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Disclaimer

This document was published in September 2016 and was correct at that time. The Department* reserves the right to modify any statement if necessary, make variations to the content or methods of delivery of programmes of study, to discontinue programmes, or merge or combine programmes if such actions are reasonably considered to be necessary by the College. Every effort will be made to keep disruption to a minimum, and to give as much notice as possible.

* Please note, the term ‘Department’ is used to refer to both ‘Departments’, ‘Centres’ and ‘Schools’. Students on joint or combined degree programmes will need to use two departmental handbooks.

An electronic copy of this handbook can be found on your Departmental website https://www.royalholloway.ac.uk/mathematics/home.aspx where it will be possible to follow the hyperlinks to relevant webpages.
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1 Introduction to the Department

1.1 Welcome

Welcome to the Department of Mathematics.

This booklet contains important information for graduates registered for a taught degree programme in Mathematics; please read it carefully.

The Department complies with the College Regulations, Student Charter and Codes of Practice. The Codes of Practice cover Academic Welfare, Freedom of Speech, Student Union Affairs, Personal Harassment, and Health and Safety. No interpretation of the information presented here should conflict with these regulations or a Code of Practice. In the case of any apparent difference, the College regulations will prevail.

A satisfactory programme of study at university requires students and the Department to enter an informal `contract' of obligations and expectations by which all should abide.

What you can expect from us:

The Mathematics Department is committed to effective teaching, but we judge our success in terms of how well you learn. We will do all we can to stimulate your interest in Mathematics, to make the aims of each course clear, to train you by means of interesting coursework and projects, to provide appropriate support, and to monitor and guide your progress. We hope our enthusiasm for the subject will prove infectious and will motivate you to pursue your studies energetically. Most of all, we hope you will find the Department a friendly, supportive and inspiring place in which to work.

You can expect the Department to:

- provide lectures and projects in a series of course units which will make up your degree programme;
- help finding a research topic and a supervisor for your dissertation;
- take reasonable steps to assist students who are disadvantaged through illness or other problems;
- nominate a personal adviser who will act as your point of contact with the Department;
- assess and examine your work;
• provide verbal or written feedback on coursework and drafts of your dissertation where appropriate;

• provide a feedback mechanism for student evaluation of courses through questionnaires;

• provide reasonable notice of all coursework deadlines at lectures or electronically;

• treat all students in a fair and just manner without any form of prejudice.

What we expect from you:

Your degree course should challenge you to deal with difficult concepts, to become skilled in new and demanding techniques, and to push your intellectual powers to the limit. If not, then you will not have used your opportunity to the full. The MSc and PgDip programmes aim to provide students with a solid mathematical foundation and a knowledge and understanding of the subjects of cryptography and communications, and various applications of mathematics, as appropriate. Students who successfully complete the programme will be prepared for research or professional employment in these areas.

Employers and PhD supervisors are not only interested in the knowledge you have acquired, though knowledge is obviously relevant to careers in mathematics. They are also interested in personal qualities like self-reliance and initiative, and in your capacity to think rationally and independently, to work in a team, to write clear reports within a firm deadline, and so on.

These qualities cannot be taught. They depend on many factors, among them the energy you put into your studies and the drive with which you pursue your career goals. We want you to enjoy your studies and your time here; when you enjoy what you do, you will work harder and learn more effectively.

You are expected to:

• attend all lectures, workshops and tutorials;

• keep your personal adviser fully informed of any problems which may affect your studies;

• complete all coursework and attend all examinations;
hand in coursework by the set deadline;
fill in all course questionnaires (anonymously) and provide constructive feedback;
check your College e-mail daily;
check your Moodle course pages regularly;
always behave in a manner which reflects well on the Department and the College.

1.2 How to find us: the Department

The Department of Mathematics is located in the McCrea Building, at the centre of the campus and close to the spectacular Founder's Building. This can be found on the College campus map as building 17.

1.3 Map of the Egham campus

Student parking is limited and a parking permit is required. This can be obtained via Security. You will need proof of insurance and ID before a permit will be issued.
1.4 How to find us: the staff

Academic staff all have offices in the McCrea Building. You should only visit them during their office hours; these are posted on the door of their office and on the Department’s website. If you cannot visit during office hours, please email the staff member asking for an appointment and saying when you are free. There is a staff list with office information on the Department’s website, and in the foyer of the McCrea Building.

If you have problems, the following list shows who to contact:

- **Course units** – the lecturer
- **Course selection** – your personal adviser
- **Your degree programme** – your personal adviser and the MSc Programme director
- **A personal problem** – your personal adviser, or the Welfare Services (Counsellors, Health Centre, Chaplaincy, Student Union)
- **A problem common to other students** – the lecturer, your Student-Staff Committee representative
- **College registration, enrolment, fees, accommodation, loans etc.** – the Student Administration Centre

Your key contacts for 2016-17 are:

- **Personal Adviser**: You will be allocated a Personal Adviser during Induction week (see 2.5 for the role of Personal Advisers)
- **School Manager**: Mrs Lisa Cavey 01784 443085 Lisa.Cavey@rhul.ac.uk
- **Computer Technical Support**: cimhelpdesk@rhul.ac.uk 01784 44 3443
- **MSc Programme Director**: Dr Teo Sharia, 01784 414331 t.sharia@rhul.ac.uk
- **Disability & Dyslexia Services and Health & Safety Coordinator**: Mrs Lisa Cavey 01784 443085
- **Admin Support**: Ms Jenny Lee 01784 443091 jenny.lee@rhul.ac.uk
1.5 How to find us: the Departmental office

The Departmental Office is in room MC247. The office’s opening hours are 08.30-16.30. You can phone the Office on 01784 44 3091/3093, or you can email maths@rhul.ac.uk.

1.6 The Department: practical information

Safety. Please make yourself aware of the procedure for fire evacuation. The Mathematics Assembly Point is between McCrea and Horton, at Fire Assembly Point 11.

Smoking. Please note that smoking is not allowed in the McCrea Building.

1.7 Staff research interests

The research interests in the Department include information security, cryptography, coding theory, algebra, number theory, graph theory, the mathematics of atomic processes, quantum theory, quantum https://pure.royalholloway.ac.uk/portal/en/organisations/department-of-mathematics%287ff3623d-1e5a-45d1-8ab1-6929b58c0f0b%29.html

2 Communication

It is vitally important that you keep in touch with us and we keep in touch with you. Members of staff will often need to be able to contact you to inform you about changes to teaching arrangements, special preparations you may have to do for a class or meetings you might be required to attend. You will need to be able to contact members of the Department for example, if you are unable to attend a class, or wish to arrange a meeting with a tutor or your Personal Adviser.

Email to your College email address is routinely used and you should check regularly (at least daily) if any official communication has been sent to your email address. Do not ignore the email as it will be assumed that it will have been received by you within 48 hours, excluding Saturdays and Sundays.

You should also make a habit of checking the student pigeonholes in the
2.1 Email

The College provides an email address for all students free of charge and stores the address in a College email directory (the Global Address List. Your account is easily accessed, both on and off campus, via the student portal https://campus-connect.rhul.ac.uk/cp/home/displaylogin (Campus Connect) or direct via Outlook.com http://outlook.com/ Email to this address will be used routinely for all communication with students. Email may be used for urgent communication and by course tutors to give or confirm instructions or information related to teaching so it is important that you build into your routine that you check your emails once a day. Email communications from staff and all the Faculty Administrators should be treated as important and read carefully.

The College provides a number of PC Labs around Campus for student use, and you can also use your own laptop/smart phone etc, so the Department expects you to check your email regularly. It is also important that you regularly clear your College account of unwanted messages or your in-box may become full and unable to accept messages. Just deleting messages is not sufficient; you must clear the ‘Sent Items’ and ‘Deleted Items’ folders regularly. It is your responsibility to make sure your College email account is kept in working order. If you have any problems contact the IT Service Desk http://itservicedesk.rhul.ac.uk/

The Mathematics Department will only use the address in the College Global Address List and does not use private or commercial email addresses, such as Hotmail or Gmail. Students who prefer to use commercial email services are responsible for making sure that their College email is diverted to the appropriate commercial address. Detailed instructions on how to forward mail can be accessed by visiting http://help.outlook.com/ and searching for forwarding (you may need to use IE browser to access this as the link does not work on some browsers). This process is very easy, but you do have to maintain your College account. When you delete a forwarded message from, say, Hotmail, it will not be deleted from the Royal Holloway account. It is your responsibility to log on to your College account occasionally and conduct some account maintenance or your account may become full and therefore will not forward messages.

