

Phys 3766 Quantum Field Theory -- QFT-II

Instructor:

E.S. Swanson

365 Thackeray Hall

4-9057 swansone@pitt.edu <http://fafnir.phyast.pitt.edu/py3766/>

class meets Tuesday and Thursday, 2:30-3:45, 316 Old Engineering Hall.

Office Hours: Tuesday and Thursday, 3:45 - 4:45.

Introductory Texts:

- F. Mandl and G. Shaw, *Quantum Field Theory*
- F. Gross, *Relativistic Quantum Mechanics and Field Theory*

Reference Texts:

- Donoghue, Golowich, and Holstein, *Dynamics of the Standard Model*
- Peskin and Schroeder, *An Introduction to Quantum Field Theory* (the course will follow this text in large part)
- Itzykson and Zuber, *Quantum Field Theory*

Marking Scheme: final = 0.4 take home exam + 0.6 assignments

some reading for your spare time

- [Haag's theorem and inconsistency of the interaction picture](#)
- [Subtleties in defining the path integral](#)
- [Pok Man notes](#)
- [Schwinger-Dyson Equations and the Effective Potential](#)

Prerequisites: py3765 (QFT-I/relativistic quantum mechanics)

Assignments:

- asst 1 Dirac Basics [pdf](#). Due Jan 15.
- asst 2 Nuclear Interactions [pdf](#). Due Jan 22.
- asst 3 QED [pdf](#). Due Jan 29.
- asst 4 Path Integrals [pdf](#). Due Feb 14.
- asst 5 Young Tableaux [pdf](#). Due Feb 14.
- asst 6 Functional Methods [pdf](#). Due Feb 26.
- asst 7 Schwinger-Dyson Equations [pdf](#). Due Mar 21.
- asst 8 Renormalising with Broken Symmetries [pdf](#). Due Apr 4.
- asst 9 QCD beta function [pdf](#). Due Apr 18.
- asst 10 Higgs phenomenology [pdf](#). Due Apr 25.

Syllabus QFT-II

Advanced topics in QFT will be covered. The course will cover Peskin and Schroeder, chapters 9, 10, 11, 15, 16, 18, 20, and 22, with substantial supplementary material from Donoghue, Golowich, and Holstein, and various review articles. The rough syllabus is:

- Functional Methods
 - functional derivatives, Schroedinger representation, path integrals, operator ordering, curved space, Haag's theorem, Grassmann variables, Faddeev-Popov trick, symmetries, Schwinger-Dyson equations
- Renormalization II
 - BPH again, dim reg, magnetic moment, power counting, LSZ theorem, dimensional regularisation
 - QED at one loop
 - composite operators
 - renormalization and symmetry, ABJ anomaly, trace anomaly, π_0 to gamma gamma
- Renormalisation and Symmetry
 - symmetry breaking, Goldstone's theorem, linear sigma model at one-loop, the effective action, the renormalisation group improved effective action
- Non-Abelian Field Theory
 - Lie algebras and groups, irreducible representations, quadratic Casimir operators
 - gauge invariance, A is not a four-vector, Yang-Mills theory, Faddeev-Popov prescription and gauge fixing, Feynman rules, ghosts, Coulomb gauge
 - QCD: historical perspective, symmetries of QCD, theta-vacuum and topology, QCD at one loop, the beta function, asymptotic freedom and infrared slavery, scale setting
- Gauge Theory with Spontaneous Symmetry Breaking
 - Higgs mechanism, the Abelian Higgs model, nonAbelian scalar Higgs model, patterns of symmetry breaking, Glashow-Salam-Weinberg model, fermion mass, the CKM matrix, unitary gauge, Higgs decays
- Effective Field Theory
 - rationale, naturalness, electroweak EFT, operator mixing, matching, renormalisation group running, application to B and D decays
- Problems in the Standard Model
 - gauge hierarchy problem, strong CP problem, cosmological constant problem, EW baryogenesis