

Quantum Engineering

This document provides a definitive record of the main features of the programme and the learning outcomes that a typical student may reasonably be expected to achieve and demonstrate if s/he takes full advantage of the learning opportunities provided. This programme specification is primarily intended as a reference point for academic and support staff involved in delivering the programme and enabling student development and achievement, for its assessment by internal and external examiners, and in subsequent monitoring and review.

Programme Information

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|--|--|----|-------|-----|
| Programme Title | Quantum Engineering | | | |
| Award(s) | MSc | | | |
| Programme Code(s) | F342 | | | |
| Awarding Institution | Imperial College London | | | |
| Teaching Institution | Imperial College London | | | |
| Faculty | Faculty of Natural Sciences | | | |
| Department | Department of Physics | | | |
| Associateship | Royal College of Science | | | |
| Main Location of Study | South Kensington Campus | | | |
| Mode and Period of Study | 1 calendar year full-time (12 months) | | | |
| Cohort Entry Points | Annually in October | | | |
| Relevant QAA Benchmark Statement(s) and/or other external reference points | Master's Awards in Physics, Astronomy and Astrophysics | | | |
| Total Credits | ECTS: | 90 | CATS: | 180 |
| FHEQ Level | Level 7 - Master's | | | |
| EHEA Level | 2 nd cycle | | | |
| External Accrator(s) | N/A | | | |
| Specification Details | | | | |
| Student cohorts covered by specification | 2017-18 entry | | | |
| Person Responsible for the specification | Prof Myungshik Kim | | | |
| Date of introduction of programme | October 2016 | | | |
| Date of programme specification/revision | Academic Year 2017 | | | |

Programme Overview

The MSc in Quantum Engineering (QE) is a comprehensive, inter-disciplinary programme of postgraduate training that covers the fundamentals of systems engineering, quantum communication and computation, quantum metrology, imaging and sensing, as well as 'enabling skills' including innovation and entrepreneurialism.

The programme begins with the fundamentals of quantum mechanics, followed by an intensive module on systems engineering. These prepare the students for the foundation modules on the theoretical and laboratory concepts and skills of QE. The second term focusses on applications and preparation for the project. The projects may be with one of the QE Hub partners or with another Department. Workshops on innovation and entrepreneurship will further develop the transferable skills.

The students will spend much of their time with the CDT in Controlled Quantum Dynamics students on the South Kensington campus, but with contributions to teaching from the Materials, Electrical and Electronic Engineering, Civil and Environmental Engineering Departments and the Business School there will be opportunities to learn from other specialisms.

Learning Outcomes

By the end of this programme, the students will be able to:

1. Explain the unique properties of quantum mechanical systems and assess how those properties can be utilised to advance technologies such as information processing, cryptography and metrology.
2. Describe the current state-of-the-art in the preparation and control of quantum systems and critically compare the various physical platforms for quantum technologies, including atoms, ions and photons.
3. Utilise appropriate mathematical techniques to construct models of defined individual and interacting quantum systems and apply those models to predict system behaviour.
4. Apply the concepts of system engineering to define the requirements and boundaries of a quantum system and to assess the engineering viability of new quantum technologies.
5. Propose new venture ideas based on innovation in quantum technologies, critically evaluate their market viability compared to alternative and competing solutions, construct a business case and argue the case to stakeholders.
6. Demonstrate how to use the diagnostic tools available in a practical Quantum Engineering setting and develop customised control and data acquisition tools.
7. Conduct appropriately supported independent laboratory research.

The learning outcomes for individual modules are discussed in detail in the module outlines.

Entry Requirements

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|--|--|
| Academic Requirement | Normally a first class UK Bachelor's Degree in a relevant engineering or physical sciences discipline (or equivalent). |
| Non-academic Requirements | None |
| English Language Requirement | Standard requirement IELTS score of 6.5 overall (minimum 6.0 in all elements) |
| The programme's competency standards documents can be found at: http://www.imperial.ac.uk/natural-sciences/departments/physics/students/current-students/taught-postgraduates/ | |
| Learning & Teaching Strategy | |
| Scheduled Learning & Teaching Methods | <ul style="list-style-type: none"> • Lectures, • Laboratory work, • computational exercises, • workshops and • individual project work. |
| E-learning & Blended Learning Methods | <ul style="list-style-type: none"> • Lecture material; • Online discussions; • Links to other relevant learning material. |
| Project Learning Methods | <ul style="list-style-type: none"> • Several short group projects; • A six-month independent project under academic supervision. |
| Placement Learning Methods | <ul style="list-style-type: none"> • A 2-week placement with an industry partner |
| Assessment Strategy | |
| Assessment Methods | <ul style="list-style-type: none"> • Written examinations, • oral examinations, • problems sheets, • practical work, • team exercises, • project work. |
| Academic Feedback Policy | |
| The feedback policy will follow the guidelines of the Department of Physics, where written feedback should be provided to the student as per the information in the programme handbook and at the start of the programme. | |
| Re-sit Policy | |
| The College's Policy on Re-sits is available at: http://www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/ | |

