

Basic details

UID		Cohorts covered	Earliest cohort 2024-25	Latest cohort
Long title	Nuclear and Particle Physics			
New code	PHYS60001	New short title	Nuclear & Particle Physics	
Brief description of module <i>(approx. 600 chars.)</i>	In this course the students will be introduced to the physics of elementary particles and nuclei. We explore conceptually the fundamental forces and the Standard Model of particle physics, with use of basic Feynman diagrams. We introduce concepts associated with symmetries and use relativistic kinematics to calculate simple interactions. We explore the concepts of nuclear binding energy via the semi-empirical mass formula and the nuclear shell model. We explain alpha, beta and gamma decay. We conclude by studying the processes of fission and fusion and their applications. <div>578 characters</div>			
Available as a standalone module/ short course?	N			

Statutory details

Credit value	ECTS 5.0	CATS 10	Non-credit N	HECOS codes
FHEQ level	Level 6			

Allocation of study hours

	Hours	
Lectures	22	
Group teaching	6	Incl. seminars, tutorials, problem classes.
Lab/ practical	0	
Other scheduled	11	Incl. project supervision, fieldwork, external visits.
Independent study	86	Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.
Placement	0	Incl. work-based learning and study that occurs overseas.
Total hours	125	
ECTS ratio	25.00	

Project/placement activity

Is placement activity allowed?	No
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Module delivery

Delivery mode	Taught/ Campus	Other	
Delivery term		Other	Term 2, exam in term 3

Ownership

Primary department	Physics
Additional teaching departments	None
Delivery campus	South Kensington

Collaborative delivery

Collaborative delivery?	N
External institution	N/A
External department	N/A
External campus	N/A

Associated staff

Role	CID	Given name	Surname
Module Leader		Paul	Dauncey

Learning and teaching
Module description

Learning outcomes	<p>On completion of this module you will be able:</p> <p>1• To understand conceptually the content of the Standard Model and how the theoretical framework is informed, validated and scrutinised by experimental methods;</p> <p>2• To illustrate the electromagnetic, weak and strong forces using basic Feynman diagrams and calculate simple particle interactions using relativistic energy-momentum formulae;</p> <p>3• To understand conceptually the key aspects of the electromagnetic force, illustrating the idea with basic calculations of electron-electron scattering and electron-positron annihilation;</p> <p>4• To understand conceptually the key aspects of the strong force, including asymptotic freedom and quark confinement, illustrating the ideas with basic calculations of the meson masses and electron-positron annihilation to quarks;</p> <p>5• To understand conceptually the key aspects of the weak force, illustrating the ideas with basic calculations of muon decay and two-family neutrino mixing, the CKM matrix and its consequences;</p> <p>6• To explain the origin of the various terms in the semi-empirical mass formula and in the nuclear shell model, and perform basic calculations to derive the observed stable nuclei;</p> <p>7• To explain and calculate alpha, beta and gamma decays at a basic particle physics level and the interactions of the various nuclear radiations with matter;</p> <p>8• To explain the concepts of fission (spontaneous and induced), chain reactions and fusion, and perform the associated calculations demonstrating energy release.</p>
Module content	<p>PART I – PARTICLE PHYSICS</p> <p>• Introduction to the Standard Model Feynman diagrams. Recalling relativistic particles, energy and momentum conservation; 4-vectors. Decay rates, cross sections.</p> <p>• The Electromagnetic Force Photons, QED Feynman diagrams. Positronium. Rutherford scattering. Reactions: $\mu e \rightarrow \mu e$, $ee \rightarrow \mu\mu$.</p> <p>• The Strong Force Gluons and QCD Feynman diagrams. Self-interactions, “confinement”, “asymptotic freedom”. Colourless hadrons as bound states of quarks: baryons and mesons. Reaction: $ee \rightarrow qq$, with mention of hadronisation and jets.</p> <p>• The Weak Force Feynman diagrams. W and Z bosons, left-handed coupling. Muon decay; 3-body final state; tau decay. Pion decay: 2-body final state; leptonic decays. Neutrino and kaon oscillations. CKM matrix with mention of CP violation. Mention of Electroweak Unification and the Higgs.</p> <p>PART II – NUCLEAR PHYSICS</p> <p>• The Nuclear Force and Nuclear Masses Residual strong force. Nuclear binding, semi-empirical mass formula. Shell model, magic numbers.</p> <p>• Nuclear Decays and Reactions Gamma, beta and alpha decays</p> <p>• Fission and Fusion Fission, uranium and nuclear reactors. Fusion, primordial and stellar nucleosynthesis. Solar power reactions.</p>
Learning and Teaching Approach	Students will be taught over a term using a combination of lectures (supported by office hours), directed problem solving in seminars, and exercises in problem sheets to be solved as homework.
Assessment Strategy	An exam covering all learning outcomes will comprise the main part of the summative assessment and will comprise 80% of the module mark. In-course assessments will comprise 20% of the mark.
Feedback	Problem sheets and their solutions will be provided, for which the questions aim to improve students' understanding. There will also be seminar questions discussed with the tutors and their teaching assistants.
Reading list	<p>High-quality, self-contained lecture notes are provided to students and lecture slides are also made available. There are excellent textbooks that are suggested as supplementary or complementary reading for those wishing to explore further some aspects of the course:</p> <ul style="list-style-type: none"> • Particle Physics, by Martin & Shaw • Nuclear and Particle Physics, by Williams • An Introductory to Nuclear Physics, by Cottingham and Greenwood • Nuclear Physics, by Lilley

Quality assurance		Office use only	
Date of first approval		QA Lead	
Date of last revision		Department staff	
Date of this approval		Date of collection	
Module leader	Paul Dauncey	Date exported	
		Date imported	
Notes/ comments			

Associated modules

[illegible]

UID	Legacy code	Module title	Requisite type

Assessment details

Grading method

Numeric

Pass mark

40%

Assessments

[illegible]

100%