If you send an email to a member of staff in the Department during term time you should normally receive a reply within 3-4 working days of its receipt. Please remember that there are times when members of staff are away from College at conferences or undertaking research.
2.2 Post

All post addressed to MSc students in the Mathematics Department is delivered to the student pigeonholes (alphabetical by surname) in the foyer of the McCrea building. At the end of each term student pigeonholes are cleared of accumulated mail which is then destroyed. Important information from Registry is often sent by internal post and tutors sometimes return work to you via the pigeonholes so you are advised to check them regularly.

2.3 Telephone and postal address

It is your responsibility to ensure that your telephone number (mobile and landline) and postal address (term-time and forwarding) are kept up to date on the student portal (Campus Connect) https://campus-connect.royalholloway.ac.uk/cp/home/displaylogin. There are occasions when the Department needs to contact you urgently by telephone or send you a letter by post.

The Department does not disclose students’ addresses and telephone numbers to anybody else (including relatives and fellow students) without the student’s specific permission to do so.

2.4 Notice boards

The general student noticeboards are in the foyer of the McCrea building. There is a noticeboard especially for MSc students in McCrea between rooms MC250 and MC253.

Every effort is made to post notices relating to class times etc well in advance, but occasionally changes have to be made at short notice and in that case email will be used.

It is your responsibility to check the times and venues of all class meetings and of any requirements (e.g. essay deadlines) relating to your courses, so, if in doubt, please ask!

2.5 Personal Advisers

Each student has a personal adviser. The personal adviser may help with course choices, and with finding a dissertation topic and supervisor. The adviser provides a point of contact between students and the Mathematics Department.

2.6 Questionnaires

Towards the end of each teaching term there will be a questionnaire for each course. At the end of the programme we will ask the students to fill
out a questionnaire to evaluate the entire programme.

3  Teaching

3.1 Dates of terms

Term dates can be found on the College website
http://www.royalholloway.ac.uk/aboutus/collegecalendar/home.aspx

You are expected to be in the UK and engaging with your studies during term time. In the case of an emergency which requires you to leave the country and/ or miss lectures/ seminars/ practical’s etc., you are expected to keep your department informed and fill in a Notification of Absence Form (see 3.3 below). During the summer term, after the summer examination period, you are expected to attend all required academic activities organized by your department(s) and to be available should you be required to meet with College staff for any reason. Furthermore as Master’s programmes run for one calendar year from September to September you are also supposed to be available to meet with staff after the official end of term should this be required, that is, during the summer vacation period.

3.2 Reading weeks

There are no reading weeks during term times.

3.3 Attending classes and engaging with your studies

The College has a responsibility to ensure that all students are attending regularly and progressing with their studies. While it is essential that you attend all the compulsory learning activities related to your programme of study, the College recognises that emergencies may occur at any time throughout the year. In light of this, the Mathematics Department has set a minimum attendance level at 80%. You should be aware that you may also study courses that have different and specific course attendance requirements, particularly if you are taking courses in another department, so it is essential that you check all programme and course handbooks to ensure you are fully aware of the requirements.

Your regular attendance in class and consistent engagement with your studies are fundamental requirements of your learning experience with the College. As such, failure to attend and/or absence without permission can result in serious consequences and may lead to disciplinary action, including the termination of your registration (see 3.3.6 below). Your ‘classes’ are any learning or teaching activity deemed essential to your programme of study. The term is used to encompass a variety of different
activities, including lectures, seminars, tutorials, workshops, field work, laboratory work, and meetings your Personal Advisor.

It is vital that you manage your time effectively, so that any paid employment, voluntary work, extracurricular activities or social commitments do not interfere with periods where you are required to attend classes. With regard to paid employment during the course of your programme of study with the College, the **Postgraduate Taught Regulations** ([http://www.royalholloway.ac.uk/ecampus/academic Support/regulations/home.aspx](http://www.royalholloway.ac.uk/ecampus/academic Support/regulations/home.aspx)) stipulate that the amount of paid work undertaken by a student enrolled with the College on a full-time basis shall not exceed 20 hours per week during term time. No student may undertake paid work which may conflict with his/her responsibilities as a student of the College.

If you face difficulty in attending any classes or undertaking an assessment it is very important that you inform the department(s) in which you are studying as early as possible, citing the reasons for your non-attendance. The department will make a decision on whether or not to authorize your absence. If you are experiencing such difficulties on an ongoing basis, please contact your Personal Adviser or Year Tutor. In addition, an extensive range of additional support, guidance and advice is readily available from the College’s Student Advisory Service ([https://www.royalholloway.ac.uk/ecampus/welfare/home.aspx](https://www.royalholloway.ac.uk/ecampus/welfare/home.aspx)). The Students’ Union also operate an Advice and Support Centre, details on which can be found here [http://www.su.rhul.ac.uk/advice/](http://www.su.rhul.ac.uk/advice/).

### 3.3.1 Your responsibilities in relation to attendance

Your responsibilities around attendance and engagement include:

- attending all classes necessary for the pursuit of your studies (including lectures, seminars, practicals and personal tutorials);
- undertaking all summative and formative assessment requirements for your courses;
- attending all meetings and other activities as required by the department(s) in which you are studying;
- where you experience any form of difficulty in attending classes, for whatever reason, contacting the department(s) in which you are studying to notify them of your circumstances at the earliest possibility.

You are expected to fully engage in your classes, undertaking any reading, research or further preparation identified between these sessions alongside punctual attendance. It is essential that you make suitable arrangements for travel to your classes and plan to arrive in
good time, as teaching will start at five minutes past the hour and finish five minutes before the hour. You will normally be marked absent if you turn up late without good reason.

3.3.2 Departments’ responsibilities for monitoring attendance

The Mathematics Department will monitor your attendance at lectures, workshops and tutorials. It is your responsibility to complete any attendance register that is circulated and to make sure that your attendance has been noted. The activities at which your attendance is monitored may vary depending upon the discipline in which you are studying or the department in which you are taking courses in the case of electives, for example.

It is important that you attend all the learning activities related to your programme of study. Whilst attendance is compulsory at all learning activities, it is recognised that emergencies may occur at any time throughout the year and therefore as indicated above a minimum attendance requirement has been set.

You will be contacted in the event that:

i. you fail to attend for two weeks without providing notification of your absence;
ii. you display a pattern of absence that the department feel is affecting or is likely to affect your work
iii. you display a pattern of absence that the department feel is a cause for concern over your wellbeing or may point to a disability which you may not have disclosed.

3.3.3 College’s responsibilities for monitoring attendance

The College has a number of important obligations in relation to monitoring your attendance and engagement, including legal responsibilities under the Equality Act (2010). As a result, the College may adjust the attendance requirement for your programme but will only do this when such adjustment does not compromise competence standards or your ability to reach the learning outcomes of your programme. Any need to adjust attendance requirements will be treated case by case and discussed by the department with the Disability and Dyslexia Services (DDS) and Academic Quality & Policy Office (AQPO).

The College also has obligations places on it by UK Visas and Immigration (UKVI) – see 3.3.7 below.
3.3.4 Missing classes

If you are unable to attend College for whatever reason you must advise the department in which you taking the course(s) in question and complete the relevant Notification of Absence Form, which is available online.

https://www.royalholloway.ac.uk/ecampus/academicsupport/attendance/notificationofabsence.aspx

Figure 1 - Notification of Absence Form – Absence Due to Illness

This must be submitted to the relevant department(s) together with the relevant supporting documentation either before your absence or within five working days of the end of the period of absence.

You should:

a. advise the departments(s). This is done by sending an email to MathsAttendance@rhul.ac.uk.

b. complete the Notification of Absence Form, copies of which are also available from the Health Centre.
c. submit the paperwork to your department(s) either before your absence or within FIVE working days of the end of the period of absence. Failure to do so may result in the absence being counted as unacceptable and counting against the minimum attendance level.

d. meet any departmental requirements concerning notification of absence or request for leave of absence as you may be required to meet formally with an academic tutor.

This table shows the documentation that is required should you be absent for any reason.

