Quantum Field Theory course outline

Field Theory I Spring 2009

I. Basic ideas
- quantizing many body systems
- the continuum limit
- field commutation rules
- quanta
- Lagrangians for fields

II Introducing the fields
- the scalar field
- the photon
- non-relativistic fields
- fermions and the Dirac equation

III Interactions
- the time development operator
- perturbation theory
- propagators and interactions
- Wick's thoerem
- Feynman rules

IV Calculating in field theory
- transitions and decays
- scattering
- the ground state
- symmetry breaking

V Introduction to Renormalization
- the need to renormalize
- basic renormalization
- regularization techniques
- running coupling constants (the Renormalization Group)

VI Basic Quantum Electrodynamics
- the archetypical field theory
- a cultural overview

VII Non-relativistic field theory
- many body physics

VIII Path Integrals and Functional Methods
- review of path integral QM
- generalization to field theory
- generating Feynman diagrams
- functional techniques

Field Theory II – Fall 2009

I Review and extension of basic ideas
- review
- spin-statistics theorem
- LSZ reduction formula

II The Dirac Field in more detail
- calculation methods

III Gauge Theory treated right
- gauge fixing
- ghosts
- Feynman rules

IV QED treated right
- gauge invariance and Feynman rules
- renormalization of QED
- the classic calculations
- the running QED coupling constant

V Effective Field Theory
- if there is time I would do this in the first semester, but that is unlikely
- energy scales and degrees of freedom
- the sigma model as an example
- integrating out heavy degrees of freedom
- the low energy effective action
- calculating in non-renormalizable theories

VI Anomalies
- path integrals and symmetries
- perturbative and path integral treatments
- anomalies in field theory

VII. The Standard Model

- construction of the model
- asymptotic freedom and perturbative QCD
- weak decays and particle mixing