

## PROGRAMME SPECIFICATION

This document describes **M.Sci. degree programmes in Computer Science**. This specification is valid for new entrants from: **September 2017**.

The aims of all M.Sci. degree programmes in Computer Science are:

- to produce graduates with the ability to engage in the lifelong learning and with the skills required for a professional career in a computer-based environment or for a research career in Computer Science and related areas;
- to develop a mastery of computing-related cognitive abilities and skills as described in the QAA Computer Science benchmark statement;
- in a flexible and progressive structure, to develop students' knowledge and understanding of essential facts and theory, with the ability to use this knowledge to devise, specify, design, implement, test, document and critically evaluate computer-based systems;
- to develop an advanced understanding of professional and ethical issues involved in the deployment of computer technology;
- to produce graduates with a range of personal attributes relevant to the world beyond higher education, including information retrieval and use, numeracy, the ability to devise and present logical arguments to inform and support actions, and organisational skills;
- to develop an advanced understanding of knowledge and current awareness of current problems and/or new insights in the area of computing science research.

The programmes described here correspond to level 7 of the QAA framework. The length of these degrees varies from four years for the M.Sci. programmes to five years for the M.Sci. with a year in Industry programmes.

Apart from the year in industry, each stage comprises one year of full-time study during which the student must follow courses to the value of 120 national credits.

The programmes provide progressive structures in which students are able to gain ever-wider knowledge and understanding, and appropriate skills. The programmes contain a combination of mandatory and elective courses to introduce students to the theory and practice of Computer Science, including software development techniques and the technologies underlying specific application areas such as gaming and robotics.

The structure encourages students to develop their own interests through informed choice among specialist options. In the final year of the M.Sci. programmes, students undertake a project which accounts for 50% of their studies in the final year. There is a free choice of other penultimate and ultimate stage courses reflecting both core material, such as compiler theory, and currently important research areas such as machine learning, information security, software language engineering, intelligent agents, computational finance and bioinformatics. They will also attend core and optional courses in their final two years that reflect their specialism.

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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 computer learning, information security, compiler algorithm design and analysis, languages and computer architectures, combinatorial algorithms and complexity, and bioinformatics. The programmes provide opportunities for students to develop and demonstrate knowledge of both core subject material and specialised research areas.

The students will have an opportunity to develop and demonstrate the following learning outcomes:

#### *Knowledge and understanding*

- an advanced knowledge and understanding of the facts, concepts, principles and theories relating to computing and computer applications;
- mastery of the implications of recent research in Computer Science, artificial intelligence and related fields, and how such research results can be incorporated into computer-based systems;
- a command of the professional, moral and ethical aspects of the use of computer-based systems, and ability to recognise any risks or safety aspects in a given context;
- knowledge of how computers are programmed and used; advanced programming; software engineering and team work for developing a significant software system; the fundamental technologies used for artificial intelligence; the functioning of the Internet and the World Wide Web; the main concepts of database technology and design; background theory necessary for a deeper understanding of computing and computers;
- depending on their programme of studies, students may also gain a knowledge of the following key practical application technologies: operating systems; graphics; robotics, bioinformatics, information security, applied artificial intelligence and human-computer interfaces; theoretical foundations of algorithms and programming;

#### *Additional for programme with a year in industry*

- appreciation of the importance of computing and information technology for commerce and industry and an understanding of expected industry changes and the effects they will have.

#### Additional for Computer Science (Information Security)

- a command of the fundamental aspects of cyber security;
- a mastery of the identification and appropriate application of security controls.

#### *Skills and other attributes*

- ability to deploy appropriate theory, practices and tools for the modelling, specification, design, implementation and evaluation of computer-based systems (including stand-alone computer systems, information systems, embedded systems, distributed systems and web-based systems) to meet given requirements under practical constraints;
- employ the research skills needed to investigate a defined topic under supervision, through an extended individual project;
- interpersonal skills, including the ability to work as a member of a development team, recognising/respecting the viewpoints of others, recognising the different roles within a team and the different ways of organising teams;\*
- problem identification, analysis and solution using critical assessment and reasoned argument;\*
- taking responsibility for own learning and developing habits of reflection on that learning;\*
- skills in written communication, project documentation, verbal presentation; numeracy and computation\*
- use of information technology (including spreadsheets, databases, word processing, email and WWW);\*
- information handling and retrieval (including the use of libraries and computer technology);\*
- ability to work autonomously, and to demonstrate time management and organisational skills;\*

#### *Additional for programmes with a Year in Industry*

- ability to apply knowledge and skills in computing to large-scale practical applications.

