Physics 8630: Tentative Syllabus

Lecture	Topics
1	Historical overview of quantum field theory
2	Review of Lorentz invariance
3	Lagrangians and Hamiltonians in classical mechanics and classical field theory
4	Klein-Gordon equation for a complex scalar field
	Lagrangian and equation of motion
	Nonrelativistic reduction and Schrodinger field theory
5	Lagrangian for Schrodinger field theory
	Symmetries and conservation laws – Noether's theorem
6	More on symmetries and conservation laws
	space-time symmetries
	"internal" symmetries
7	Review of quantization of a simple harmonic oscillator
	Quantization of Klein-Gordon field
8	Quanta of the K-G field as relativistic particles
9	Time-dependent operators: the Heisenberg picture
	Causality
10	The Feynman propagator for the K-G field
	Retarded boundary conditions – why they're not causal
11	Klein-Gordon equation with a classical source
12	Representations of the rotation group and the Lorentz group in field theory
13	Lorentz invariance, causal propagation, and the Feynman boundary conditions
	More on Lorentz group representations
14	Dirac spinor as a representation of the Lorentz algebra
	Explicit construction of Dirac gamma matrices
15	Reducible and irreducible representations of Lorentz group – Weyl spinors
	Plane wave solutions of the free Dirac equation
16	Identities for spin sums over Dirac wave functions
	Quantization of the Dirac field
17	Electric charge of particles and anti-particles in the Dirac theory
	Discrete symmetries of the Dirac equation
18	Discrete symmetries (cont'd)
	Parity
	Time reversal
	Charge conjugation
19	Interacting field theory and Feynman diagrams
	Time-dependent perturbation theory and the interaction picture

20 Field products in the interaction picture
The fundamental formula of perturbation theory
21 Time ordered products and Wick's theorem
22 Feynman diagram expansion of field products
23 The Feynman rules
Feynman diagrams and the S-matrix: "amputation" of external lines
24 The S-matrix (cont'd)
2-body elastic scattering
25 Scattering cross-sections in ϕ^4 theory
Differential cross-sections and the phase-space formula
Decay of unstable particles
26 Feynman rules for Dirac fermions
Yukawa theory
27 Scattering amplitude in Yukawa theory
Feynman rules for quantum electrodynamics
28 Feynman diagrams and scattering amplitudes in QED
29 Gauge invariance in QED
30 Divergences in QFT
31 Infrared divergences and bremsstrahlung
32 The electron vertex function
33 The electron vertex function (cont'd.)
34 The anomalous magnetic moment of the electron
35 Path integrals – Introduction
Path integrals in nonrelativistic quantum mechanics
36 Path integrals in quantum field theory – the scalar field
37 Path integral calculation of the Feynman propagator
Momentum-space evaluation of gaussian path integrals
38 Gaussian path integrals (cont'd)
39 Path integral derivation of Feynman rules
40 Wick-rotated path integrals and statistical mechanics
Discretized path integral: hopping expansion for the scalar field
41 The hopping matrix
Charged particle propagation in gauge fields
Disordered gauge fields and quark confinement – an example of path-integral intuiti