<table>
<thead>
<tr>
<th>Reason for absence</th>
<th>Documentation required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illness up to and including 5 consecutive term-time days (excluding Saturdays and Sundays)</td>
<td>Completed Notification of Absence Form – Self Certification</td>
</tr>
<tr>
<td>Illness for more than 5 consecutive term-time days (excluding Saturdays and Sundays)</td>
<td>Completed Notification of Absence Form – Self Certification plus Formal Medical Certification signed by the Health Centre, your GP or hospital consultant</td>
</tr>
<tr>
<td>Unrelated to sickness</td>
<td>Notification of Absence Form plus supporting evidence</td>
</tr>
<tr>
<td>Leave of absence request</td>
<td>Notification of Absence Form plus any departmental requirement must be met</td>
</tr>
</tbody>
</table>

Note:
- If you are absent for a prolonged period it is essential that you keep in touch with the Department (e.g. through regular emails with your Personal Advisor).
- The Department will monitor the frequency of self-certified absences and the Head of Department may request a doctor’s medical certificate from you in the event of multiple and/or sustained instances of self-certified illness.
- The departments in which you are studying are responsible for monitoring your attendance and engagement, and deciding whether a period of absence is deemed acceptable or unacceptable (for further information please refer to the online guidance http://www.rhul.ac.uk/ecampus/academicsupport/attendance/notificationofabsence.aspx for details of what constitutes 'acceptable' and 'unacceptable' circumstances relating to absence). If deemed unacceptable the absence will be recorded as such and will count against your minimum attendance level.
3.3.5 Missing an examination

In the event that you are unable to attend an exam (e.g. through reasons of sudden illness), it is essential that you notify Student Administration at the very earliest possibility. Wherever possible, please try to ensure you contact them via e-mail at student-administration@rhul.ac.uk before the scheduled start of the exam with your name, student ID and confirmation of the exam that you are unable to attend. Please include a brief explanation within the email outlining the reasons for the non-attendance.

This notification will then be forwarded by Student Administration to your department so that they are aware of your non-attendance.

Please note, this notification is not a substitute for formally notifying your department of Extenuating Circumstances. It is essential that you inform your department and Chair of the Sub-board of Examiners by completing the Extenuating Circumstances form. For further information, please refer to the website https://www.royalholloway.ac.uk/ecampus/academicsupport/examinations/extenuatingcircumstances.aspx.

In the event that you do not complete the Extenuating Circumstances form, your department will be unable to consider the reasons for your non-attendance at your departmental Sub-Board of Examiners.

3.3.6 Consequences of failing to attend

As indicated in 3.3.2 above the Department may contact you if there are concerns about your attendance.

Should it become apparent that there are no acceptable reasons for your non-attendance and/or general lack of engagement with your studies, the Department may issue you with a formal warning which can escalate to the termination of your registration at the College. You are strongly advised to read the guidance on the formal warning process and the consequences of receiving such a warning on http://www.royalholloway.ac.uk/ecampus/academicsupport/formalwarnings/formalwarnings.aspx and in the relevant regulations. http://www.royalholloway.ac.uk/ecampus/academicsupport/regulations/home.aspx.

In situations where you are experiencing documented severe difficulties the Department and College will make every effort to support you and counsel you as to the best course of action. However, there may be cases where, although non-attendance is explained by an acceptable reason, your level of attendance falls to a level which compromises
educational standards and/or your ability to reach the learning outcomes of the course. In such cases it will be necessary to implement disciplinary procedures as detailed above.

3.3.7 Withdrawal of visa

If you are in receipt of a Tier-4 (General) Student Visa sponsored by Royal Holloway, it is a requirement of your Visa that you attend classes and complete assessments. This is also a requirement of the College's academic regulations. The College has a legal responsibility to report any student admitted to the College on a student visa who does not appear to be in attendance to UK Visas and Immigration (UKVI). Therefore if you fail to meet UKVI visa requirements and/or fail to respond to informal and formal warnings from the College in this regard you could have your sponsorship withdrawn, your Visa cancelled and your registration with the College terminated. The termination of registration due to a breach in Visa requirements is conducted independently of the College’s formal warning process and the decision is not open to appeal.

Please see the College Postgraduate Taught Regulations (http://www.rhul.ac.uk/ecampus/academicsupport/regulations/home.aspx)

4 Degree Structure

The full time MSc lasts for 50 weeks, from late September until beginning of September of the following year. The full time PgDip lasts from late September until early June of the following year.

The MSc is examined in two parts: by written examination (mainly in May), and by a dissertation on a main project to be submitted early in September. This is called the main project to distinguish it from any projects that form part of a course unit. The PgDip has the same course structure but there is no main project.

Students initially choose 8 courses of which they specify 6 courses (20 credits each) during the second term that will count towards the examination. The two unspecified courses are ‘electives’. Elective courses appear on students’ transcripts but do not contribute to the final degree classification.

The 6 specified courses carry 20 credits each. The main project carries 60 credits, so that each MSc student will be registered for 6×20+60=180 credits and PgDip students will be registered for 6×20=120 credits.

Students write at least the 6 examination papers of their specified courses but may choose to write examination papers in their elective courses in addition.
The marks for the elective courses will appear on their transcript but do not count towards the degree classification.

A part time MSc lasts for 102 weeks, from September to September two years later. Part-time Masters Students are typically expected to take four courses in their first year (typically the core courses would be taken in the first year) and complete the remaining courses and the dissertation in the second year. They will only be permitted to proceed to the second year if they pass at least three courses by the end of the first year. Part-time students will be encouraged to begin work on their dissertation during the summer between their first and second years.

The Examinations office will probably ask you to specify the examination papers that you intend to write very early. The reason is the involved exam timetable. In the past, the department was able to negotiate a later deadline, watch out for information (by email) from the programme director.

Full details about your programme of study, including, amongst others, the aims, learning outcomes to be achieved on completion, courses which make up the programme and any programme-specific regulations are set out in the programme specification available through http://www.royalholloway.ac.uk/coursecatalogue/home.aspx or http://www.royalholloway.ac.uk/studyhere/progspecs/home.aspx

4.1 List of Courses

Core Courses on the MSc Mathematics for Applications

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<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Term</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT5400</td>
<td>Main Project</td>
<td>Summer</td>
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</tbody>
</table>

Core Courses on the MSc Mathematics of Cryptography and Communications

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Term</th>
<th>Lecturer</th>
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<tbody>
<tr>
<td>MT5400</td>
<td>Main Project</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>MT5441</td>
<td>Channels</td>
<td>1</td>
<td>Dr Kay</td>
</tr>
<tr>
<td>MT5462</td>
<td>Advanced Cipher Systems</td>
<td>1</td>
<td>Dr Ng</td>
</tr>
<tr>
<td>MT5461</td>
<td>Theory of Error Correcting Codes</td>
<td>2</td>
<td>Professor Murphy</td>
</tr>
<tr>
<td>MT5466</td>
<td>Public Key Cryptography</td>
<td>2</td>
<td>Professor Murphy</td>
</tr>
</tbody>
</table>
### Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Term</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT5400</td>
<td>Main Project</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>MT5414</td>
<td>Principles of Algorithm Design</td>
<td>1</td>
<td>Dr Gerke</td>
</tr>
<tr>
<td>MT5441</td>
<td>Channels</td>
<td>1</td>
<td>Dr Kay</td>
</tr>
<tr>
<td>MT5454</td>
<td>Combinatorics</td>
<td>1</td>
<td>Professor Blackburn</td>
</tr>
<tr>
<td>MT5462</td>
<td>Advanced Cipher Systems</td>
<td>1</td>
<td>Dr Ng</td>
</tr>
<tr>
<td>MT5485</td>
<td>Applications of Field Theory</td>
<td>1</td>
<td>Professor Dietmann</td>
</tr>
<tr>
<td>MT5412</td>
<td>Computational Number Theory</td>
<td>2</td>
<td>Dr Widmer</td>
</tr>
<tr>
<td>MT5432</td>
<td>Inference</td>
<td>2</td>
<td>Dr Sharia</td>
</tr>
<tr>
<td>MT5436</td>
<td>Applied Probability</td>
<td>2</td>
<td>Dr Koloydenko</td>
</tr>
<tr>
<td>MT5445</td>
<td>Quantum Information and Coding</td>
<td>2</td>
<td>Dr Kay</td>
</tr>
<tr>
<td>MT5448</td>
<td>Advanced Financial Mathematics</td>
<td>2</td>
<td>Professor Schack</td>
</tr>
<tr>
<td>MT5461</td>
<td>Theory of Error Correcting Codes</td>
<td>2</td>
<td>Professor Murphy</td>
</tr>
<tr>
<td>MT5466</td>
<td>Public Key Cryptography</td>
<td>2</td>
<td>Professor Murphy</td>
</tr>
<tr>
<td>MT5491</td>
<td>Topology</td>
<td>2</td>
<td>Professor Nucinkis</td>
</tr>
</tbody>
</table>

Note that some courses consist of 3 lectures a week, and others consist of 4 lectures a week. Courses with 4 lectures a week: MT5461, MT5462, MT5432, MT5436. Ask the lecturer for details.