\* transferable skills

#### **Teaching, learning and assessment**

Teaching and learning is mostly by means of lectures, small-group tutorials, practical and problem classes, supervised computing laboratory work, group work, completion of coursework and private study, guided independent study and research in the stage three individual project.

Assessment of knowledge and understanding is typically by formal, unseen written examination, coursework assignments, project reports, oral presentations, and the final stage project report. Transferable skills are also inherently assessed through the assignments, reports and oral presentations. Feedback is provided on students' performance in coursework, both assessed and non-assessed, and during tutorial and practical sessions. Full details of the assessments for individual courses can be obtained from the [Department](#).

#### **Details of the programme structure(s)**

Please note that the list of available courses offered is subject to change and not all courses run each year. A full list of courses for the current academic year can be obtained from the [Department](#).

<b>STAGE 1</b>		
CS1811	Object oriented programming I	15 credits

CS1812	Object oriented programming II	15 credits
CS1813	Software development	15 credits
CS1820	Computing laboratory (robotics)	15 credits
CS1830	Computing laboratory (games)	15 credits
CS1840	Internet services	15 credits
CS1860	Mathematical structures	15 credits
CS1870	Machine fundamentals	15 credits
CS1890	Software design	15 credits

<b>STAGE 2</b>			<b>Strand</b>
CS2800	Software engineering	15 credits	
CS2810	Team project	15 credits	
CS2846	Human Computer Interaction	15 credits	
CS2850	Operating systems	15 credits	
CS2855	Databases	15 credits	
CS2860	Algorithms and complexity	15 credits	
CS2900	Multi-dimensional Data Processing	15 credits	AI
CS2910	Introduction to Artificial Intelligence	15 credits	AI
IY2760	Introduction to information security	15 credits	
IY2840	Computer and network Security	15 credits	

<b>STAGE 3</b>			<b>Strand</b>
CS3110	Bioinformatics	15 credits	
CS3220	Digital Audio and Applications	15 credits	
CS3470	Compilers and code generation	15 credits	
CS3490	Computational optimisation	15 credits	
CS3510	Functional programming and applications	15 credits	
CS3870	Advanced Algorithms and Complexity	15 credits	
CS3250	Visualisation and exploratory analysis	15 credits	AI
CS3920	Machine learning	15 credits	AI
CS3930	Computational finance	15 credits	AI
CS3940	Intelligent agents and multi-agent systems	15 credits	AI

CS3945	Semantic Web	15 credits	AI
CS3580	Advanced data communications	15 credits	DNS
CS3750	Concurrent and parallel programming	15 credits	DNS
CS3840	Interconnected devices	15 credits	DNS
IY3501	Security Management	15 credits	IS
IY3606	Smart cards/Token security and applications	15 credits	IS
IY3609	Digital forensics	15 credits	IS
IY3612	Cyber security	15 credits	IS
IY3660	Applications of cryptography	15 credits	IS
IY3840	Malicious software	15 credits	IS
CS3480	Software language engineering	15 credits	SE
CS3846	Human-Computer Interaction ( <i>cannot be taken with CS2846</i> )	15 credits	SE

STAGE 4/5			Strand
CS4001	Year in Industry	30 credits	
CS4821	Computer Science M.Sci. project	60 credits	
CS4822	Computer Science (Artificial Intelligence) M.Sci. project	60 credits	AI
CS4826	MSci Individual Project in Distributed and Networked Systems	60 credits	DNS
IY4500	Information Security M.Sci. project	60 credits	IS
CS4220	Digital audio and applications ( <i>cannot be taken with CS3220</i> )	15 credits	
CS4490	Computational optimization ( <i>cannot be taken with CS3490</i> )	15 credits	
CS4504	Business Intelligence Systems, Infrastructures and Technologies	15 credits	
CS4100	Data analysis	15 credits	AI
CS4200	On-line machine learning	15 credits	AI
CS4250	Visualisation and exploratory analysis ( <i>cannot be taken with CS3250</i> )	15 credits	AI
CS4920	Machine learning ( <i>cannot be taken with CS3920</i> )	15 credits	AI
CS4930	Methods of computational finance ( <i>cannot be taken with CS3930</i> )	15 credits	AI
CS4940	Intelligent agents and multi-agent systems ( <i>cannot be taken with CS3940</i> )	15 credits	AI
CS4945	Semantic Web ( <i>cannot be taken with CS3945</i> )	15 credits	AI
CS4950	Deep Learning	15 credits	AI
CS4234	Large-scale data storage and processing	15 credits	DNS
CS4580	Advanced data communications ( <i>cannot be taken with CS3580</i> )	15 credits	DNS
CS4860	Advanced distributed systems	15 credits	DNS

