

PROGRAMME SPECIFICATION

This document describes the **Master of Science, Postgraduate Diploma and Postgraduate Certificate in the Internet of Things** and the **Master of Science and Postgraduate Diploma in the Internet of Things with a Year in Industry**. This specification is valid for new entrants from **September 2016**.

The aims of this programme are to:

- produce specialists in technologies for the Internet of Things that are capable of developing and operating the generation of networks of connected devices that are starting to proliferate (e.g. smart homes, smart cities and smart cars);
- provide a combination of Data Analysis, Information Security, and Computer Networks, which are the key areas required for professionals in the Internet of Things area;
- offer courses in which the teaching of theory and practice in the Internet of Things is informed by research activity and professional expertise;
- develop an understanding of professional and ethical issues involved in the deployment of specific technologies;
- develop the subject-specific and generic skills and techniques that will facilitate progression to MPhil/PhD studies in distributed systems or a related field;
- foster the ability to learn independently, whether for career enhancement, progression to research, or personal intellectual development; and
- provide a strong foundation for a professional career as an Internet of Things specialist.

In addition, the Year in Industry programme further enables students to gain industrial experience (which is very useful when applying for jobs in the future) and acquire skills that can only be fully gained in a work environment. It also allows students to develop a better appreciation of how what they have learned relates to real-world problems or situations, and to put into practice the techniques that they will have been taught.

The Internet of Things programme is delivered in a single stage, equating to one year (52 weeks) of full-time study, or up to five years (260 weeks) of part-time study. The programme consists of courses worth a total of 120 credits and a project worth 60 credits.

The Internet of Things with a Year in Industry programme is delivered in a single stage, equating to up to two years of full-time study including an industrial placement. This programme is not available in part-time mode.

On successful completion of any of the programmes, students should have an understanding of the area of Internet of Things at a level appropriate for a postgraduate qualification. Whilst being a self-contained degree in its own right, each programme provides suitable and recognised qualifications that can facilitate entry to PhD study in the same or a closely related field.

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This document provides a summary of the main features of the programme(s), and of the outcomes which a student might reasonably be expected to achieve if full advantage is taken of the learning opportunities provided. Further information is contained in the College prospectus, the College Regulations and in various handbooks issued to students upon arrival. Whilst Royal Holloway keeps all its information for prospective applicants and students under review, programmes and the availability of individual courses are necessarily subject to change at any time, and prospective applicants are therefore advised to seek confirmation of any factors which might affect their decision to follow a specific programme. In turn, Royal Holloway will inform applicants and students as soon as is practicable of any substantial changes which might affect their studies.

Learning outcomes

Teaching and learning in the programmes are closely informed by the active research of staff, particularly in the areas of: data analysis, machine learning, distributed systems, computer networks and information security. In general terms, the programmes provide opportunities for students to develop and demonstrate knowledge of both core subject material and specialised research areas, and for students to develop and demonstrate the following learning outcomes:

Knowledge and understanding

- a strong background in data modelling, distributed and networked systems, and information security;
- a strong background in fault-tolerance and data replication techniques;
- an advanced understanding of distributed coordination and time-synchronisation techniques (leader-election, consensus, and clock synchronisation);
- a strong background on data communication protocols and software stacks for wireless, sensor, and *ad hoc* networking technologies;
- an advanced understanding of principles of failure detection and monitoring;
- a strong background in virtualisation and cloud computing technologies;
- an advanced understanding of principles of scalable storage; and
- an appreciation of how the role of an Internet of Things specialist fits into the organisational and development processes of a company.*

* For the Year-in-Industry programme

Skills and other attributes

- a highly analytical approach to problem solving; *
- ability to apply well-founded principles to building reliable and scalable distributed systems;
- ability to analyse complex distributed systems in terms of their performance, reliability, and correctness;
- ability to design and implement middleware services for reliable communication in unreliable networks;
- ability to work with state-of-the-art wireless, sensor, and *ad hoc* networking technologies;
- ability to design and implement reliable data communication and storage solutions for wireless, sensor, and *ad hoc* networks;
- ability to detect sources of vulnerability in networks of connected devices and deploy the appropriate countermeasures to information security threats;
- ability to enforce privacy in "smart" environments;
- ability to work with open source and cloud tools for scalable data storage and coordination;
- ability to work with modern network management technologies and standards;