This booklet gives descriptions of all postgraduate (MT5xxx) courses. Note that many of these courses are related to the corresponding third year and fourth year (MSci) courses and the corresponding course numbers are different but related: for example MT5485 (MSc) is related to MT4850 (MSci) and MT3850 (BSc).

The following final year undergraduate, and MSc courses may be relevant. The syllabi are on the web sites: [https://www.royalholloway.ac.uk/mathematics/informationforcurrentstudents/nextyearcourses/201415undergraduate.aspx](https://www.royalholloway.ac.uk/mathematics/informationforcurrentstudents/nextyearcourses/201415undergraduate.aspx) and [https://www.royalholloway.ac.uk/isy/informationfornewreturningstudents/mscsyllabus.aspx](https://www.royalholloway.ac.uk/isy/informationfornewreturningstudents/mscsyllabus.aspx)
<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT3200</td>
<td>Quantum Theory I</td>
<td>1</td>
</tr>
<tr>
<td>MT3220</td>
<td>Dynamics of Real Fluids</td>
<td>2</td>
</tr>
<tr>
<td>MT3340</td>
<td>Time Series Analysis</td>
<td>1</td>
</tr>
<tr>
<td>MT3470</td>
<td>Mathematics of Financial Markets</td>
<td>1</td>
</tr>
<tr>
<td>MT3110</td>
<td>Number Theory</td>
<td>1</td>
</tr>
<tr>
<td>MT3280</td>
<td>Non-Linear Dynamical Systems</td>
<td>1</td>
</tr>
<tr>
<td>MT3860</td>
<td>Groups and Group Actions</td>
<td>2</td>
</tr>
<tr>
<td>IY5511</td>
<td>Network Security</td>
<td>1</td>
</tr>
<tr>
<td>IY5512</td>
<td>Computer Security</td>
<td>1</td>
</tr>
<tr>
<td>IY5604</td>
<td>Database Security</td>
<td>2</td>
</tr>
<tr>
<td>IY5605</td>
<td>Cyber Crime</td>
<td>2</td>
</tr>
<tr>
<td>IY5607</td>
<td>Software Security</td>
<td>2</td>
</tr>
</tbody>
</table>

### 4.2 Course choices

Each student should attend lectures on 8 taught courses. MSc students write a dissertation in addition.

For the Cryptography and Communications programme, the eight taught courses should include the core courses listed above. At the discretion of the Programme Director, the requirement to take a core course may be dropped if a student has already taken an equivalent course at a comparable level as part of their previous studies (in which case the student will take an extra optional course). Recommended optional courses for the MSc of Cryptography and Communications are Applications of Field Theory (MT5485), Computational Number Theory (MT5412), Combinatorics (MT5454), and Principles of Algorithm Design (MT5414).

Students on the MSc Mathematics for Applications may choose from the whole range of MT5xxx courses.

A student may also, in agreement with the Programme Director, choose courses from the third year options of the undergraduate degree programme in Mathematics (MT3xxx range), and from the list of MSc courses in Information Security (IY5xxx range). Normally, permission will only be given if the material has not been covered as part of their previous studies. Note that these courses can only be taken as `electives', and the marks obtained in such courses cannot be included in the calculation of the degree classification.

All MSc students (but not PgDip students) will do a main project, MT5400, which is a major piece of independent study. This project work will be undertaken under the supervision of a member of staff. The assessment will be on the basis of a written dissertation; the examiners may also at their discretion require an oral examination. Please refer to Section 6.2 for more information on the dissertation. The dissertation must be submitted by the first Thursday of September of the calendar year of completion of the written part of the
examination by 2pm (14:00).

The final assessment is based on the courses and dissertation listed above.
- 66.7% of the assessment is taken to be the average mark of the six weighted taught courses. The six weighted taught courses over which the marks are averaged must all be of Masters level.
- 33.3% of the assessment is on the written dissertation.

4.3 Course registrations

While you have the option of changing course unit registrations within the first two weeks after the start of teaching (excluding Welcome Week) subject to agreement from the department, once you have submitted assessment for the course, you may not replace it with another either in that term or in a subsequent term (e.g. Spring term). Any courses that you wish to take on an extracurricular basis (that is, as extra and not counting towards your degree) must be identified at the start of the academic year or before any assessment has been completed for the course.

5 Facilities

5.1 Libraries

There are 2 libraries on campus:
- Founder’s Library, located on the South Side of Founder’s Building houses most language, literature, film, music and theatre material;
- Bedford Library, located up the hill from the Students’ Union next to the History Department, houses science, social science and history material;

Details, including further resources available, opening times and regulations, can be found online:
http://www.royalholloway.ac.uk/library/home.aspx

If you cannot find the specific items that you require in the libraries, it is possible to order items from other libraries by inter-library loan or to gain access to the Senate House Library or other university libraries. You can obtain further information on this by asking at the library helpdesks. The Information Consultant for Mathematics is Adrian Machiraju, who can be contacted at Adrian.Machiraju@royalholloway.ac.uk.

The Library provides a range of training sessions designed to enhance your existing library and research skills. These are available in both class-based and self-study formats. For information on available sessions and to book a place, go to:
5.2 Photocopying, printing and computing

5.2.1 Photocopying
The departmental photocopier is in constant use by office staff and lecturers. For this reason, we are unable to allow undergraduate students to use it. Instead you can use copier-printers (MFDs) located in the libraries, the Computer Centre and many PC labs, which will allow you to make copies in either black and white or colour. Further information is available online:
https://www.royalholloway.ac.uk/it/printing/home.aspx

If you require copying to be done for a seminar presentation, you need to give these materials to your tutor to copy on your behalf. Please make sure that you plan ahead and give the materials to your tutor in plenty of time.

5.2.2 Printing and Computing

At the start of your first year, the Department will give each student an approved calculator. These are the only calculators permitted in the examination rooms. If you need a replacement, please contact lisa.cavey@rhul.ac.uk.

You will be given a department printing allowance at the start of session which may be used to print on departmental and Computer Centre printers. Once the departmental allowance has been used additional print credit may be purchased from the Computer Centre service desk or credit machines around campus. Please note that the departmental allowance is used in preference to any personal credit you may have. Please do not disclose your password to anyone or permit anyone else to use your account. Always ensure you have logged off whenever you have finished using a computer. Department print credit will not be refunded if you forget to logout and someone else uses your account.

The department has a PC lab in C103 (shared with the Computer Science Department) which is available for use when not booked for teaching, please check the timetable on the door. Outside of working hours you may access the lab using your college card. You also have access to PCs in the Computer Centre, the library and elsewhere on campus. Many of the PC labs are open 24 hours a day, 7 days a week. PC Finder may be used to check PC lab availability (https://www.royalholloway.ac.uk/it/pcfinder/home.html).
Departmental staff are unable, in any circumstances, to print anything out on your behalf. Copier-printers (MFDs) are located across the campus in the PC labs (including C103), libraries and Computer Centre. Further information on printing is available online: https://www.royalholloway.ac.uk/it/printing/home.aspx

Departmental support for any hardware or software issues can be obtained from the Department IT helpdesk at https://cimhelpdesk.rhul.ac.uk

Use of the Departments computer facilities is subject to the Computer Centre regulations as listed on the Computer Centre website: https://www.royalholloway.ac.uk/it/tos/regulations.aspx

Please note the Department operates a no food or drink policy within the computer laboratories. Breaches of these regulations are treated very seriously and may result in withdrawal of access to facilities.

The Computer Centre provides a range of IT training sessions designed to enhance your current IT skills. These are available in both class-based and self-study formats, and successful completion of the course is rewarded by a College IT Skills certificate. To participate in these sessions, go to: http://www.royalholloway.ac.uk/it/training/home.aspx

5.3 Online resources, Moodle

Moodle is Royal Holloway's Virtual Learning Environment. Lecturers for most of our courses use Moodle for providing information: course details, announcements, worksheets, project materials, useful links, and so on. Many lecturers use Moodle (http://moodle.rhul.ac.uk/) to post their weekly problem sheets or other information on the course. Some departmental online resources, for example previous exams, are at http://www.ma.rhul.ac.uk/static/PastExams/

The library also has many online resources that may be of use for your course.

6 Coursework Essays and Dissertation

6.1 Coursework

There are homework exercises for each course. These are distributed during
lectures or are available on the course page on Moodle. Each lecturer will specify when and how the homework has to be submitted. The homework exercises are marked but these marks do not contribute to the final grade for the course.

Solving problems is an essential part of the learning process in mathematics. The homework exercises are designed to reinforce and progressively develop the ability to solve problems in mathematics. Some problems are harder than others, and students should not necessarily expect to solve every exercise on every sheet.

