of Lie Algebras. Simple and semisimple groups and algebras. Compact algebras. SU(N), SO(N), Sp(N): definition and generators. Finite dimensional unitary representations of Lie Groups. Fundamental, Conjugate and Adjoint representations. Casimir Operator.

   Euler-Lagrange euqtions. Noether's theorem. Gauge theories. Abelian case: QED. [1]

3. **October 8th 2026**

   Yang - Mills theories [1]. Geometry of gauge invariance [3]. Definition and properties of the S matrix. [4]

4. **October 13th 2026**

   Cross section for scattering processes: definition and derivation of the formula. Decay width of a particle.[1] Optical theorem [4]. LSZ reduction formula [1, 2].

5. **October 15th 2026**

   Introduction to the Feynman path integral [2, 1]. Green's functions and generating functional.[1]

6. **October 20th 2026**

   Prescriptions for derivation of the Feynman rules.[1] Propagator of the free scalar field.

7. **October 22th 2026**

   Self intereacting scalar field: Feynman rules. [1] Grassman numbers. [1, 3] Quantization of gauge theories. Gauge fixing . Generating functional of QED. [1]

8. **October 27th 2026**

   Feynman rules for QED: photon and fermion propagators, interaction vertex . Fadeev-Popov Determinant.[1]

9. **October 29th 2026**

   Exponentiation of the Fadeev Popov determinant [1, 2]. Lagrangian density of QCD and its generating functional. [1] Dimensional regularization [1]. Feynman parametrization. Calculation of integrals with one propagator in D dimensions.[1] **November 10th 2026**

   Quark self-energy: calculation at one loop. [1, 2] Power counting. Superficial degree of divergence and index of divergence. Theorem of convergence. Renormalizable interactions.[1]

10. **November 12th 2026**

    Primitively divergent diagrams in QED [3]. Renormalizability of QCD. Primitively divergent diagrams in QCD [1, 3]. Systematics of renormalization: counterterms. QCD: renormalized lagrangian, counterterms. Slavnov-Taylor identities.[1]

11. **November 17th 2026**

    Pole mass. Subtraction schemes. Calculation of the quark field and quark mass renormalization constants in the MSbar scheme [1, 2]. Calculation of the quark field and quark mass renormalization constants in the on-shell subtraction scheme [1, 2].

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[2] M.D. Schwartz,
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Cambridge University Press.

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[4] O. Nachtmann,
Elementry particle Physics: Concepts and phenomena
Springer-Verlag.

[5] B. Kayser, https://arxiv.org/abs/hep-ph/9702264