

## PROGRAMME SPECIFICATION

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

The overall aim of the programme is to produce specialists in data science capable of handling and analysing different types of data in different fields and, thanks to a deeper understanding of Machine Learning, can create, innovate, and contribute to the definition of the next generations of search and analysis technologies.

The Year-in-Industry programme further enables students to gain industrial experience (which gives them an extra edge when applying for jobs in the future) and acquire skills that can only be fully picked up 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.

This programme is offered by the Department of Computer Science. The Machine Learning 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 120 credits and a project worth 60 credits.

The Machine Learning with 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, student should have an understanding of the area of Machine Learning 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 for 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 programme are closely informed by the active research of staff. In general terms, the programme provides opportunities for students to develop and demonstrate the following learning outcomes, all on a level appropriate for a postgraduate degree:

### *Knowledge and understanding*

- a strong theoretical background in machine learning, statistics, and data mining;
- advanced knowledge of computational and statistical data analysis;
- advanced knowledge of methods and techniques such as clustering, regression, support vector machines, boosting, decision trees, and neural networks;
- advanced knowledge and appreciation of non-statistical approaches to data analysis and machine learning;
- appreciation of how the role of a data analyst or scientist 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 extract value and insight from data (\*);
- ability to analyse and critically evaluate applicability of both machine learning and statistical models;
- ability to work with structured, unstructured, and time-series data;
- ability to work with software (including software packages such as MATLAB and R) to automate tasks and perform data analysis;
- ability to present logical and coherent written arguments of varying lengths (\*);
- 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, small group tutorials, laboratory sessions, coursework assignments, and a supervised individual project. Assessment of knowledge and understanding is typically by coursework assignments, examinations, and a dissertation. Full details of the assessments for individual courses can be obtained from the [Department](#).

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## Details of the programme structure(s)

### 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. Note, however, that the examination for CS5100 takes place in January. The list of compulsory courses depends on the academic or professional background of each student. During the induction week, all students will be required to take tests to assess their background knowledge and skills.

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

- CS5100 Data Analysis (20 credits) condonable
- CS5810 Programming for Data Analysis (10 credits) condonable
- CS5800 Computation with Data (\*) (10 credits) condonable
- CS5920 Machine Learning (\*) (10 credits) condonable

- Optional courses (to top up the total term value to 60 credits)

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

- CS5200 On-line Machine Learning (20 credits) condonable
- MT5432 Inference or MT5436 Applied Probability (20 credits) condonable
- Optional courses (20 credits)

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

- Courses marked with (\*) must be taken 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 and the results of tests taken during the induction week.
- 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 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 the [Department](#).

In the **Summer Term** the students take the examinations (with the exception of the examination for CS5100, which takes place in January). In June, the Exam Sub-board confirms which students have passed the taught part of the programme as specified in Section 6 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 (except CS5100's examination, which takes place in January); no resits are offered during the Summer-Resit examination period.

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 Machine Learning with a Year with Industry must attend all events of this programme. Failure to engage with the programme may lead to the student being transferred to the Machine Learning degree.

Students registered for the MSc in Machine Learning with a Year with Industry who have not passed the taught part of the programme or have not been able to secure a placement are transferred to the Machine Learning programme.

The **Industrial Placement**, available only to the eligible Machine Learning with a Year with 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.

The **Individual Project**, CS5821, (60 credits, non-condonable) takes 12 weeks to complete, starting immediately after the June meeting of the Exam Sub-board. It is assessed through a dissertation. The Project Handbook provides full details and is available from the [Computer Science](#) web site.

The **Individual Project for Year-in-Industry students**, CS5822, (60 credits, non-condonable) takes 12 weeks starting immediately after the end of the placement. It is assessed through a dissertation (90%) and a placement report (10%). Except for the assessment, its rules and procedures are identical to CS5821.

#### Part-time mode

The part-time programme, which is not available to Year-in-Industry students, 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:

- CS5100 Data Analysis (20 credits) condonable
- CS5810 Programming for Data Analysis (10 credits) condonable

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

- CS5800 Computation with Data (\*) (10 credits) condonable
- CS5920 Machine Learning (\*) (10 credits) condonable
- CS5200 On-line Machine Learning (20 credits) (20 credits) condonable
- MT5432 Inference or MT5436 Applied Probability (20 credits) condonable

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, CS5821, (60 credits, non-condonable) takes 12 weeks starting immediately after the June meeting of the Exam Sub-board.

\*\* 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.

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### Progression and award requirements

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

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, which currently consists of CS5100's examination, 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:

- 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.
- To **pass the Individual Project**, a student must achieve a mark of at least 50% in the dissertation (in the case of CS5821) or in the combined dissertation and placement report (in the case of CS5822). A failure mark (i.e., below 50%) cannot be condoned.

The award of degrees is confirmed at the October Sub-board according to the following classification:

- 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 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.

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### 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 Employability Lead.
- 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](#).

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## Further learning and career opportunities

The programme provides suitable qualifications for entry to PhD studies in Machine Learning 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 wide area of “Big Data” offer excellent career opportunities for graduates of the programme. As highlighted in “Big data: The next frontier for innovation, competition, and productivity” (McKinsey Global Institute, 2011), there is a worldwide shortage of managers and analysts who know how to operate companies by using insights from big data. There is a particular shortage of people with deep expertise in statistics and machine learning. The report “Big Data Analytics: An assessment of demand for labour and skills, 2012-2017” published by E-skills UK in 2013 forecasts that there will be approximately 28,000 gross job opportunities generated in this field per annum by 2017.

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](#).

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.

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## 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. The 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 was ranked 11th in the UK for the quality of its research output, with 32.2% classified as 4\* (world leading) and 54.5% as 3\* (internationally excellent). This is an outstanding performance that reflects the department’s strong research culture and significant expansion in its research portfolio, which transmits to the inspiring teaching that delivered across the degree programmes. 40% of the Research Impact has also been classified as 4\* (world leading), which reflects the strong engagement the department has with companies and the influence that its research has in the economy and society.

The Department has a unique combination of expertise in machine learning and distributed computing necessary to handle big data. 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 ground-breaking 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.

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### **List of programmes with details of awards, teaching arrangements and accreditation**

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 Machine Learning**

MSc in Machine Learning (2626)

#### **Master of Science Programme in Machine Learning with a Year in Industry**

MSc in Machine Learning with a Year in Industry (2629)

The following qualifications are only available to students who fail to graduate, subject to passing required courses as detailed in Section 6. These qualifications are not normally available for direct admission.

#### **Postgraduate Diploma in Machine Learning**

PG Diploma in Machine Learning (2632)

#### **Postgraduate Diploma in Machine Learning with a Year in Industry**

PG Diploma in Machine Learning with a Year in Industry (xxxx)

#### **Postgraduate Certificate in Machine Learning**

PG Certificate in Machine Learning (xxxx)

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