CS4870	Wireless sensor and actuator networks	15 credits	DNS
IY4501	Security management ( <i>cannot be taken with IY3501</i> )	15 credits	IS
IY4523	Secure business architectures	15 credits	IS
IY4606	Smart cards/Token security and applications ( <i>cannot be taken with IY3606</i> )	15 credits	IS
IY4609	Digital forensics ( <i>cannot be taken with IY3609</i> )	15 credits	IS
IY4610	Security testing theory and practice	15 credits	IS
IY4612	Cyber security ( <i>cannot be taken with IY3612</i> )	15 credits	IS

- Key to the strands of courses presented above:
  - AI – Artificial Intelligence
  - IS – Information Security
  - SE – Software Engineering
  - DNS – Distributed and Networked Systems
- At stage two or stage three, students may choose to substitute a 15 credits course for another one outside the department provided the department approves the external unit. Students taking an industrial year take the additional course CS4001 and thus have 150 credits in their final year.
- While students are normally allocated a specific lab for any given course they are registered for, they may if they wish attend additional labs of that course where space allows.
- Students for each year are expected to take part in the Advanced topics seminar course (CS3010). This course is not part of the degree programme but attendance will be placed in the student's transcripts.

The course units taken for each of the M.Sci. Degree Programmes are as follows:

### **M.Sci. Computer Science G403**

First	CS1811 <i>non-condonable for the purposes of progression</i> CS1812* <i>non-condonable for the purposes of progression</i> CS1820, CS1830, CS1840, CS1860, CS1870, CS1890
Second	CS2800 <i>non-condonable for the purposes of progression</i> CS2810 <i>non-condonable for the purposes of progression</i> CS2850, CS2855, CS2860, IY2760 <i>two further non-project CS2XXX or IY2XXX elective courses</i>
Third	<i>Eight non-project CS3XXX or IY3XXX elective courses</i>
Final	CS4821 <i>non-condonable for degree title</i>

	<i>Four further non-project CS4XXX or IY4XXX elective courses</i>
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### **M.Sci. Computer Science with Year in Industry G404**

First	<i>CS1811 non-condonable for the purposes of progression</i> <i>CS1812* non-condonable for the purposes of progression</i> <i>CS1820, CS1830, CS1840, CS1860, CS1870, CS1890</i>
Second	<i>CS2800 non-condonable for the purposes of progression</i> <i>CS2810 non-condonable for the purposes of progression</i> <i>CS2850, CS2855, CS2860, IY2760</i> <i>two further non-project CS2XXX or IY2XXX elective courses</i>
Third	<i>Eight non-project CS3XXX or IY3XXX elective courses</i>
Fourth	<i>CS4001 non-condonable for degree title</i>
Final	<i>CS4821 non-condonable for degree title</i> <i>Four further non-project CS4XXX or IY4XXX elective courses</i>

### **M.Sci. Computer Science (Artificial Intelligence) GG47**

First	<i>CS1811 non-condonable for the purposes of progression</i> <i>CS1812* non-condonable for the purposes of progression</i> <i>CS1820, CS1830, CS1840, CS1860, CS1870, CS1890</i>
Second	<i>CS2800 non-condonable for the purposes of progression</i> <i>CS2810 non-condonable for the purposes of progression</i> <i>CS2850, CS2855, CS2860, IY2760</i> <i>two further non-project CS2XXX elective courses from the Artificial Intelligence (AI) strand</i>
Third	<i>Eight non-project CS3XXX or IY3XXX elective courses, of which at least two must be from the Artificial Intelligence (AI) strand</i>
Final	<i>CS4822 non-condonable for degree title</i> <i>Four further non-project CS4XXX or IY4XXX elective courses, of which at least two must be from the Artificial Intelligence (AI) strand</i>

### **M.Sci. Computer Science (Artificial Intelligence) with Year in Industry GG74**

First	<i>CS1811 non-condonable for the purposes of progression</i>
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	<p>CS1812* <i>non-condonable for the purposes of progression</i></p> <p>CS1820, CS1830, CS1840, CS1860, CS1870, CS1890</p>
Second	<p>CS2800 <i>non-condonable for the purposes of progression</i></p> <p>CS2810 <i>non-condonable for the purposes of progression</i></p> <p>CS2850, CS2855, CS2860, IY2760</p> <p><i>two further non-project CS2XXX elective courses from the Artificial Intelligence (AI) strand</i></p>
Third	<p><i>Eight non-project CS3XXX or IY3XXX elective courses, of which at least two must be from the Artificial Intelligence (AI) strand</i></p>
Fourth	<p>CS4001 <i>non-condonable for degree title</i></p>
Final	<p>CS4822 <i>non-condonable for degree title</i></p> <p><i>Four further non-project CS4XXX or IY4XXX elective courses, of which at least two must be from the Artificial Intelligence (AI) strand</i></p>

