



Indian Association for the Cultivation of Science

School of Physical Sciences

PHS 5102/PHD 110

INTEGRATED MSc-PHD COURSE

Quantum Field Theory

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Room Number: *C-404*

Teaching Assistant:

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1 Main points to remember

- **Course Webpage:** I have created a google classroom, where all the details regarding this course will be posted. You are encouraged to check the classroom webpage in regular intervals. You can access it by clicking [here](#). You are also encouraged to check the “announcements” section located [here](#) on my webpage, where also details regarding the course will be provided.
- **Assignments and Evaluation:** I will hand over one assignment for every **five** classes and its evaluation will reflect in your internal assessment. Further evaluation will be based on a mid-semester exam of **twenty five** marks and then a final examination with **fifty** marks. Please contact the academic office for further clarifications regarding the course.
- **Communications:** The main mode of communication outside the class will be through emails. Thus I would request all of you to check emails at least once everyday. The assignments as well as other instructions will be handed over through emails and the google classroom alone.

2 Syllabus

- Basics of field theory and canonical quantization, quantization of scalar field, quantization of Dirac field, Grassmann calculus, Quantization of Abelian gauge fields, Faddeev-Popov method, QED Feynman rules, LSZ theorem, 2-2 scattering amplitudes.
- Functional derivatives and integrals, Functional integrals for interacting scalar field theory, One loop renormalization of interacting scalar field theory, Dimensional regularization.

3 Books and Articles

- *Quantum Field Theory* — M.E. Peskin and D.V. Schroeder — Levant.
- *Quantum Field Theory: Volume I* — S. Weinberg — Cambridge University Press.
- *Quantum Electrodynamics* — L.D. Landau and E.M. Lifschitz — Pergamon Press.
- *Quantum Field Theory* — T. Padmanabhan — Springer.
- *A first book of Quantum Field Theory* — A. Lahiri and P.B. Pal — Narosa.
- *Particle, Sources and Fields: Volume I* — J. Schwinger — Perseus Books.
- *Quantum Electrodynamics* — R.P. Feynman — CRC Press.
- *Quantum Field Theory* — L. Ryder — Cambridge University Press.
- *Quantum Field Theory* — C. Itzykson and J.B. Zuber — McGraw Hill.
- *Quantum Field Theory* — M.A. Srednicki — Cambridge University Press.
- *Quantum Field Theory in a Nutshell* — A. Zee — Princeton University Press.

4 Time Scale

The course have started from **22nd August** and will continue till **9th December**. The mid semester examination will take place within **17th - 25th October** and the final examination will happen in between **19th-27th December**. Possibly we will have around **25** classes. Below a tentative course structure has been presented, I will try to stick to this schedule.

- **Class-01** — Why fields? — an intuitive picture; Propagation amplitude for a non-relativistic particle.
- **Class-02** — Jacobi action; Propagation amplitude for a relativistic particle.
- **Class-03** — Connecting particles and fields; Notion of anti-particle and implications from causality.
- **Class-04** — Symmetry transformation in the quantum domain; The Poincare group.
- **Assignment-01** — First assignment will be handed over.
- **Class-05** — Representation and algebra of the Poincare group; Introduction to the Little group.
- **Class-06** — Quantization of a complex scalar field.
- **Class-07** — The Dirac representation; The γ matrices and their algebra.
- **Assignment Submission-01** — First assignment must be submitted.
- **Class-08** — Quantization of the Dirac field; Hint of Pauli's exclusion principle.
- **Class-09** — Emergence of electromagnetic field as spin-1 representation of the Lorentz group.
- **Assignment-02** — Second assignment will be handed over.
- **Class-10** — Quantization of the Electromagnetic field; Issues with gauge degrees of freedom.
- **Class-11** — Necessity for a S-matrix; Its Lorentz invariance and unitarity.
- **Class-12** — Introduction to Perturbation Theory.
- **Assignment Submission-02** — Second assignment must be submitted.
- **Class-13** —
- **Class-14** —
- **Assignment-03** — Third assignment will be handed over.
- **Class-15** —
- **Class-16** —
- **Class-17** —
- **Assignment Submission-03** — Third assignment must be submitted.
- **Class-18** —
- **Mid-Semester Examination.**
- **Class-19** —

- Class-20 —
 - **Assignment-04** — Fourth assignment will be handed over.
 - Class-21 —
 - Class-22 —
 - Class-23 —
 - Class-24 —
 - **Assignment Submission-04** — Fourth assignment must be submitted.
 - **Assignment-05** — Fifth assignment will be handed over.
 - Class-25 —
 - Class-26 —
 - **Assignment Submission-05** — Fifth assignment must be submitted.
 - **Final Examination will take place.**
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