# Group Theory

<table>
<thead>
<tr>
<th>Module Code</th>
<th>PHYS96019</th>
<th>FHEQ Level</th>
<th>Level 6</th>
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<tbody>
<tr>
<td>Pre-requisites</td>
<td>None</td>
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<td>None</td>
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<tr>
<td>Primary Department</td>
<td>Physics</td>
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<tr>
<td>Module Leader</td>
<td>Professor Matthew Foulkes</td>
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<td>Additional Teaching Departments</td>
<td>None</td>
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<tr>
<td>Teaching Staff</td>
<td>Matthew Foulkes + Associate</td>
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<tr>
<td>Programmes on which the Module is delivered</td>
<td>All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)</td>
<td>Core/Elective</td>
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## Learning Outcomes

On completing the Group Theory course, students will have:

- understood the fundamentals of the abstract group theory
- understood the fundamentals of the representation theory of finite groups
- been able to apply the tools of group theory to problems in non-relativistic quantum mechanics, including
  - prediction of degeneracies and their lifting by perturbation
  - developing selection rules
  - classification of vibrational normal modes
  - application of projection operator technique
  - application of Wigner-Eckart theorem
- mastered the beginnings of the theory of Lie groups
- understood the representations of SO(2) and SO(3)

## Description of Content

This is a course on group theory, representation theory and their applications to quantum mechanics. The main part of the course deals with discrete finite groups, while a brief introduction into infinite continuous groups is given in the last part. The main objective is to make the participants fluent in the language of representation theory and confident in its applications to non-relativistic quantum mechanics.

1. Abstract group theory for finite groups: properties of the group, subgroups, cosets, Lagrange's theorem, invariant subgroup, factor-group, conjugate classes, Abelian vs 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 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, representations of direct products.
4. Quantum mechanical applications: symmetry-induced and accidental degeneracies, lifting of degeneracy by perturbation, selection rules, molecular vibrations, molecular orbitals as linear combination of atomic orbitals.
5. Continuous groups: Lie groups and Lie algebras, irreducible representations of SO(2) and SO(3), Clebsch-Gordan coefficients, Wigner-Eckart theorem.

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<th>Assessment</th>
<th>Assessment Type</th>
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<td>Written exam</td>
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<tbody>
<tr>
<td>October 2016</td>
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