#### **M.Sci. Computer Science (Distributed and Networked Systems) G4G5**

First	<p>CS1811 <i>non-condonable for the purposes of progression</i></p> <p>CS1812* <i>non-condonable for the purposes of progression</i></p> <p>CS1820, CS1830, CS1840, CS1860, CS1870, CS1890</p>
Second	<p>CS2800 <i>non-condonable for the purposes of progression</i></p> <p>CS2810 <i>non-condonable for the purposes of progression</i></p> <p>CS2850, CS2855, CS2860, IY2760, IY2840</p> <p><i>One further non-project CS2XXX or IY2XXX elective courses</i></p>
Third	<p><i>Eight non-project CS3XXX or IY3XXX elective courses, of which at least one must be from the Distributed and Networked Systems (DNS) strand</i></p>
Final	<p>CS4826 <i>non-condonable for degree title</i></p> <p><i>Four further non-project CS4XXX or IY4XXX elective courses, of which at least one must be from the Distributed and Networked Systems (DNS) strand</i></p>

#### **M.Sci. Computer Science (Distributed and Networked Systems) with Year in Industry G4G9**

First	<p>CS1811 <i>non-condonable for the purposes of progression</i></p> <p>CS1812* <i>non-condonable for the purposes of progression</i></p> <p>CS1820, CS1830, CS1840, CS1860, CS1870, CS1890</p>
Second	<p>CS2800 <i>non-condonable for the purposes of progression</i></p>



	<p>CS2810 non-condonable for the purposes of progression</p> <p>CS2850, CS2855, CS2860, IY2760</p> <p>Two further non-project CS2XXX or IY2XXX elective courses</p>
Third	<p>Eight non-project CS3XXX or IY3XXX elective courses, of which at least one must be from the Distributed and Networked Systems (DNS) strand</p>
Fourth	<p>CS4001 non-condonable for degree title</p>
Final	<p>CS4826 non-condonable for degree title</p> <p>Four further non-project CS4XXX or IY4XXX elective courses, of which at least one must be from the Distributed and Networked Systems (DNS) strand</p>

### M.Sci. Computer Science (Information Security) G500

First	<p>CS1811 non-condonable for the purposes of progression</p> <p>CS1812* non-condonable for the purposes of progression</p> <p>CS1820, CS1830, CS1840, CS1860, CS1870, CS1890</p>
Second	<p>CS2800 non-condonable for the purposes of progression</p> <p>CS2810 non-condonable for the purposes of progression</p> <p>CS2850, CS2855, CS2860, IY2760, IY2840</p> <p>One further non-project CS2XXX or IY2XXX elective course</p>
Third	<p>IY3840, IY3660</p> <p>Six further non-project CS3XXX or IY3XXX elective courses from the above Stage 3 list, with a maximum of two from the Information Security (IS) strand</p>
Final	<p>IY4500 non-condonable for degree title</p> <p>IY4501, IY4523, IY4610</p> <p>One further non-project CS4XXX or IY4XXX elective course</p>

### M.Sci. Computer Science (Information Security) with Year in Industry G502

First	<p>CS1811 non-condonable for the purposes of progression</p> <p>CS1812* non-condonable for the purposes of progression</p> <p>CS1820, CS1830, CS1840, CS1860, CS1870, CS1890</p>
Second	<p>CS2800 non-condonable for the purposes of progression</p> <p>CS2810 non-condonable for the purposes of progression</p>

	CS2850, CS2855, CS2860, IY2760, IY2840 <i>One further non-project CS2XXX or IY2XXX elective course</i>
Third	IY3840, IY3660 <i>Six further non-project CS3XXX or IY3XXX elective courses from the above Stage 3 list, with a maximum of two from the Information Security (IS) strand</i>
Fourth	CS4001 <i>non-condonable for degree title</i>
Final	IY4500 <i>non-condonable for degree title</i> IY4501, IY4523, IY4610 <i>One further non-project CS4XXX or IY4XXX elective course</i>

\* Students taking the above degree programmes may take CS1813 instead of CS1812 as *non-condonable for the purposes of progression* at the discretion of the department.

