Imperial College London

Module Specification (Curriculum Review)

Basic details

UID		Cohorts covered	Earliest cohort: 2025-26; Latest cohort:
Long title	Nuclear and Particle Physics		
New code	PHYS60001	New short title	Nuclear & Particle Physics

Brief description of module *(approx. 600 chars.)*

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.

578 characters

Available as a standalone module/ short course? N

Statutory details

	ECTS	CATS	Non-credit
Credit value	7.5	15	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	149	*Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.*
Placement	0	*Incl. work-based learning and study that occurs overseas.*
Total hours	188	
ECTS ratio	**25.00**	

Project/placement activity

Is placement activity allowed? No

Module delivery

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

Ownership

Primary department: Physics

Additional teaching: None

departments	

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	On completion of this module you will be able: 1• To understand conceptually the content of the Standard Model and how the theoretical framework is informed, validated and scrutinised by experimental methods; 2• To illustrate the electromagnetic, weak and strong forces using basic Feynman diagrams and calculate simple particle interactions using relativistic energy-momentum formulae; 3• To understand conceptually the key aspects of the electromagnetic force, illustrating the idea with basic examples of electron-electron scattering and electron-positron annihilation; 4• To understand conceptually the key aspects of the strong force, including asymptotic freedom and quark confinement, illustrating the ideas with basic examples of the hadron masses and electron-positron annihilation to quarks; 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; 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; 7• To explain and calculate alpha, beta and gamma decays at a basic particle physics level. 8• To explain the concepts of fission (spontaneous and induced), chain reactions and fusion, and perform the associated calculations demonstrating energy release.

Module content	**PART I – PARTICLE PHYSICS** • **Introduction to the Standard Model** Feynman diagrams. Recalling relativistic particles, energy and momentum conservation; 4-vectors. Decay rates, cross sections. • **The Electromagnetic Force** Photons, QED Feynman diagrams. Positronium. Rutherford scattering. Reactions: μe→μe, ee→μμ. • **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-→qq, with mention of hadronisation and jets. • **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. **PART II – NUCLEAR PHYSICS** • **The Nuclear Force and Nuclear Masses** Residual strong force. Nuclear binding, semi-empirical mass formula. Shell model, magic numbers. • **Nuclear Decays and Reactions** Gamma, beta and alpha decays • **Fission and Fusion** Fission, uranium and nuclear reactors. Fusion, primordial and stellar nucleosynthesis. Solar power reactions.
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. A fraction of problems are for in-course assessment (see below).
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 in the form of 3-5 assessed problem sheets (online quiz) will comprise 20% of the mark.
Feedback	Formative feedback will be provided throughout the module following formative assessment in forms such as online tests and verbal feedback in seminars by teaching assistants. Feedback for assessed problems are provided as written solutions. Solutions for non-assessed problem sheets are published 1-2 weeks after release of the problems. General feedback on written examinations for each module is provided in the form of written reports from the examiners for the students.
Reading list	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: • 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

Date of first approval

Office use only

QA Lead

Date of last revision		Department staff	
Date of this approval		Date of collection	
		Date exported	
Module leader	Paul Dauncey	Date imported	
Notes/ comments			

Template version 16/06/2017

Programme structure

Associated modules

UID	Legacy code	Module title	Requisite type

UID	Legacy code	Module title	Requisite type

Assessment details

Grading method	Numeric	Pass mark	40%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
Examination	2-hour written examination	80%	40%	N
Coursework	Assessed problem sheets	20%	40%	N
		100%		