Imperial College London

Module Specification (Curriculum Review)

Basic details

			Earliest cohort	Latest cohort
UID		Cohorts covered	2024-25	

Long title: Foundations of Quantum Mechanics

New code	PHYS60011	New short title	Foundations of Quantum Mechs

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

This course will introduce the conceptual and mathematical foundations of quantum mechanics. Emphasis will be on Hilbert Space (bra-ket) methods, formal operator methods and density matrices. Students will also be introduced to topics such as syymmetry, angular momentum, quantum entanglement, coherent states, and Feynman path integrals.

338 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	26	
Group teaching	10	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	0	
Other scheduled	12	*Incl. project supervision, fieldwork, external visits.*
Independent study	139.5	*Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.*
Placement	0	*Incl. work-based learning and study that occurs overseas.*
Total hours	187.5	
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		Jerome	Gauntlett

Learning and teaching

Module description

Learning outcomes	On completing the Foundations of Quantum Mechanics course, students will: (1) Have acquired mathematical techniques (Hilbert spaces) to understand and solve quantum problems (2) Have the conceptual background required to understand the foundations of quantum mechanics and how it is used to compute probabilities. (3) Understand the equivalence and use of different quantum formalisms for dynamical evolution (Heisenberg/Schrodinger/interacting pictures) (4) Have a general understanding of symmetry in quantum mechanics, including rotations, translations, parity. In addition have an understanding of the role of generators of symmetries and, in particular, an understanding of representation theory of angular momentum. 5) Be familiar with solutions for standard problems such as the harmonic oscillator.
Module content	•Hilbert Space Formalism: States, linear operators, bra and ket notation, Hilbert spaces, tensor products, general uncertainty principle •Postulates of quantum mechanics, including the Born rule for computing probabilities of measurements and the Copenhagen interpretation. •Position and momentum representations and the recovery of wave mechanics. Momentum operator as the generator of translations. •Quantum Dynamics: The propagator and the Hamiltonian as the generator of time translations. Schrodinger and Heisenberg pictures. The interacting picture. •The simple harmonic oscillator and coherent states. •Angular momentum. Rotations and representation of angular momentum algebra. Spin and spinors. Addition of angular momentum. Parity in quantum mechanics. •Density Matrices: Mixed and pure states and density matrices. Reduced density matrices and entanglement. von Neumann entropy. Thermal density matrices. •Path Integrals: Derivation of the path integral for free particles. Propagator. Aharonv Bohm effect. Canonical quantisation and path integral quantisation. •Quantum mechanics in the presence of electromagnetic fields. Gauge invariance. Landau levels.

Learning and Teaching Approach	Students will be taught over one term using a combination of lectures, office hours and directed exercises on theoretical work.
Assessment Strategy	100% summative assessment based on final exam of 2h or more with 3 questions that will evaluate competency in the topics covered in the lectures and in the problem sheets.
Feedback	Problem sheets are provided each week (10 in total) with questions and examples students can practise with. Students will have the opportunity to solve problems real time in interactive Rapid Feedback sessions with assistance and advice provided by several teaching assistants. Solutions will be provided after the rapid feedbacks.
Reading list	Lecture notes are provided to students. The notes (and problem sheets) are designed to be self-contained and there is no designated textbook required for this module. There are however also some excellent textbooks, that are suggested as supplementary or complementary reading for those of wishing to explore further some aspects of the module. J. J. Sakurai and J. Napolitano, Modern Quantum Mechanics R. Shankar, Principles of Quantum Mechanics Other books include Chris Isham, Lectures On Quantum Theory: Mathematical And Structural Foundations P.A.M. Dirac, Principles of Quantum Mechanics Landau-Lifshitz, Quantum Mechanics (Nonrelativistic theory)

Quality assurance

Date of first approval	
Date of last revision	
Date of this approval	
Module leader	Jerome Gauntlett

Office use only

QA Lead	
Department staff	
Date of collection	
Date exported	
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

		Pass mark
Grading method	Numeric	40%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
			40%	
final exam	Written exam over 2 hours	100%	40%	N
		100%		