- ability to design custom-built application-driven networking topologies using OpenFlow, and other modern tools;
- ability to develop, validate, and use effectively machine learning models and statistical models;
- ability to work with software to automate tasks and perform data analysis and visualisation;
- ability to work with structured, unstructured, and time-series data;
- ability to work with methods and techniques such as clustering, regression, support vector machines, boosting, decision trees, neural networks;
- ability to work with software packages such as MATLAB and R;
- ability to work with relational databases, non-relational databases, as well as with Hadoop/Pig scripting and other big data manipulation techniques;
- analysing, problem-solving, decision-making;*
- managing time and resources effectively, by drawing on planning and organisational skills;*
- ability to abstract and synthesise information;*
- ability to work autonomously, and to demonstrate time management and organisational skills;*
- ability to present logical and coherent written arguments of varying lengths;* and
- enhanced time management and organisational skills including working to deadlines, prioritising tasks, organising work-time. *

* transferable skills

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Teaching, learning and assessment

Teaching and learning is mostly by means of lectures, supervised laboratory work, coursework assignments, a supervised individual project, and guided independent study. Assessment of knowledge and understanding is typically by coursework assignments, examinations, and a dissertation. Details of the assessments for individual courses can be obtained from the departmental web site:

<http://www.royalholloway.ac.uk/computerscience/>

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Details of the programme structure(s)

Please note that not all optional courses run each year. A full list of optional courses for the current academic year can be obtained from the Department of Computer Science, including courses offered by other departments.

All taught courses are condonable. However, the Individual Project is non-condonable.

Full-time mode

The taught part takes two academic terms to complete, each with 11 weeks of lectures, followed by a 7-week examination period.

In the **Autumn Term**, students must take:

- CS5100 Data Analysis (20 credits)
- CS5840 Interconnected Devices (10 credits)
- CS5860 Advanced Distributed Systems (20 credits)
- Optional courses (10 credits) **or** IY5760 Information Security (10 credits) (*)

In the **Spring Term**, students must take:

- CS5870 Wireless, Sensor and Actuator Networks (20 credits)
- IY5606 Smart Cards, RFIDs and Embedded Systems Security (20 credits)
- Optional courses (20 credits)

The choice of courses a student can take is subject to the following rules:

- Courses marked with (*) must be taken but only by students with weaker skills on the academic subjects covered by the courses. For each student on the programme, the decision on whether those courses need to be taken is made by the Programme Director based on the student's background.
- Optional courses are chosen from the list provided by the Department to complete each term to a total of 60 credits. Pre-requisites based on prior study or academic background may apply. The list of electives for each student must be approved by the Programme Director in advance. In exceptional cases when timetabling or other administrative reasons prevent them from taking courses worth 60 credits in each term, students will be allowed to take courses worth 50 credits in one term and 70 in the other term.
- Please note that not all optional courses run each year. The full list of courses available for the current academic year can be obtained from <http://www.royalholloway.ac.uk/computerscience/>.

In the **Summer Term** the students take the examinations. In June, the Exam Sub-board confirms which students have passed the taught part of the programme as specified in the Progression and award requirements section, and may proceed to the Individual Project. Students who have not passed the taught part of the programme may be allowed to repeat or resit certain courses depending on the progression rules. All resits must be taken during the Summer term of the following year; no resits are offered during the Summer-Resit examination period.

The Individual Project (CS5825) (60 credits) takes 12 weeks to complete, starting immediately after the June meeting of the Exam Sub-board for those students who are eligible to progress. It is assessed through a dissertation. The Project Handbook provides full details and is available from <http://www.royalholloway.ac.uk/computerscience/>.

The Department of Computer Science and the Careers Service organise a programme of seminars, training sessions and events aimed at helping students find and secure placements. Students registered for the MSc in the Internet of Things with a Year in Industry must attend all events of this programme. Failure to engage with the programme may lead to the student being transferred to the MSc in the Internet of Things programme.

Students registered for the MSc in the Internet of Things with a Year in Industry who have not progressed to the year in industry or have not been able to secure a placement are transferred to the MSc in the Internet of Things programme.

The industrial placement, available only to the eligible MSc in the Internet of Things with a Year in Industry students, takes up to one year, starting at the end of the Summer term. At the end of the placement, the student produces a report, which is submitted and assessed as part of the individual project. Details of the industrial placement are available from the placement handbook on the Computer Science web site <http://www.royalholloway.ac.uk/computerscience/>.

The Individual Project for Year-in-Industry students (CS5826) (60 credits) takes 12 weeks starting immediately after the end of the placement for those students who are eligible to progress. It is assessed through a dissertation (90%) and a placement report (10%). Except for the assessment, its rules and procedures are identical to CS5825.