It is a college regulation that all course work is completed and submitted for assessment. Failure to comply may lead to a formal warning and the award of incomplete or non-examined status on that course.

If, due to illness or another good cause, students fail to attend an examination or their performance is affected, the record of their homework marks will be taken into account.

6.2 The dissertation

The dissertation accounts for 33.3% of the assessment for the MSc degree. Two bound hard-copies of the dissertation have to be submitted to the administrators in McCrea 247 by 2pm on the first Thursday of September in the year of the written examination. You should plan to work conscientiously throughout the summer if you are to produce a satisfactory dissertation by the September deadline. You are reminded that the MSc course is full time education until beginning of September (unless you have part time status) and that you are not supposed to take on any commitment during the summer that prevents you from spending most of your time on the dissertation.

In Term 2, there will be a training session to provide guidance on the project, with particular emphasis on mathematical writing and on plagiarism.

Students are advised to use Latex or Word for preparing the MSc dissertation. Latex is particularly suitable for mathematical content and we encourage the use of it. For some help please see http://www.ma.rhul.ac.uk/latex-help.

The dissertation is usually of length between 8,000 and 16,000 words. The margins should be at least 2cm wide and the font size 11pt. Two bound hard-copies of the thesis have to be submitted. You can find some of the dissertations by students of previous years in the mathematics office C247 to get an idea how they look like.

6.3 Choice of dissertation topic
The first task, which should be completed by the middle of term 2, is to decide upon a general area of research (this can be rather vague, e.g., coding theory, symmetric cryptography, quantum computing etc.) and a suitable project supervisor.

6.4 The dissertation supervisor

Your department will assign you a dissertation supervisor who will oversee your work. In most cases students are happy with the supervisory relationship. However, there are occasions where for some reason the supervisory relationship does not work and breaks down. If this happens, you should speak as soon as possible with the Programme Director or your Personal Advisor to see whether the problem can be resolved informally, e.g. through mediation, changing supervisor. You should not wait until after you have received your final degree results to raise the matter as it is very difficult for the College to resolve such matters or take remedial action at that point.

Course lecturers, the adviser and the programme director may help in suggesting research areas and finding a supervisor. The supervisor will help the student to find a specific topic in the area of the student's interest. Note that students are not guaranteed the supervisor of their choice, though we try to ensure that all students have a supervisor who is willing to supervise the student's chosen topic. If you are unable to find a supervisor or a research area then you should see the programme director during the first half of term 2.

6.5 Proposal

By the end of term 2 (last week of lectures) students should produce a brief research proposal, of about 10 pages. This should give an introduction to the general subject area and of the more specific problems and objectives to be studied. It should mention which literature has been studied so far and how the research will continue. This will usually be prepared in consultation with the project supervisor.

While this proposal does not count toward the final grade it is still compulsory part of the dissertation. Failure to complete a satisfactory proposal may result in the student being moved from the MSc programme to the PgDip.

6.6 Content of dissertation

The final part of the main project is to prepare the dissertation. It is important to allow plenty of time for this stage (typically at least one month). It is usually best not to leave writing of the entire dissertation to the end but to write parts of it during the summer. Usually your supervisor will read one draft version, (but will not usually read the same chapter several times) if it is given to her/him in good time. The students may want to give draft parts to the supervisor at earlier
stages and not the entire dissertation towards the end of project.

The dissertation must include:

- Title page.
- Abstract (or Summary), which explains the aims of the dissertation and summarises the results.
- An introduction which outlines and motivates the topic of the thesis.
- A discussion of the existing literature on the subject.
- A presentation of the original content of the project, with a full explanation of the methods used and outcomes obtained.
- Conclusions which describe how the results relate to the wider subject area and/or suggests some possible future lines of enquiry.
- Bibliography

6.7 Bibliography

It is crucial to properly acknowledge other people's work. The bibliography usually consists of a list of publications in alphabetical order of the author's names. Each entry contains at least the author's names, the title of the publication, the journal, publisher or website, the year of publication and in case of a journal article, the volume and the page numbers of the entire article. It is unusual to quote verbatim in mathematics (apart from definitions, lemmas and theorems), and one usually refers to the entire article if one is using a result of it. Sometimes when citing long articles or books it is helpful if one refers to a particular theorem. If you use material from websites you must reference the sites.

The supervisor will give feedback on your citing, referencing and the bibliography if she/he is given a draft.

6.8 Marking criteria

Each dissertation is independently marked by two examiners; one of these is normally the supervisor. An external examiner moderates the assessment. The examiners may conduct an oral examination if they wish to check the depth of the student's understanding and to ensure that the dissertation is the student's own work. **Student must obtain a pass grade on the dissertation to pass the MSc degree.** The examiners give up to 100 points where the points translate to the following categories:
85–100: An exceptionally high level of understanding and outstanding research potential.
70–84.99: Very high competence and excellent research potential.
60–69.99: Evidence of some creativity and independence of thought.
50–59.99: Sound understanding of the literature, but lack of accuracy or originality.
0–49.99: Insufficient or no understanding of the topic, poor quality of work.

The points are given according to the following guidelines:

**Knowledge of subject (25)**
21–25: Deep understanding and near-comprehensive knowledge
18–20: Deep understanding
15–17: Very good understanding
12–14: Sound knowledge of relevant information
10–11: Basic understanding of the main issues
  0–9: Little or no understanding of the main issues

**Organisation of material (25)**
21–25: Of publishable quality
18–20: Arguments clearly constructed; material very well-organised
15–17: Well-organised; aims met with no significant errors or omissions
12–14: Coherent and competent organisation
10–11: Lack of clarity in written presentation or aims only partially met
  6–9: Major flaws in arguments; aims of project not met
  0–5: Arguments are missing/deficient. Disorganised or fragmentary

**Originality, interpretation and analysis (20)**
17–20: Significant originality in the interpretation and/or analysis; project aims challenging
14–16: Some originality; evidence of excellent analytical and problem-solving skills
12–13: Good attempt to interpret and analyse existing literature
10–11: Minor flaws in interpretation/analysis of existing literature
  5–9: Poor interpretation/analysis or project aims too simple
  0–4: Little or no interpretation or analysis; project aims trivial

**Evidence of reading (10)**
8–10: Independent reading including research papers
6–7: Good use of outside reading
4–5: Some evidence of outside reading
0–3: Little or no evidence of outside reading
Bibliography and referencing (10)
9–10: Of publishable quality
7–8: Good referencing and bibliography
5–6: Either poor bibliography or poor referencing
3–4: Poor bibliography and little or no referencing
0–2: No bibliography and little or no referencing

Style, spelling, punctuation and grammar (10)
9–10: Incisive and fluent, no errors of spelling, punctuation or grammar
7–8: Very minor errors of spelling, punctuation or grammar
4–6: Some errors of spelling, punctuation or grammar
0–3: Many errors of spelling, punctuation or grammar

7 Prizes

7.1 The MSc Achievement Medal

The MSc Achievement Medal is awarded to an MSc student in the Department of Mathematics in recognition of outstanding performance across the taught part of the programme (excluding dissertation).

7.2 The MSc Dissertation Medal

The MSc Dissertation Medal is awarded to an MSc student in the Department of Mathematics in recognition of outstanding performance in their dissertation.

8 Assessment Information

8.1 Illness or other extenuating circumstances

Students are advised to carefully read the Instructions to candidates as well as the Extenuating circumstances – Guidance for students.

Extenuating circumstances are defined as unforeseen circumstances which are outside a student’s control and which may temporarily prevent a student from undertaking an assessment or have a marked/significant detrimental/adverse impact on their ability to undertake assessment by coursework or examination to the standard normally expected.

This means that such circumstances rarely occur. They are outside your control as they are:

- Unforeseeable - you would not have prior knowledge of the event (e.g. you cannot foresee that you will be involved in a car accident);
• Unpreventable – you could not reasonably do anything in your power to prevent such an event (e.g. you cannot reasonably prevent a burst appendix.)

It is these short-term (temporary) circumstances that the College normally regards as extenuating circumstances.

**Inability to submit coursework**

If you are unable to submit coursework through unexpected illness or other acceptable cause (i.e. events which are unpreventable and unforeseeable) it is assumed that you will request an extension to the submission deadline from your department. In order for an extension to be granted you will need to provide the department with adequate documentation in accordance with the guidance in Appendix B of the *Extenuating Circumstances – Guidance for students*. The decision on whether to grant an extension rests with your department.

