Imperial College London

Module Specification (Curriculum Review)

Basic details

		Earliest cohort	Latest cohort
UID			
Cohorts covered		2021-22	

Long title: Group Theory

New code: PHYS60015

New short title: Group Theory

Brief description of module *(approx. 600 chars.)*: This is a module about group theory, representation theory and the physical applications of representation theory, mainly to non-relativistic quantum mechanics of atoms and molecules. The abstract group theory is developed rigorously for finite groups, then the finite group representation theory is constructed, again rigorously, followed by quantum-mechanical applications. The last part of the course is devoted to the introduction to the theory of Lie groups.

464 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 1, exam in term 3

Ownership

Primary department: Physics

Additional teaching 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
Lecturer		Dimitri	Vvedensky

Learning and teaching

Module description

Learning outcomes

On completion of this module you will:
•understand of the fundamentals of the abstract group theory and representation theory of finite groups;
• be able to apply the tools of group theory to problems in non-relativistic quantum mechanics, including prediction of degeneracies and selection rules, classification of normal modes, application of projection operator technique,
•be able to apply Wigner-Eckart theorem;
•have an understanding of the basics of the theory of Lie groups, incl. irreducible representations of SO(2) and SO(3).

Module content

1. Abstract group theory for finite groups: properties of the group, subgroups, cosets, Lagrange's theorem, invariant subgroup, factor-group, conjugate classes, Abelian and non-Abelian groups, isomorphism, homomorphism, symmetric group, Cayley's theorem.
2. Symmetry groups, point groups and their classification.
3. Representation theory for finite groups: existence of equivalent unitary representation, reducible and irreducible representations, Schur's lemmas, orthogonality relations, characters and character tables, regular representation, expansion in the basis functions of irreducible representations, projection operators, direct product representation.
4. Quantum-mechanical applications: symmetry-induced and accidental degeneracies, lifting of degeneracy by low-symmetry perturbation, selection rules, symmetry classification of normal modes, tight-binding wavefunctions for multi-well potentials.
5. Continuous groups: Lie groups and Lie algebras, irreducible representations of SO(2) and SO(3), Clebsch-Gordan coefficients, Wigner-Eckart theorem.

Learning and Teaching Approach

Students are taught over one term using a combination of lectures, rapid feedback sessions and video-blog-style discussion board on Blackboard. The latter consists of 26 lecture recordings forming the root entries, to which discussion threads are attached. The discussions consist of students' questions in the form of 1st-level comments, lecturer's and other students' answers at the 2nd level, etc.

Assessment Strategy

Summative assessment is by a 2h written exam.

Feedback

Problem sheets are provided weekly (10 in total) with questions and examples students can practise with. Out of those questions, all or almost all are marked as Rapid Feedback questions. Students can hand in their answers to these questions and these will be reviewed and annotated (no formal mark) for formative feedback. Rapid Feedback questions are then reviewed during a Rapid Feedback session with a teaching assistant.

Reading list

Core reading:
•Group theory and its application to physical problems by Hamermesh, Morton
•Applications of group theory in quantum mechanics by Petrashen

Quality assurance

Date of first approval	
Date of last revision	
Date of this approval	
Module leader	Dimitri Vvedensky

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

Programme structure
Associated programmes

UID	Legacy code	Programme title	Core?

Assessment details

Grading method	Numeric	Pass mark	40%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
Examination	2h final examination in term 3.	100%	40.00	N
		100%		