PARTICLE PHYSICS

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The course will build on the material presented in the Part II Particles Course, with the aim of providing a reasonably complete description of our understanding of modern particle physics. The course will concentrate on the Standard Model of Particle Physics with the aim of providing both a detailed description of current experimental data, and the theoretical understanding to place these experimental results in context. The Minor Option courses on "Frontiers of Particle Physics" covers physics beyond the Standard Model and the Minor Option course on "Gauge Field Theories" covers particle physics theory at a more advanced level.

Introduction: The structure of the Standard Model; relativistic phase space and its role in two-body decays and two-body scattering; interactions via particle exchange and Feynman diagrams.

Relativistic wave equations: The Klein-Gordon equation; the Weyl equations, spin and helicity; the Dirac equation and Dirac spinors.

QED: e^+e^- scattering and annihilation in QED; *global and local gauge invariance;* the role of spin and helicity in QED; calculations using the Dirac equation.

Quark model: Mesons and baryons; the proton form factor; deep-inelastic scattering and structure functions; Bjorken scaling and the Callan-Gross relation.

QCD: Colour and gluons; the binding of mesons, the long-range QCD potential, confinement, running couplings and asymptotic freedom; hadron production; experimental evidence for QCD. *SU(3) symmetry.*

Particle Detectors: Particle interactions in matter, particle detection and large detectors at modern particle colliders.

Charged-current Weak interactions: V-A Theory and parity violation, lepton universality, and neutrino helicity; neutrino scattering, structure functions, anti-quark content of nucleon, valence and sea quarks; The GIM mechanism, the Cabibbo angle, and the CKM matrix.

CP violation: C and P symmetries; the K^0 system and evidence for CP violation; CP violation in the Standard Model and the CPT theorem.

Electroweak Unification: Weak interactions; weak isospin and weak neutral currents; the W and Z bosons and a unified electroweak theory; *the Higgs mechanism, spontaneous symmetry breaking, generation of vector boson masses;* Tests of the electroweak theory at e^+e^- colliders.

Neutrinos and astroparticle physics: Solar and atmospheric neutrinos; neutrino oscillations and the PMNS matrix; recent neutrino experiments.

Beyond the Standard Model: Problems with the Standard Model and possible solutions; Supersymmetry and extra dimenstions; the baryon asymmetry in the universe and dark matter; future experiments, the Large Hadron Collider and the International Linear Collider.

BOOKS

There are many books available on particle physics, at various levels. The following are suggested as useful for this course:

Particle Physics, Martin B R and Shaw G (2nd edn Wiley 1997). A good introductory text, more suited to Part II but covers most of the basic material.

Introduction to High Energy Physics, Perkins D H (4th edn CUP 2000).
Good coverage of experimental techniques as well as theory. About the right level for the course although with adopts a more historical approach.

Introduction to Elementary Particles, Griffiths D (Harper & Row 1987) out of print
Theoretical treatment, going beyond the level of the course, but well written and clear. Good reference for those wishing to pursue the mathematical details.