Engineering Tripos Part IIB, 4B5: Quantum and Nano-technologies, 2026-27

Module Leader

Dr L Sapienza [1]

Lecturer

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Timing and Structure

Michaelmas term. 14 lectures + examples class. Assessment: 100% exam. Lectures will be recorded

Prerequisites

3B5

Aims

The aims of the course are to:

- Understand the basic principles of quantum mechanics and be able to apply them to problems relevant to Electrical Engineering
- Become familiar with nanotechnology: what it is, where it is used for, and how it relates to quantum systems and quantum engineering
- Explore the concepts of quantum information processing, communication and quantum computing

Objectives

As specific objectives, by the end of the course students should be able to:

- Apply quantum principles to understand charge transport and current flow at the nanoscale
- Understand quantum confinement, the origin of band structure, and how it relates to quantum size effects
- Be able to predict basic electrical properties of materials
- Understand the basic relationships between size and properties of materials, their quantum origin, and their application via nanotechnology
- Describe the operation principle of quantum devices, the key parameters in play and what the potential/perspectives of quantum engineered systems are.

Content

The aim of this module is to introduce, building on material covered in 3B5, the concepts underlying quantum engineering and nanotechnology, and see how to apply them to problems relevant to electrical engineering. We will explore the quantum origin of many of the properties of materials, ranging from resistivity, mechanical properties, colour, and band structure, and how these properties evolve with size. We will approach this from two angles: from the theoretical principles and predictions of quantum mechanics to the manifestations of these as exploited using nanotechnology.

All lectures will be delivered by Dr Sapienza.

Lecture content:

- The need for a quantum description of the world around us
- The basic assumptions of quantum mechanics
- Solutions to the Schrodinger equation: confinement, band structures, quantum harmonic oscillator
- A quantum description of electrical properties of materials
- A look into the principles underlying quantum information processing
- Nanotechnology: what it is and relationship to quantum mechanics
- Nanomaterials: evolution of properties of materials with decreasing size, dimensionality
- Ultimate nanostructures: graphene, molecular systems, novel device architectures
- Entanglement, superposition and quantum phenomena relevant to quantum engineering
- Introduction to quantum communication, quantum computing and quantum engineered devices.

Further notes

Change of Rubric: In order to bring the paper structure in line with other IIB modules, the exam format from 2023 will comprise a paper with 4 questions, of which 3 need to be answered, as opposed to previous years where it was 3 out of 5.

Booklists

Please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [3] standard:

Toggle display of UK-SPEC areas.

General Learning Outcomes

Graduates with the exemplifying qualifications, irrespective of registration category or qualification level, must satisfy the following criteria:

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Links
[1] mailto:ls2052@cam.ac.uk
[2] https://teaching26-27.eng.cam.ac.uk/content/form-conduct-examinations
[3] https://teaching26-27.eng.cam.ac.uk/content/uk-spec