**Absence from an examination**

The Sub-board of Examiners may take the following into account when considering your results: if you miss an examination through unexpected illness, or other acceptable cause (events which are unpreventable and unforeseeable), if you commence an examination and have to leave due to acute illness or if you believe your performance on the day was seriously compromised by an unexpected and acute illness that you could not reasonably have been expected to have managed otherwise. You will, however, need to submit an *Extenuating Circumstances form* and have adequate supporting documentation in accordance with Appendix B of *Extenuating Circumstances – Guidance for students*. You should also read the section *Illness & absences from an examination and departmental assessments and extenuating circumstances* in the *Instructions to Candidates* issued by Student Administration [http://www.royalholloway.ac.uk/ecampus/academicsupport/examinations/examinations/home.aspx](http://www.royalholloway.ac.uk/ecampus/academicsupport/examinations/examinations/home.aspx) for full details on how to inform your department about extenuating circumstances relating to missed examinations as well as the *deadline for submission of such information*.

**Ongoing circumstances**

If you have ongoing circumstances that you believe are adversely affecting your performance during the year, these should be raised with your department and with the College’s *Support and Advisory Services* as soon as possible so that strategies to help you manage the situation can be considered e.g. you have an illness that does not constitute a disability, a family member is ill and needs your support or you have suffered an adverse life event.
It may that the circumstances are severely impacting on your ability to study by causing you to repeatedly miss scheduled teaching and/ or impacting on your ability to complete assessments at the designated time. If this is the case and there is not a reasonable method available to enable you to manage the situation, you may need to consider, in consultation with your department and Support and Advisory Services, whether it would not be in your best interests to interrupt until the issues have been resolved and you are able to fully commit to and benefit from your academic studies.

Ongoing adverse circumstances do not normally constitute extenuating circumstances as they are not unforeseen and in some cases are not unpreventable. There is therefore very little that the Sub-board can do, in terms of current College regulations, to mitigate such circumstances.

Please read the Extenuating circumstances – Guidance for students, in particular Section 5.

Support and exam access arrangements for disabled students and those in need of support

Some students at the College may have a physical or mental impairment, chronic medical condition or a Specific Learning Difficulty (SpLD) which would count as a disability as defined by the Equality Act (2010) that is, “a physical or mental impairment which has a long-term and substantial effect on your ability to carry out normal day-to-day activities”. It is for such conditions and SpLDs that Disability and Dyslexia Services can put in place support and exam access arrangements. Please note that a “long-term” impairment is one that has lasted or is likely to last for 12 months or more.

If you have a disability or SpLD you must register with the Disability and Dyslexia Services Office for an assessment of your needs before support and exam access arrangements (‘reasonable adjustments’) can be put in place. There is a process to apply for special arrangements for your examinations. Disability and Dyslexia Services can discuss this process with you when they assess your needs. Please see the section Students in need of support (including disabled students) for further guidance about registering with the Disability and Dyslexia Services Office.

Please note that if reasonable adjustments, including exam access arrangements, have been put in place for you during the academic year, the Sub-board will not normally make further allowance in relation to your disability or SpLD.
8.2 Submission of written work

Usually homework assignments are collected during lectures but some lecturers may have different arrangements of which they will inform the students at the beginning of the course. The dissertation resulting from the main project must be given to the administrators in MC247 during the office hours by 2pm on the first Thursday of September in the year of the written exams.

8.3 Extensions to deadlines

An extension to a deadline can only be given if there are extenuating circumstances. A written request to extend the deadline must reach the programme director before the deadline.

8.4 Penalties for late submission of work

Work submitted after the published deadline will be penalised in line with Section 13 (5) of the College’s Postgraduate Taught Regulations 2015-16 (https://www.royalholloway.ac.uk/ecampus/academicsupport/regulations/home.aspx)

Please ensure that you are aware of the deadlines set by your department(s) and also the requirements to meet this deadline, e.g. whether you need to submit electronic and/or paper copies for your submission to be deemed complete (see 7.2 above).

Section 13 (5)
In the absence of acceptable extenuating cause, late submission of work will be penalised as follows:

- for work submitted up to 24 hours late, the mark will be reduced by ten percentage marks;*
- for work submitted more than 24 hours late, the mark will be zero.

*eg. an awarded mark of 65% would be reduced to 55% and a mark of 42% would be reduced to 32%.

If you have had extenuating circumstances which have affected your ability to submit work by the deadline these should be submitted in writing, accompanied by any relevant documentary evidence, to your department(s). As with all extenuating circumstances it is the discretion of the examiners whether to accept these as a reason for having not submitted work on time. Please see the section on applying for an
extension to the deadlines set, and the section for details on submitting requests for extenuating circumstances to be considered.

8.5 Anonymous marking and cover sheets

All work that is submitted for assessment is marked anonymously. The only exception to this is the main project.

8.6 Penalties for over-length work

Work which is longer than the stipulated length in the assessment brief will be penalised in line with Section 13 (6) of the College’s Postgraduate Taught Regulations 2015-16 (https://www.royalholloway.ac.uk/ecampus/academicsupport/ regulations/home.aspx)

Section 13 (6)
All over-length work submitted on undergraduate and taught postgraduate programmes will be penalised as follows:

- For work which exceeds the upper word limit by at least 10% and by less than 20%, the mark will be reduced by ten percentage marks*, subject to a minimum mark of a minimum pass.

- For work which exceeds the upper word limit by 20% or more, the maximum mark will be zero.

*eg. an awarded mark of 65% would be reduced to 55%.

In addition to the text, the word count should include quotations and footnotes. Please note that the following are excluded from the word count: candidate number, title, course title, preliminary pages, bibliography and appendices.

8.7 Return of written coursework

The following College policy applies to the return of coursework:

Assessed work (other than formal examinations) should be returned within 4 weeks of the submission deadline, except in cases where it is not appropriate to do so for academic reasons. The deadline for the return of marked work should be made clear to students when they receive their assignments. In the event that the intended deadline cannot be met, the revised deadline must be communicated to students as soon as possible.
8.8 Assessment offences

The College has regulations governing assessment offences which can found on the following webpage:

http://www.royalholloway.ac.uk/ecampus/academicsupport/regulations/home.aspx

Assessment offences include, but are not limited to plagiarism (see below), duplication of work, that is, submitting work for assessment which has already been submitted for assessment in the same or another course, falsification, collusion, for example, group working would constitute collusion where the discipline or the method of assessment emphasises independent study and collective ideas are presented as uniquely those of the individual submitting the work, failure to comply with the rules governing assessment (including those set out in the ‘Instructions to candidates’. The Regulations set out some of the types of assessment offences in more detail, the procedures for investigation into allegations of such offences and the penalties. Students are strongly encouraged to read these Regulations and to speak with their Personal Advisors or other members of staff in their department should they have any queries about what constitutes an assessment offence. The College treats assessment offences very seriously and misunderstanding about what constitutes an assessment offence will not be accepted as an excuse. Similarly extenuating circumstances cannot excuse an assessment offence. Students with extenuating circumstances which affect their ability to submit work should contact their departments about the possibility of an extension or other support.

8.9 Plagiarism

Definition of plagiarism

'Plagiarism' means the presentation of another person's work in any quantity without adequately identifying it and citing its source in a way which is consistent with good scholarly practice in the discipline and commensurate with the level of professional conduct expected from the student. The source which is plagiarised may take any form (including words, graphs and images, musical texts, data, source code, ideas or judgements) and may exist in any published or unpublished medium, including the internet.

Plagiarism may occur in any piece of work presented by a student, including examination scripts, although standards for citation of sources may vary dependent on the method of assessment. Identifying plagiarism is a matter of expert academic judgement, based on a comparison across the student’s work and on knowledge of sources,
practices and expectations for professional conduct in the discipline. Therefore it is possible to
determine that an offence has occurred from an assessment of the student’s work alone, without reference to further
evidence.

8.10 Marking of illegible scripts

It is College policy not to mark scripts which are illegible. If you anticipate
that you may have difficulty in handwriting scripts which would lead to
your scripts being illegible you should contact the Disability and Dyslexia
Services (ESO).
http://www.royalholloway.ac.uk/ecampus/welfare/disabledstudents/home.aspx

8.11 Progression and award requirements

8.11.1 Course Outcomes

Section 13 of the Postgraduate Taught Regulations requires that to qualify for
final consideration in a course unit, the Sub-board of Examiners will take into
consideration whether you have satisfied

(a) the attendance requirements stated in the course specification;

(b) the assessment requirements stated in the course specification.

and determine an outcome and a percentage mark recorded as an integer
between 0% and 100% inclusive for you, as follows:

(a) an outcome of Pass (P) with a percentage mark will be returned
where you have gained a mark of 50% or above overall and in all
elements of the assessment which carry an individual pass requirement;

(b) an outcome of Fail (F) with a percentage mark will be returned where
you have gained a mark of 49% or below overall or in any element of
the assessment which carries an individual pass requirement.