Part-time mode

The part-time programme, which is not available to Year-in-Industry students, normally lasts two years+. Students may take up to 60 credits worth of courses in each term to a total of 120 credits.

The following courses must be taken in the Autumn term of Year 1:

- CS5840 Interconnected Devices (10 credits)
- CS5860 Advanced Distributed Systems (20 credits)
- IY5760 Information Security (10 credits) (*)

The following courses must be taken either in Year 1 or in Year 2:

- CS5100 Data Analysis (20 credits)
- CS5870 Wireless, Sensor and Actuator Networks (20 credits)
- IY5606 Smart Cards, RFIDs and Embedded Systems Security (20 credits)

Courses marked with (*) are subject to the rules detailed under the Full-time mode section above.

Optional courses are chosen to complete the total over two years to 120 credits. The Individual Project (CS5825) (60 credits) takes 24 weeks starting immediately after the June meeting of the Exam Sub-board in the second year and subject to meeting the progression requirements.

+ part time students are permitted under College regulations to complete their programme of study over a period of up to 5 years. Students who are unable to complete the programme within the standard 2 year timeframe should liaise with the programme director to agree a time frame for completion. The part time route is not available to Year in Industry students.

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Progression and award requirements

Progression throughout the year/s is monitored through performance in summative or formative coursework assignments.

Please note that if you hold a Tier 4 (General) Student Visa and you choose to leave (or are required to leave because of non-progression) or complete early (before the course end date stated on your CAS), then this will be reported to UKVI.

The decision on progression to the individual project is taken by the examination sub-board. Normally, to progress to the project a student must pass the taught part of the programme (as defined below).

The decision on progression to the Year in Industry is taken by the examination sub-board. Normally, to progress to the Year in Industry a student must:

- Engage with the activities run by the Careers service throughout the year.
- Achieve a good result in the placement test and show good performance in coursework assignments (as detailed in the programme handbook).
- Pass the taught part of the programme (as defined below).

To pass the programme a student must pass the taught part and the individual project, and achieve an overall weighted average of at least 50.00%:

- To **pass the taught-part**, a student must achieve in every taught course the aggregate mark of at least 50%. Failure marks between 40-49% can be condoned in courses which in total do not constitute more than 40 credits, provided that the overall weighted average is at least 50.00%.
- To **pass the Individual Project**, a student must achieve a mark of at least 50% in the dissertation (in the case of CS5825) or in the combined dissertation and placement report (in the case of CS5826). A failure mark (i.e., below 50%) cannot be condoned.

The **Masters degree with Merit** may be awarded if a student achieves an overall weighted average of 60% or above, with no mark in any element which counts towards the final assessment falling below 50%. A Merit will not normally be awarded if a student re-sits or re-takes any element of the programme.

The **Masters degree with Distinction** may be awarded if a student achieves an overall weighted average of 70% or above, with no mark in any element which counts towards the final assessment falling below 50%. A Distinction will not normally be awarded if a student re-sits or re-takes any element of the programme.

The **Postgraduate Diploma** may be awarded if a student has passed the taught part and has either chosen not to proceed to the Individual Project or has failed the Individual Project.

The **Postgraduate Diploma with Merit** may be awarded if a student achieves an overall weighted average of 60% or above, with no mark in any element that counts towards the final assessment falling below 50%.

The **Postgraduate Diploma with Distinction** may be awarded if a student achieves an overall weighted average of 70% or above, with no mark in any element that counts towards the final assessment falling below 50%. A Distinction will not normally be awarded if a student re-sits or re-takes any element of the programme.

The **Postgraduate Certificate** may be awarded if a student achieves marks of at least 50% in taught courses that constitute at least 60 credits (40 of which from mandatory courses) but fails to qualify for the award of a Postgraduate Diploma.

Please note that the Postgraduate Diploma with a Year in Industry (which is not available at degree application time) may be awarded if a student has passed the taught part, completed an industry placement and achieved a mark of at least 50% in the corresponding report, and has either chosen not to proceed or has failed the Individual Project.

