Quantum Theory of Matter

Module Code	PHYS97086	FHEQ Level	Level 7
Pre-requisites	Light and Matter, Advanced Classical Physics	Co-requisites	None
Primary Department	Physics		
Module Leader	Professor Dimitri Vvedensky + Dr Derek Lee		
Additional Teaching Departments	None		
Teaching Staff	Professor Dimitri Vvedensky, Dr Derek Lee + Course Associates		
Programmes on which the Module is delivered			Core/Elective
All UG Physics programmes (F300, F303, F309, F325, F390, F3W3)			Elective
Learning Outcomes	On completing the Quantum Theory of Matter course, students will: • be able to illustrate the concept of **topology in condensed matter physics** using examples of current interest • understand the electronic structure of **polyacetylene** and the existence of an edge state in relation to the Zac phase • understand how the **integer quantum Hall effect** arises from topological structure of electron wavefunctions in a magnetic field • understand the concept of the **Berry phase** in adiabatic quantum mechanics • be able to describe the basic electronic properties of **graphene** • To understand how topology guarantees metallic conduction on the surface of **topological insulators**.		
Description of Content	1. **Recap: Electrons in Crystalline Solids** a. Bloch's theorem and electron bands b. tight binding model 2. **Geometric Phase** a. Berry phase b. Two-level system and diabolic points 3. **Su–Schrieffer–Heeger Model** a. Topological quantum phase transition b. Symmetry-protected edge states c. Adiabatic transport: Thouless pump & Chern number 4. **Aharonov-Bohm effect** 5. **Integer Quantum Hall Effect** a. classical Hall effect b. Landau levels c. Quantized Hall conductance d. Edge states		

	6. Graphene a. Tight binding theory b. Dirac fermions at low energy **7. Symmetries of Electronic States** a. Time-reversal and inversion symmetry b. Time reversal with spin: Kramers degeneracy c. Spin-orbit interaction **8. Topological Insulators** a. Topological band theoryfd b. Kane–Mele model c. Edge states d. Topological character of the Kane–Mele model

Assessment		Assessment Type	Weighting
Written Exam		Exam	100%
Learning & Teaching Hours	Independent Study Hours	Placement Hours	Total Hours
57	93	0	150
ECTS Credit	6	CATS Credit	12
Date of introduction	October 2016	Date of Last Revision	May 2020