Resits/ repeats

If you do not pass a course unit at a first attempt you may be given an
opportunity to resit or repeat the course unit (Section 12 Postgraduate Taught
Regulations). Please bear in mind that decisions on which course units you may
be permitted to resit or repeat and when (summer or following academic year)
will be made by the Sub-board of examiners in line with the provisions of the
Postgraduate Taught Regulations.

<table>
<thead>
<tr>
<th>Resit/Repeat</th>
<th>Clarification</th>
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| **Resit of a failed course unit** | The opportunity to resit a failed course unit will either be over the Summer (August) or in the following academic year/ session, depending upon the nature of the assessment and your department’s policy in terms of summer resits. Where summer resits are permitted by your department, this will normally be in course units to a maximum of 40 credits. If you are given a resit in a course unit you do not have to attend any further classes. Marks for work which has been passed will be carried forward. The mark for a course unit being resat will normally be capped at 50%.

Please note that you are required to register to resit course units. |
| **Repeat of a failed course unit** | If you are given the opportunity to repeat a course unit in attendance you will need to register for the course unit for the following academic year and satisfy afresh all the assessment and attendance requirements; that is, you are expected to attend all classes and redo all required coursework and examinations for the course unit. No marks from the previous attempt at the course unit are carried forward and no work completed as part of the first attempt at the course may be resubmitted for assessment. The mark for a course unit repeated in attendance is not capped at 50%. If you are repeating in attendance you can substitute a new course unit for the one failed. The new course unit counts as a second attempt at the unit. |

Unless you have extenuating circumstances you are only permitted two opportunities to pass a course unit in line with Section 12 (2) of the *Postgraduate Taught Regulations*.

**Extenuating Circumstances**

If you miss an assessment or you believe your performance in an assessment was *severely* affected by adequately documented extenuating circumstances which are acceptable to the Sub-board, the board has various options available. For further details please see Section 14 of the *Postgraduate Taught Regulations* where these options are outlined.
8.11.2 Award Classifications

For details on the requirements about the requirements for the award of PGCert, PGDip and Master’s degree please see Section 15 of the Postgraduate Taught Regulations:

http://www.royalholloway.ac.uk/ecampus/academicsupport/regulations/home.aspx

and your Programme Specification:

http://www.rhul.ac.uk/coursecatalogue/home.aspx

In particular you are advised to note the following stipulations in Section 15:

(a) **Condoning of fails:** a mark of Fail in up to 40 credits will be condoned at the first attempt where an award can be made unless there are extenuating circumstances warranting a further attempt, or a requirement from a Professional or Regulatory Body that you must pass all courses to qualify for the award.

(b) **Award of merit:** if you have taken more than one attempt at a course you will not normally be considered for the award of a Merit or Distinction.

8.11.3 Concurrent Registration

You are reminded that the College does not permit students to be registered on two programmes at the same time. If you are completing resits/ repeats on a programme at the College or another institution while registered at the College on your postgraduate programme, you are in breach of College regulations and should speak with your department about this as soon as possible. The same applies if you are completing resits/ repeats at the College and register for a programme of study at another institution.

8.11.4 Appeals

The most important change is that the deadline for the submission of appeals has been amended. You are now required to submit an appeal within **15 working days** of notification of your examination results on the portal, notification of a termination of registration, notification of an assessment offence penalty, etc.

The Regulations governing progression and award requirements are set out in your Programme Specification (http://www.rhul.ac.uk/coursecatalogue/home.aspx) and also more
generally in the Postgraduate Taught Regulations
http://www.royalholloway.ac.uk/ecampus/academicsupport/regulations/home.aspx

For details on the requirements governing the level of award please see the section on the Consideration and Classification of Candidates for the Award in the Postgraduate Taught Regulations.

http://www.royalholloway.ac.uk/ecampus/academicsupport/regulations/home.aspx

8.12 Examination/assessment results

Please see the Examinations & Assessments website http://www.royalholloway.ac.uk/ecampus/academicsupport/examinations/home.aspx for details of how you will be issued with your results.

http://www.royalholloway.ac.uk/ecampus/academicsupport/examinations/results.aspx

The Examinations & Assessments website is the place where you can access the “Instructions to Candidates” and details of the examinations appeals procedures.

http://www.royalholloway.ac.uk/ecampus/academicsupport/academicappealsandcollegecomplaints.aspx

9 Student Support

9.1 Non-academic related enquiries & support

The Student Services Centre is located in the Windsor Building and provides a single point of contact for all non-academic related queries including accommodation, fees and funding, enrolment and graduation. For further details please visit http://www.royalholloway.ac.uk/ssc

9.2 Students in need of support (including students with special needs)

Your first point of reference for advice within the Department is the School Manager Mrs Lisa Cavey. Inevitably, problems will sometimes arise that the School Manager is not qualified to deal with. The College offers a high level of student welfare support which includes a comprehensive Health Centre, a highly regarded Counselling Service, dedicated educational and disability support, as well as a wealth of financial, career and other advice. Further details of each service can
be found on the College web on the **Student Welfare** page: http://www.royalholloway.ac.uk/ecampus/welfare/home.aspx

If you have a disability or specific learning difficulty, it is important that you bring it to our attention as soon as possible. The Departmental Disability and Dyslexia Service (ESO) representative is the School Manager. You must also contact the DDS (Founders West 151; tel: +44 (0)1784 443966; email: educational-support@royalholloway.ac.uk) who will arrange for an assessment of needs to be carried out and will advise on appropriate sources of help. Further information is available on the College web on the **Support, health and welfare** page http://www.royalholloway.ac.uk/ecampus/welfare/disabledstudents/home.aspx

### 9.3 Academic Skills Support

The Centre for the Development of Academic Skills (**CeDAS**) offers a variety of courses, workshops, 1:1 tutorials, online resources that aim to ensure all students at Royal Holloway reach their full academic potential in a range of areas, including academic writing, oral communication skills and Maths and Statistics.

Whatever your needs, CeDAS is there to ensure that you can perform to the best of your ability, whether it be through a workshop that introduces you to a crucial academic skill, a session within your department that focuses on writing in the discipline, a course that develops your confidence and competence in academic English language, or a 1:1 tutorial with a specialist to help you master a maths technique or sharpen your essay skills.

The Centre also oversees the Royal Holloway Proofreading Scheme, which enables students to pay for an approved third-party proofreader to identify surface error in final drafts. Please note that Royal Holloway does not permit the use of paid third-party proofreaders who are not part of this scheme.

The CeDAS Office can be found on the ground floor of the International Building, room IN002, and you can follow them on Twitter: @cedashul. Further details can be found on the **CeDAS** webpages: www.royalholloway.ac.uk/cedas.

### 9.4 Student-staff committee

There is a student-staff committee on which both taught and research
students are represented. For constitution see committee’s handbook under Compliance/Governance
http://www.royalholloway.ac.uk/iquad/collegepolicies/home.aspx
The Committee meets at least three times each year and plays an important role in the Department as a forum for airing student views.

You can use the Committee to raise any issues which concern students. Notices will appear on departmental notice boards giving details of forthcoming elections or the names of current representatives.

9.5 Students’ Union

The Students’ Union offers a wide range of services and support, from entertainment and clubs/societies to advice on welfare and academic issues. The Advice and Support Centre, situated on the first floor of the Students’ Union, runs a confidential service that is independent from the College. Open 9.30am - 5pm, Monday – Friday, it operates an open door policy exclusively for students during term time. However, during vacation periods students should call to book an appointment. Full details can be found at www.su.rhul.ac.uk/support

9.6 Careers information

The College has a careers advisory service, housed in the Horton Building, which is open to any student during normal College hours.
http://www.royalholloway.ac.uk/careers/home.aspx

9.7 Non-academic policies

Please see the Codes and Regulations webpage
http://www.royalholloway.ac.uk/ecampus/onlinestudenthandbook.aspx which includes information on non-academic policies, regulations, and codes of practice as well as the Student Charter.
http://www.royalholloway.ac.uk/aboutus/governancematters/studentcharter.aspx

9.8 Complaints and academic appeals procedure

If you have a complaint relating to any aspect of the Department or its staff or to any academic or College matter, you should first discuss it informally with your Personal Advisor or with another member of staff in the Department. We would hope that the majority of issues of this kind can be resolved by informal discussion. There are, however, procedures that can be invoked in serious cases. These are set out in the College Complaints Procedures for students
http://www.royalholloway.ac.uk/ecampus/academicsupport/complain
You should raise your complaint as soon as possible.

