

**1. September 24th 2024- Introduction**

Reminders of Group Theory.

Definition of a Group. Finite and Infinite Groups. Order of a Group. Abelian Groups. Subgroups. Left and Right Cosets. Invariant Subgroups.

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.

**2. October 3rd 2024**

The Action. Hamilton principle. Euler-Lagrangian equations. Noether's Theorem. Noether's currents and conserved charges.[1] Gauge theories. Abelian case: QED. [2]

**3. October 8th 2024**

Yang - Mills theories [2].

**4. October 10th 2024**

Geometry of gauge invariance [1]. Definition and properties of the S matrix. [3] Cross section for scattering processes: definition and derivation of the formula. Decay width of a particle.[2] Optical theorem [3].

**5. October 15th 2024**

LSZ reduction formula.[2, 4].

**6. October 17th 2024**

Introduction to the Feynman path integral [2, 4]. Green's functions and generating functional [2].

**7. October 22th 2024 [2]**

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

**8. October 24th 2024 [2, 1]**

Self interacting scalar field: Feynman rules. Grassman numbers.

**9. October 29th 2024 [2]**

Quantization of gauge theories. Gauge fixing . Generating functional of QED.

**10. October 31th 2024**

Feynman rules for QED.[2]

## References

- [1] M. E. Peskin and D. V. Schroeder,  
*An Introduction to quantum field theory*, Addison-Wesley publishing Company.
- [2] T. Muta,  
*Foundations of Quantum Chromodynamics*, World Scientific.
- [3] O. Nachtmann,  
*Elementary particle Physics: Concepts and phenomena*  
Springer-Verlag.
- [4] M.D. Schwartz,  
*Quantum Field Theory and the Standard Model*  
Cambridge University Press.
- [5] B. Kayser, <https://arxiv.org/abs/hep-ph/9702264>