### Progression and award requirements

The College's [Undergraduate Regulations](#) include full details on progression and award requirements for all undergraduate programmes offered by the College. On some programmes there may be a requirement to pass specific courses in order to progress to the next stage or to qualify for a particular degree title and this will put restrictions on courses in which failing marks can be condoned (see programme structure above for details). Additionally there are requirements on the number of courses that must be passed in order to qualify for particular joint or combined Honours degrees.

Note that the College progression requirements for MSci programmes are different to those for BSc programmes.

Students on degree programmes with Year in Industry need to fulfil the requirements set out in the departmental Year in Industry Handbook in order to progress to the placement and be eligible for the degree title.

### Student support and guidance

- Tutor: All students are allocated a personal academic tutor who meets with them regularly through the programme. The tutor's role is to advise on academic, pastoral and welfare issues. Students have tutorials with their tutor during the first year.
- The programme co-ordinator, the director of pastoral care, the director of undergraduate studies and the head of department provide a back-up system of academic, pastoral and welfare advice.
- All staff are available and accessible. Initial contact can be arranged via email or through the departmental office.
- A student handbook is supplied to every student, and course notes and other learning resources are available either in hard copy or on the department's web site.
- Induction sessions are run at the start of each academic year by technical support staff on the use of the departmental computing systems.
- Technical back up is provided by the systems support staff for problems with using the departmental computing system.

- Extensive supporting materials and learning resources are available in the College libraries and the Computer Centre.
- Careers advice is provided by the [College Careers and Employability Service](#) and the Departmental Employability Tutor.
- Students have access to all College and University support services, including Student Counselling Service, Health Centre and the Disability and Dyslexia Services for students with disabilities and Specific learning Difficulties.

### Admission requirements

Details of the Department's typical offer for each programme of study is available on the [Course Finder](#) web page. However, the Department also has flexibility in its admissions and offers policy and strongly encourages applications from non-standard applicants. Students whose first language is not English may also be asked for a qualification in English Language at an appropriate level. For further guidance it may also be helpful to contact the [Recruitment and Partnership Office](#).

### Further learning and career opportunities

Computer Science opens up a wide range of career opportunities for graduates and the department has a number of important links with industry. Computer Science graduates from the Department have found employment in a wide range of jobs. Many have gone into software houses such as Logica, while others have entered larger organisations such as British Telecom, Texas Instruments and BAE Systems. A large number enter careers with a management or financial slant, for example Accenture or large multi-national companies. The College Careers Office organises recruitment visits by companies and there are a number of careers fairs during the year when final year students can make useful contacts with prospective employers. In addition, the industrial year programme allows students to work within a company for one year between the second and final years. Students taking this option often find that the employer will encourage them to apply for posts at the completion of their degree. For further details please refer to the [Careers and Employability Service](#).

### 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.

Computer Science is 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.

With the exception of the MSci Computer Science (Distributed and Networked Systems) and its Year in Industry variant all of the MSci single-honours degree programmes in Computer Science are accredited by the British Computer Society and by the European Quality Assurance Network (EQANIE). The 2014 BCS accreditation visit panel also identified our teaching of Software Engineering as an area of best practice. In addition, the MSci Computer Science (Information Security) degree has received provisional certification by GCHQ. Note that

accreditation is given on an individual student basis as accrediting bodies apply specific criteria (e.g. conditional to certain courses being passed). Details can be found in the student handbook published by the department at the start of the academic year.

In the 2014 National Student Survey the Computer Science Department was joint sixth in the UK (third in England) rankings for Computer Science departments.

### **List of programmes**

All the programmes are taught by staff at Royal Holloway, University of London, and either lead to degree awards of the University of London or alternatively Diploma of Higher Education awards of Royal Holloway and Bedford New College. The QAA subject benchmark statement in Computer Science describes the general features which one might expect from Honours Degree programmes in the subject, and can therefore be used as a point of reference when reading this document (see [www.qaa.ac.uk](http://www.qaa.ac.uk)). UCAS codes are given in parentheses (see [www.ucas.ac.uk](http://wwwucas.ac.uk)).

### **MSci Honours Degree programmes in Computer Science**

MSci Computer Science (G403)

MSci Computer Science with Year in Industry (G404)

### **Specialist Honours Degree programmes within Computer Science**

MSci Computer Science (Artificial Intelligence) (GG47)

MSci Computer Science (Artificial Intelligence) with Year in Industry (GG74)

MSci Computer Science (Distributed and Networked Systems) (G4G5)

MSci Computer Science (Distributed and Networked Systems) with Year in Industry (G4G9)

### **Combined Honours Degree programmes with Computer Science as a major component**

MSci Computer Science (Information Security) (G500)

MSci Computer Science (Information Security) with Year in Industry (G502)