# Indian Institute of Technology, Kanpur

## Particle Physics: PHY-680 (2025 Spring semester)

1. Lectures per week: 2 (Location - to be announced. Timing Monday, Wednesday 3:30PM to 5:00PM)
   Duration of Course: Full Semester
2. **Instructor: Sanmay Ganguly (PHY) (sanmay@iitk.ac.in ; Office : 111, Old SAC building, block - A)**
3. Course Description:

| S. No. | Broad Title | Topics | No. of Lectures |
|---|---|---|---|
| | **Introduction to particle physics** | A broad overview of current understanding about elementary particles. Relativistic kinematics and scattering 2-body/3-body phase space evaluation. | **3** |
| | **Aspects of Quantum Electrodynamics** | 2 -> 2 tree level process (Compton Scattering) : crossing symmetry, Mandelstam variables, photon polarization sums and high energy behavior.<br>Introduction to radiative corrections in Q.E.D, precision tests of Q.E.D (computation of 1-loop vertex function, g-2). Infrared divergences in Q.E.D. | **5** |
| | **Global symmetries and gauge redundancies.** | Invariance and Noether theorem. Difference between Global symmetries and gauge redundancies. Global accidental symmetries of standard model. General features of Non-Abelian gauge theory. | **5** |
| | **Symmetry breaking** | Spontaneous vs explicit symmetry breaking, spontaneously broken chiral symmetry, Nambu-Goldstone theorem. Higgs Mechanism. | **4** |
| | **The electroweak theory** | Weak interaction processes, precision test of standard model. Quantization of spontaneously broken gauge theory, Goldstone boson equivalence theorem and it's application. Electroweak precision fits.<br>CKM matrix, CP violation and unitarity, FCNC | **8** |
| | **Physics of Higgs boson and future prospects.** | Interaction of Higgs boson, properties and searches. Implication of Higgs discovery. Precision Higgs measurement at LHC and future colliders. Higgs as a probe to beyond standard model physics. | **5** |
| | | **Total number of lectures:** | **30** |

Pre-requisites: Quantum Field Theory - 1 equivalent material (PHY-685).

**Evaluation: 3 Assignments ( 50 Marks) + 1end-sem exam (50 Marks) = 100 Marks**

7. Recommended resources:

   1. The Standard Model and Beyond. Paul Langacker, 2nd Edition CRC Press, 2017.
   2. Dynamics of Standard Model. J. F. Donoghue, E. Golowich, B. Holstein, Cambridge University Press, 2014.

3. The Standard Model : From Fundamental Symmetries to Experimental Tests. Y. Grossman, Y. Nir. Princeton University Press, 2023.
4. An Introduction to Quantum Field Theory. M. Peskin, D. Schroeder. CRC Press, 2019
5. Quantum Field Theory and the Standard Model. Matthew Schwartz. Cambridge University Press, 2013.
6. Lectures on the Theory of the Weak Interaction. Michael Peskin. arXiv : 1708.09043.
7. The Anatomy of Electro-Weak Symmetry Breaking. 1 : The Higgs boson in the Standard Model. arXiv:hep-ph/0503172.
8. Lectures on the Standard Model : https://www.damtp.cam.ac.uk/user/tong/standardmodel.html
9. Cambridge Lectures on The Standard Model : https://arxiv.org/abs/2409.09211 .
10. Strong Dynamics and Electroweak Symmetry Breaking. C. Hill, E. Simmons. https://arxiv.org/abs/hep-ph/0203079.