Mitigating Circumstances Policy

The College's Policy on Mitigating Circumstances is available at: <http://www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/>

Programme Structure

| Full-time | | Term One | Term Two | Term Three | |
|------------------|--|----------|----------|------------|--|
| Core Modules | | 6 | 0 | 2 | |
| Elective Modules | | 0 | 3 | 0 | |
| Projects | | 0 | 1 | | |

Assessment Dates & Deadlines

| | |
|------------------------|-----------------|
| Written Examinations | April |
| Coursework Assessments | Continuous |
| Project Deadlines | Mid - September |
| Practical Assessments | Continuous |

Assessment Structure

Rules of Progression

N/A

Marking Scheme

The MSc consists of three elements:

- Core modules, accounting for 38% of the total programme mark, and
- Elective modules, accounting for 21% of the total programme mark, and
- Project, accounting for 41% of the total programme mark.

The marking scheme for the elements and components will follow the 'Regulations for the Examinations of Masters Degrees'

| Module Weightings | | |
|--------------------------|--|-----------------------|
| Element (% Weighting) | Module | % Module Weighting |
| Core Modules (38%) | Introductory Quantum Mechanics | 17.6% |
| | Quantum Engineering Laboratory | 8.8% |
| | Systems Engineering | 17.6% |
| | Qi Information/Post-Quantum Cryptography | 14.7% |
| | Atoms and Photons | 14.7% |
| | Tools for QE | 14.7% |
| | Innovation and Entrepreneurship for QE | 11.8% |
| Elective modules (21%) | 18 ECTS of elective modules | 100% |
| Project (41%) | Project | 100% |

| Code | Title | Core/ Elective | L&T Hours | Ind. Study Hours | Place- ment Hours | Total Hours | % Written Exam | % Course- work | % Practical | FHEQ Level | ECTS |
|--|--|-------------------|--------------|------------------------|-------------------------|----------------|----------------------|----------------------|----------------|---------------|------|
| PH9-QQM | Introductory Quantum Mechanics | Core | 30 | 120 | 0 | 150 | 100% | 0% | 0% | 7 | 6 |
| PH9-CGLABP | Quantum Engineering Laboratory | Core | 36 | 39 | 0 | 100 | 0% | 100% | 0% | 7 | 3 |
| PH9-QSE | Systems Engineering | Core | 30 | 145 | 0 | 175 | 0% | 100% | 0% | 7 | 6 |
| F342QIPQC | Quantum Information and Post- Quantum Cryptography | Core | 20 | 105 | 0 | 125 | 100% | 0% | 0% | 7 | 5 |
| PH9-QAP | Atoms and Photons | Core | 20 | 105 | 0 | 125 | 50% | 50% | 0% | 7 | 5 |
| PH9-CINSP/PH9- CLVIEW/PH9- CMATH | Tools for QE | Core | 24 | 76 | 0 | 100 | 0% | 50% | 50% | 7 | 5 |
| PH9-QBUS | Entrepreneurship and Innovation for Quantum Engineering | Core | 48 | 52 | 0 | 100 | 0% | 0% | 100% | 7 | 4 |
| PH9-CERCQD | Platforms for Quantum Technology | Elective | 30 | 120 | 0 | 150 | 52.5% | 47.5% | 0% | 7 | 6 |
| EE4-40 | Information Theory | Elective | 30 | 120 | 0 | 150 | 100% | 0% | 0% | 7 | 6 |
| PH9-QMNQE | Metrology and Navigation for Quantum Engineering | Elective | 26 | 124 | 0 | 150 | 80% | 20% | 0% | 7 | 6 |
| PH9-OLO/PH9- OFT | Frontiers in Photonics Technology | Elective | 24 | 126 | 0 | 150 | 100% | 0% | 0% | 7 | 6 |
| PH9-QPRJ | Project | Core | 0 | 950 | 0 | 950 | 0% | 100% | 0% | 7 | 38 |

Supporting Information

The Programme Handbook is available at: <http://www.imperial.ac.uk/physics/students/current-students/taught-postgraduates/>

The Module Handbook is available at: <http://www.imperial.ac.uk/physics/students/current-students/taught-postgraduates/>

The College's entry requirements for postgraduate programmes can be found at: www.imperial.ac.uk/study/pg/apply/requirements

The College's Quality & Enhancement Framework is available at: www.imperial.ac.uk/registry/proceduresandregulations/qualityassurance

The College's Academic and Examination Regulations can be found at: <https://www.imperial.ac.uk/about/governance/academic-governance/regulations>

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<http://www.imperial.ac.uk/admin-services/secretariat/college-governance/charters-statutes-ordinances-and-regulations>

Imperial College London is regulated by the Higher Education Funding Council for England (HEFCE) <http://www.hefce.ac.uk/reg/register/>

Modifications

| Description | Approved | Date | Paper Reference |
|-------------|----------|------|-----------------|
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