Student support and guidance

- The Programme Director meets with the students on a regular basis to advise on academic issues and any questions about the programme throughout the year.
- The Director of Pastoral Care in the Department of Computer Science acts as a point of contact for pastoral support and advice on welfare issues in general.
- Overseas students benefit from additional support provided by a dedicated tutor at the Department of Computer Science.
- Course coordinators, tutors and dissertation supervisors provide a back-up system of academic, pastoral and welfare advice.
- All students are allocated a personal adviser with whom they meet at least once a term, and more regularly if required, to discuss all matters relating to their programme and for pastoral support.
- Induction programmes for orientation and introduction to the Department and College by the Programme Director during the induction week.
- All staff available and accessible through an office-hour system.
- Students in this programme are represented on the Student-Staff Committee.
- A detailed PG handbook and course specifications are made available to all students.
- Extensive supporting materials and learning resources are made available in College and University libraries, as well as the Computer Centre.
- Computing facilities are available in College-wide laboratories.
- Computing facilities are also available in the Department.
- Careers support is provided by the College Careers Service and the Departmental Careers Tutor.
- The Department of Computer Science and the Careers Service organise a programme of seminars, training sessions and events aimed at helping students find and secure placements.

- Access to all College and University support services, including Student Counselling Service, Health Centre, Students' Union and students with additional learning needs also have access to Disability and Dyslexia Services (DDS).

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Admission requirements

For details of admissions requirements please refer to the [Course Finder entry](#).

Further learning and career opportunities

The programme provides suitable qualifications for entry to PhD studies in the Internet of Things or a closely related field. Being an internationally recognised centre of research excellence, graduates of the programme have excellent opportunities to embark on PhD studies under the supervision of staff in the Department of Computer Science or in co-supervision with staff in other departments in interdisciplinary research topics.

The Internet of Things is a new and fast expanding area in Computer Science, technology and engineering: it concerns the systems of networked devices that are now sensing, transmitting and acting on data. A series of reports place the IoT as a new and transformative technology domain that will require millions of developers.

The programme has been carefully planned to educate and train people with the skills required to fill this gap. In addition to the academic, credit-bearing courses, a dedicated timetable slot for careers events, research seminars, and lectures on advanced topics will be offered to students.

For more details on career opportunities please contact the Royal Holloway Careers Service <http://www.royalholloway.ac.uk/careers/>.

Whilst being a self-contained degree in its own right, the programme provides a suitable qualification for entry to PhD study in the same or a closely related field.

Indicators of quality and standards

Royal Holloway's position as one of the UK's leading research-intensive institutions was confirmed by the results of the most recent Research Excellence Framework (REF 2014) conducted by the Higher Education Funding Council (HEFCE). The scoring system for the REF 2014 measures research quality in four categories, with the top score of 4* indicating quality that is world-leading and of the highest standards in terms of originality, significance and rigour and 3* indicating research that is internationally excellent. 81% of the College's research profile was deemed to be within the 4* or 3* categories, an increase of over 20% since 2008. This results for the quality of our research outputs placed Royal Holloway 15th in the UK based on an overall Grade Point Average (GPA) score and 20th in the UK for 4* and 3* research. The Department of Computer Science is ranked 22 in the UK for research of 4* standard and 21 for 3* and 4* research..

The Department is internationally recognised for the excellence of its research. In the REF 2014, the Department's research publications were rated as of international quality, with nearly a third recognised as world-leading, and a further half internationally excellent.

The College has a unique combination of expertise in data analysis, information security, machine learning and distributed computing. For instance, Computer Science is home to the Computer Learning Research Centre whose members work in several areas of theoretical machine learning, including kernel methods, prediction with expert advice, reinforcement learning, and prediction with confidence. The Centre is also involved in industrial applications of machine learning, including medicine and finance. A number of distinguished honorary and visiting members form a network of international connections. The group originated or made groundbreaking contributions to the development of state-of-the-art machine learning techniques such as support vector machines, kernel ridge regression, exponential weights algorithms, conformal predictors, and Q-learning.

List of programmes

The programmes are taught entirely by staff at Royal Holloway, University of London, and the Masters leads to an award of the University of London. The Postgraduate Diploma and Certificate leads to an award of Royal Holloway and Bedford New College. The programmes are not subject to accreditation by a professional body. The Banner programme codes are given in parentheses.

Master of Science Programme in the Internet of Things

MSc in the Internet of Things (2962)

Master of Science Programme in the Internet of Things with a Year in Industry

MSc in the Internet of Things with a Year in Industry (2965)

The following qualifications are only available to students who fail to graduate, subject to passing required courses as detailed previously. These qualifications are not available for direct admission.

Postgraduate Diploma in the Internet of Things

PG Diploma in the Internet of Things (2963)

Postgraduate Diploma the Internet of Things with a Year in Industry

PG Diploma in the Internet of Things with a Year in Industry (xxxx)

Postgraduate Certificate in the Internet of Things

PG Certificate in in the Internet of Things (2964)

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