The University Of Sheffield.

DEPARTMENT OF PHYSICS AND ASTRONOMY

PHY304	***Particle Physics***
Autumn	***10 Credits***
Staff contact	***Dr Chris Booth - c.booth@shef.ac.uk***

Outline Description	This 10-credit Level 3 Physics module introduces students to the exciting field of modern particle physics. It provides the mathematical tools of relativistic kinematics, enabling them to study interactions and decays and evaluate scattering form factors. Particles are classified as fermions - the constituents of matter (quarks and leptons) – or as bosons, the propagators of field. The four fundamental interactions are outlined. Three are studied in detail: Feynman diagrams are introduced to describe higher order quantum electrodynamics; weak interactions are discussed from beta decay to high energy electroweak unification; strong interactions, binding quarks into hadrons, are presented with the experimental evidence for colour. The role symmetry plays in the allowed particles and their interactions is emphasised.
Restrictions	None
Prerequisites	PHY250, PHY251
Co requisites	None
Approx Time allocation (hours)	Lectures - 22, Independent - 66, Coursework - 10, Examination - 2
Assessment (%)	Examination 85%, Coursework 15%
Aims	To provide an introduction to the field of modern particle physics, incorporating a description of the fundamental particles and their interactions, with the tools to perform kinematic calculations in simple situations.
Outcomes	On successful completion of this course, you should: 1. understand the difference between fermions and bosons, and how they behave; 2. know the characteristics of the electromagnetic, strong and weak interactions; 3. be familiar with the consequences of boson exchange in the mediation of forces; 4. be able to use Feynman diagrams to describe interactions; 5. understand scattering, and the role of form factors, being able to calculate the form factor for simple charge distributions; 6. know the quantum numbers of particles in the lowest lying multiplets; 7. recognise allowed and forbidden processes for each of the interactions; 8. be able to calculate the kinematics of 2-body interactions and decays.
Recommended Books	Text Book: “Introduction to Elementary Particles” David Griffiths (recommended) Background Reading: “Ideas of Particle Physics” G D Coughlan, J E Dodd and B M Gripaios Further Reading: “Introduction to High Energy Physics” Donald H Perkins Supplementary material is provided on the Web at: http://www.cbooth.staff.shef.ac.uk/phy304

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Syllabus	**1. Introduction** Units - energy, momentum and mass. Lorentz transformations and invariants. **2. Cross-Sections and Decay Rates** Total and partial cross-sections. Differential cross-sections $d\sigma/d\Omega$. Elastic scattering. Form factor $F(\underline{q})$. Born approximation. Fourier relationship between $\rho(\underline{r})$ and $F(\underline{q})$. **3. Kinematics** Energy-momentum relationship. 4-vectors $P = (\underline{p}, iE)$. 4-momentum transfer, q. **4. Classification of Particles** Elementary particles. Fermions and bosons. Constituents of matter and fields. Pauli Exclusion Principle. Introduction to the Standard Model. Leptons and quarks. **5. Interactions and Fields** Exchange bosons. The 4 fundamental forces; their ranges and relative strengths. Feynman diagrams. Virtual particles. Yukawa potential. **6. Invariance Principles and Conservation Laws** Origin of conservation laws, properties of space-time. Conservation of $\underline{p}$, E and $\underline{L}$. Global phase or gauge transformations; multiplicative conservation laws; charge conjugation (C), parity (P) and time-reversal (T) symmetries; CPT theorem. **7. Fundamental Interactions** a) Electromagnetic - QED, electron self-energy, vacuum polarisation, renormalisation. Magnetic moments, g–2 experiment and theory. b) Weak - Low energies, beta decay, W^+, W^-. High energy divergences and electroweak unification, Z^0. e^+e^- annihilation experiments; number of fermion generations. c) Strong - QCD, quarks and gluons, colour, α_s (running). Allowed hadrons, confinement, hadronisation and jets. **8. Properties of Quarks** Isospin & strangeness, charm, beauty (bottom), top. Quark content of hadrons. Symmetries and allowed combinations of quarks. CKM matrix and weak eigenstates. Strangeness regeneration. **9. Evidence in support of quark model** e^+e^- scattering and annihilation; time-like and space-like virtual photons, R and colour factor. Deep inelastic scattering, scaling. Jets and gluon bremsstrahlung. **10. Summary** A course booklet is provided, consisting of a summary of key points and definitions, diagrams and other information.

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Academic Notes	