QUANTUM FIELD THEORY I

U. of Chicago, Physics 443 Fall Quarter 2005
J. Rosner, Instructor Tues. and Thurs., 10:30 - 11:50 a.m., KPTC 105

Prerequisite: Graduate quantum mechanics or permission of Instructor

This course is for prospective students of elementary particle and many-body theory and for others interested in the subject who wish to obtain experience with calculations using Feynman diagrams. An introduction is given to Lagrangian field theory; fields of spin-0, spin-1/2, and spin-1 particles; quantum electrodynamics (QED); and elementary divergences in higher-order calculations. The goal is to calculate cross sections for elementary scattering processes by the end of the first quarter. Emphasis will be placed on processes and observables which can be examined experimentally. The second quarter (Physics 444) will continue the discussion of divergent quantities and how to deal with them using renormalization, and will embark on the study of non-Abelian (Yang-Mills) gauge fields.

Problem sets, constituting 75% of the grade, will be assigned each week, due the following week, and returned the week after that. A final project, due on the last day of classes (Dec. 8), will constitute 25% of the grade. A list of suggested topics will be presented within the next month, and you will be asked to choose a topic by mid-November. The project will involve an explicit piece of field theory which requires a calculation on your part and could include discussion of the relevance of that calculation to experiment.

SYLLABUS (approximate guidelines)

Week	Dates	Text pages	Topics
1	9/27, 9/29	1–34	Lagrangian field theory; scalar fields
2	10/6[a]	35–44	Lorentz group; Dirac equation
3	10/11[b]	45–52	Dirac equation solutions; bilinears
4	10/18, 10/20	52–76	Quantization; discrete symmetries
5	10/25, 10/17	77–99	Interactions; Feynman diagrams
6	11/1. 11/3	99–115	Cross section calculations
7	11/8, 11/10	115–138	Feynman diagrams for fermions; QED
8	11/15, 11/17	139–158	Elementary QED processes
9	11/22	158–174	Compton scattering; pair annihilation
10	11/29, 12/1	175–198	Bremsstrahlung; electron vertex
11[c]	12/6, 12/8	199–210	Infrared divergences

Notes: [a]No class 10/4. [b]No class 10/13, [c]Makeup week.

Text: Michael E. Peskin and Daniel V. Schroeder, *An Introduction to Quantum Field Theory*, ISBN Number: 0-201-50397-2, Addison-Wesley (1995). This will also be the text for Physics 444 and likely for 445.

In addition, the following will be *recommended* (not required):

1. F. Mandl and G. Shaw, *Quantum field theory,* Wiley, New York, 1984 (QC174.45.M320), ISBN Number: 0 471 90650 6 (paper).

2. A. Zee, *Quantum Field Theory in a Nutshell,* Princeton University Press, 2003 (QC174.45.Z44), ISBN Number: 0-691-01019-6.

The following references also may be useful:

1. V. Barger and R. J. N. Phillips, *Collider physics,* Addison-Wesley, Redwood City, CA, 1987 (QC793.2.B37)

2. J. D. Bjorken and S. D. Drell, *Relativistic quantum mechanics,* McGraw-Hill, New York, 1964 (QC174.1.B63)

3. J. D. Bjorken and S. D. Drell, *Relativistic quantum fields,* McGraw-Hill, New York, 1965 (QC174.45.B63)

4. Ta-Pei Cheng and Ling-Fong Li, *Gauge theory of elementary particle physics,* Clarendon Press, Oxford, 1984 (QC793.3.F5C480).

5. E. Commins and P. H. Bucksbaum, *Weak interactions of leptons and quarks,* Cambridge University Press, Cambridge, 1983 (QC794.8.W4C650).

6. Francis Halzen and Alan D. Martin, *Quarks and Leptons: An Introductory Course in Modern Particle Physics,* Wiley, New York, 1984 (QC 793.Q2522H34).

7. S. Gasiorowicz, *Elementary particle physics,* Wiley, New York, 1966

8. H. Georgi, *Weak interactions and modern particle theory,* Benjamin/Cummings, Menlo Park, CA, 1984 (QC794.8.W4G46)

9. C. Itzykson and J.-B. Zuber, *Quantum field theory,* McGraw-Hill, New York, 1980 (QC174.45.I770).

10. T. D. Lee, *Particle physics and introduction to field theory,* Harwood, New York, 1981 (QC793.2.L430)

11. D. H. Perkins, *Introduction to high energy physics,* 3rd edition, Addison-Wesley, Reading, Mass., 1987 (QC793.2.P470)

12. M. Perl, *High energy hadron physics,* Wiley, New York, 1974 (QC793.5.H322.P45)

13. Chris Quigg, *Gauge theories of the strong, weak, and electromagnetic interactions,* Benjamin/Cummings, Reading, Mass., 1983 (QC794.Q5), ISBN Number: 0-8053-6020-4.

14. P. Ramond, *Field theory - a modern primer,* Benjamin/Cummings, Reading, Mass., 1981 (QC174.45.R35)