

# Particle Physics, Quantum Fields and Strings

The courses on *Symmetries, Fields and Particles, Quantum Field Theory, Advanced Quantum Field Theory and The Standard Model* are intended to provide a linked course covering *High Energy Physics*. The remaining courses extend these in various directions. Knowledge of *Quantum Field Theory* is essential for most of the other courses. The *Standard Model* course assumes knowledge of the course *Symmetries, Fields and Particles*.

## Desirable previous knowledge

Basic quantum mechanics, wave functions, amplitudes and probabilities. Quantisation in terms of commutation relations between coordinates  $q$  and corresponding momenta  $p$ . Schrödinger and Heisenberg pictures. Dirac bra and ket formalism.

Harmonic oscillator, its solution using creation and annihilation operators.

Angular momentum operators and their commutation relations. Determination of possible states  $|jm\rangle$  from the basic algebra. Idea of spin as well as orbital angular momentum. Two body systems. Clebsch-Gordan coefficients for decomposition of products of angular momentum states.

Perturbation theory, degenerate case and to second order. Time dependent perturbations, ‘Golden Rule’ for decay rates. Cross sections, scattering amplitudes in quantum mechanics, partial wave decomposition.

Lagrangian formulation of dynamics. Normal modes. Familiarity with Lorentz transformations and use of 4-vectors in special relativity, 4-momentum  $p^\mu$  for a particle and energy-momentum conservation in 4-vector form. Relativistic formulation of electrodynamics using  $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$  and Lagrangian density  $\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu}$ .

Basic knowledge of  $\delta$ -functions (including in 3 dimensions) and Fourier transforms. Basic properties of groups and the idea of a matrix representation. Permutation group.

The desirable previous knowledge needed to tackle the Particle Physics, Quantum Fields and Strings courses is covered by the following Cambridge undergraduate courses. Students starting Part III from outside might like to peruse the syllabuses on the WWW at

<http://www.maths.cam.ac.uk/undergrad/schedules/>

Year	Courses
Second	<i>Essential:</i> Quantum Mechanics, Methods, Complex Methods. <i>Helpful:</i> Electromagnetism.
Third	<i>Essential:</i> Principles of Quantum Mechanics, Classical Dynamics. <i>Very helpful:</i> Applications of Quantum Mechanics, Statistical Physics, Electrodynamics.

If you have not taken the courses equivalent to those denoted ‘essential’, then you should review the relevant material over the vacation.