PHYS7314: Quantum field theory I

Fall 2018

Time and location:	Tuesdays and Thursdays, 9:30am-10:50pm, 152 Fondren Science
Instructor:	Pavel Nadolsky
E-mail:	nadolsky@smu.edu
Phones:	(214) 768-1756 (office)
Mailbox:	102 Fondren Science
Office:	203 Fondren Science
Office hours:	By appointment, request an appointment at doodle.com/pavelnadolsky.
Course webpage	Posted on SMU Canvas (courses.smu.edu). To view, enter your 8-digit SMU ID and password.

Textbook, learning objectives, grading, policies

Text	*1*, *Quantum field theory*, by Mark Srednicki, 1st Edition *2. Gauge theories in particle physics: a practical introduction, vol. 1,* by Ian Aitchison and Anthony Hey, CRS Press, 4th edition
Recommended reading and materials	1. *Classical Electromagnetism in a nutshell,* by Anupam Garg (selected sections) 2. *Quantum Field Theory in a nutshell,* by Anthony Zee 3. *An Introduction to Quantum Field Theory,* by G. Sterman 4. *Introduction to Quantum Field Theory,* by M. Peskin and D. Schroeder 5. *The Quantum Theory of Fields*, volumes 1, 2,3 by Steven Weinberg 6. *Fields*, by Warren Siegel (free, hep-th/9912205). 7. Simon DeDeo's online course on an Introduction to Renormalization.

Grading	Your grade will be based on weekly homework problems (70%) and a final project (30%) • Late Homework: 15% off per day for the first four days, or until graded (whichever is first). Thereafter I'll accept (but won't grade) them at any time for 25% credit.
Homework assignments	In the Assignments folder on the website.

PHYS 7314 Syllabus

Sections from Srednicki's book

Plan to read 3-4 chapters per week

Part I. Spin Zero:

1. Attempts at relativistic quantum mechanics
2. Lorentz invariance
3. Canonical quantization of scalar fields
4. The spin-statistics theorem
5. The LSZ reduction formula
6. Path integrals in quantum mechanics
7. The path integral for the harmonic oscillator
8. The path integral for free field theory
9. The path integral for interacting field theory
10. Scattering amplitudes and the Feynman rules
11. Cross sections and decay rates
12. Dimensional analysis with hbar=c=1
13. The Lehmann-Källén form
14. Loop corrections to the propagator
15. The one-loop correction in Lehmann-Källén form
16. Loop corrections to the vertex
17. Other 1PI vertices
18. Higher-order corrections and renormalizability
19. Perturbation theory to all orders
20. Two-particle elastic scattering at one loop

21. The quantum action
22. Continuous symmetries and conserved currents
23. Discrete symmetries: P, T, C, and Z
24. Nonabelian symmetries (skip until later)
25. Unstable particles and resonances (elective)
26. Infrared divergences
27. Other renormalization schemes
28. The renormalization group
29. Effective field theory (skip until later)
30. Spontaneous symmetry breaking (skip until later)
31. Broken symmetry and loop corrections (elective)
32. Spontaneous breaking of continuous symmetries (skip until later)

Part II. Spin One Half

33. Representations of the Lorentz Group
34. Left- and right-handed spinor fields
35. Manipulating spinor indices
36. Lagrangians for spinor fields
37. Canonical quantization of spinor fields I
38. Spinor technology
39. Canonical quantization of spinor fields II
40. Parity, time reversal, and charge conjugation
41. LSZ reduction for spin-one-half particles
42. The free fermion propagator
43. The path integral for fermion fields
44. Formal development of fermionic path integrals (skip until later)
45. The Feynman rules for Dirac fields
46. Spin sums
47. Gamma matrix technology
48. Spin-averaged cross sections
49. The Feynman rules for majorana fields (elective)
50. Massless particles and spinor helicity (elective)
51. Loop corrections in Yukawa theory
52. Beta functions in Yukawa theory
53. Functional determinants (skip until later)

Part III. Spin One

54. Maxwell's equations
55. Electrodynamics in coulomb gauge
56. LSZ reduction for photons

57. The path integral for photons
58. Spinor electrodynamics
59. Scattering in spinor electrodynamics
60. Spinor helicity for spinor electrodynamics (elective)
61. Scalar electrodynamics (elective)
62. Loop corrections in spinor electrodynamics
63. The vertex function in spinor electrodynamics
64. The magnetic moment of the electron
65. Loop corrections in scalar electrodynamics (elective)
66. Beta functions in quantum electrodynamics
67. Ward identities in quantum electrodynamics I
68. Ward identities in quantum electrodynamics II
24.
69. Nonabelian gauge theory
70. Group representations
44.
53.
71. The path integral for nonabelian gauge theory
72. The Feynman rules for nonabelian gauge theory
73. The beta function for nonabelian gauge theory
74. BRST symmetry (elective)
75. Chiral gauge theories and anomalies
76. Anomalies in global symmetries
77. Anomalies and the path integral for fermions
78. Background field gauge
79. Gervais-Neveu gauge
80. Feynman rules for NxN matrix fields
81. Scattering in quantum chromodynamics
82. Wilson loops, lattice theory, confinement
84. Spontaneous breaking of gauge symmetries
85. Spontaneously broken abelian gauge theory
86. Spontaneously broken nonabelian gauge theory
87. The standard model: Gauge and Higgs sector
88. The standard model: Lepton sector
89. The standard model: Quark sector
90. Electroweak interactions of hadrons
91. Neutrino masses