If the complaint concerns an academic decision, there is an academic appeals process. Please note that an academic appeal can only be submitted once you have received your results via the College portal. Details of the appeals procedures and permitted grounds for appeal can be found on the following webpage http://www.royalholloway.ac.uk/ecampus/academicsupport/academiacppealsandcollegecomplaints.aspx

10 Health and Safety Information

10.1 Code of practice on harassment for students

This can be found on the student home pages under codes and regulations http://www.students.royalholloway.ac.uk/study/read-our-college-regulations-and-procedures/

10.2 Lone working policy and procedures

The College has a ‘Lone Working Policy and Procedure’ that can be found at http://www.royalholloway.ac.uk/iquad/services/healthandsafety/policiesandprocedures/loneworking.aspx

Lone working is defined as working during either normal working hours at an isolated location within the normal workplace or when working outside of normal hours. The Department and the type of work conducted by students is classified as a low risk activity.

Any health and safety concerns should be brought to the attention of the Departmental Health and Safety Coordinator Mrs Lisa Cavey or the College Health and Safety Office.

It is likely that most activities will take place on College premises. However, the principles contained in the above section will apply to students undertaking duties off campus.

11 Equal Opportunities Statement and College Codes of Practice

11.1 Equal opportunities statement

The University of London was established to provide education on the basis of merit above and without regard to race, creed or political belief
and was the first university in the United Kingdom to admit women to its degrees.

Royal Holloway, University of London (hereafter ‘the College’) is proud to continue this tradition, and to commit itself to equality of opportunity in employment, admissions and in its teaching, learning and research activities.

The College is committed to ensure that:

• all staff, students, applicants for employment or study, visitors and other persons in contact with the College are treated fairly, have equality of opportunity and do not suffer disadvantage on the basis of race, nationality, ethnic origin, gender, age, marital or parental status, dependants, disability, sexual orientation, religion, political belief or social origins

• both existing staff and students, as well as, applicants for employment or admission are treated fairly and individuals are judged solely on merit and by reference to their skills, abilities qualifications, aptitude and potential

• it puts in place appropriate measures to eliminate discrimination and to promote equality of opportunity

• teaching, learning and research are free from all forms of discrimination and continually provide equality of opportunity

• all staff, students and visitors are aware of the Equal Opportunities Statement through College publicity material

• it creates a positive, inclusive atmosphere, based on respect for diversity within the College

• it conforms to all provisions as laid out in legislation promoting equality of opportunity.

11.2 College codes of practice

Royal Holloway is committed to upholding the dignity of the individual. Personal harassment can seriously harm working, learning and social conditions at the College. Harassment will be regarded seriously and could be grounds for disciplinary action, which may include termination of registration as a student. Royal Holloway’s Code of Practice on Personal Harassment for Students is available at

http://www.rhul.ac.uk/registry/onlinestudenthandbook/studentharassment.p...
## 12 Course descriptions

The information contained in these course outlines is correct at the time of publication, but may be subject to change as part of the Department’s policy of continuous improvement and development. Every effort will be made to notify you of any such changes.

### COURSE SPECIFICATION FORM

<table>
<thead>
<tr>
<th>Department/School:</th>
<th>Mathematics</th>
<th>Academic Session:</th>
<th>2016-17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Title:</td>
<td>Computational Number Theory</td>
<td>Course Value:</td>
<td>20 credits</td>
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<tr>
<td></td>
<td></td>
<td>(UG courses = unit value, PG courses = notional learning hours)</td>
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<tr>
<td>Course Code:</td>
<td>MT5412</td>
<td>Course JACS Code:</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(Please contact Data Management for advice)</td>
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</tr>
<tr>
<td>Availability:</td>
<td>Term 2</td>
<td>Status:</td>
<td>Optional Condonable</td>
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<td></td>
<td></td>
<td>(Please state which teaching terms)</td>
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</tr>
<tr>
<td>Pre-requisites:</td>
<td>UG course in number theory</td>
<td>Co-requisites:</td>
<td>-</td>
</tr>
<tr>
<td>Aims:</td>
<td>To provide an introduction to many major methods currently used for testing/proving primality and for the factorisation of composite integers. The course will develop the mathematical theory that underlies these methods, as well as describing the methods themselves.</td>
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</tbody>
</table>
| Learning Outcomes:       | 1. Be familiar with a variety of methods used for testing/proving primality, and for the factorisation of composite integers.  
2. Have an introductory knowledge of the theory of binary quadratic forms, elliptic curves, and quadratic number fields, sufficient to understand the principles behind state-of-the art factorisation methods.  
3. Be equipped with the tools to analyse the complexity of some fundamental number-theoretic algorithms.  
4. Demonstrate independent learning skills |
| Course Content:          | Background: Complexity analysis; revision of Euclid's algorithm, and continued fractions; the Prime Number Theorem; smooth numbers; elliptic curves over a finite prime field; square roots modulo a prime; quadratic number fields; binary quadratic forms; fast polynomial evaluation.  
Primality tests: Fermat test; Carmichael numbers; Euler test; Euler-Jacobi test;  
Miller-Rabin test; Lucas test; AKS test.  
Primality proofs: succinct certificates; p – 1 methods; elliptic curve method; AKS method.  
Factorisation: Trial division; Fermat's method, and extensions; methods using binary quadratic forms; Pollard's p – 1 method; elliptic curve method; Pollard's rho and rho methods; factor-base methods; quadratic sieve; number field sieve. |
| Teaching & Learning Methods: | The total number of notional learning hours associated with this course are 200.  
3 hours of lectures over 11 weeks. 33 hours in total. 167 hours of private study, including work on the miniproject, problem sheets and examination preparation. This may include discussions with the course leader if the student wishes. |
| Formative Assessment & Feedback: | Formative assignments in the form of 8 problem sheets.  
The students will receive feedback as written comments on their attempts. |
Summative Assessment: Exam: Written exam 90%. Two hour paper.
Coursework: 10% Individual unsupervised mini-project.

COURSE SPECIFICATION FORM

<table>
<thead>
<tr>
<th>Department/School:</th>
<th>Mathematics</th>
<th>Academic Session:</th>
<th>2016-17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Title:</td>
<td>Principles of Algorithm Design</td>
<td>Course Value: (UG courses = unit value, PG courses = notional learning hours)</td>
<td>20 credits</td>
</tr>
<tr>
<td>Course Code:</td>
<td>MT5414</td>
<td>Course JACS Code:</td>
<td>G100</td>
</tr>
<tr>
<td>Availability:</td>
<td>Term 1</td>
<td>Status:</td>
<td>Optional Condonable</td>
</tr>
<tr>
<td>Pre-requisites:</td>
<td>An undergraduate course in discrete mathematics</td>
<td>Co-requisites:</td>
<td>-</td>
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</tbody>
</table>

Aims:
- To provide an introduction to the theory of algorithms;
- To develop the skill of designing algorithms.

Basic algorithmic principles: Greedy algorithms, divide-and-conquer, dynamic programming, randomized algorithms.
Analysis of algorithms: Recurrences, O-notation, worst-case analysis, amortized analysis, probabilistic analysis; lower bounds for comparison-based sorting and finding the median.
Basic data structures: arrays, stacks, balanced search trees, hashing.

Learning Outcomes:
1. Understand and apply the fundamental principles of algorithm design;
2. Analyse basic algorithms; know amortized, average-case and worst-case analysis;
3. Know basic data-structures
4. Know efficient algorithms for sorting numbers; know lower bounds on comparison based algorithms for sorting numbers;
5. Know asymptotic notation.
6. Demonstrate independent learning skills

Course Content:
The development of efficient algorithms is essential when considering problems with large inputs. Usually an algorithm has certain specifications, for example that it should solve a problem and take at most \( f(n) \) steps on any input of size \( n \). This course is about the design of efficient algorithms and proving that they meet the desired specification. The course introduces basic principles and methods of algorithm design and analysis and considers fundamental problems like sorting numbers and multiplying matrices.

Teaching & Learning Methods:
The total number of notional learning hours associated with this course are 200.
3 hours of lectures over 11 weeks. Total 33 hours.
167 hours of private study, including work on the mini-project, problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.

Key Bibliography:
- Introduction to Algorithms by Cormen, Leiserson, Rivest, and Stein

Formative Assessment & Feedback:
Formative assessment in form of 8 problem sheets. The student will receive feedback as written comments on their attempts.
### COURSE SPECIFICATION FORM

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<tr>
<th>Department/School:</th>
<th>Mathematics</th>
<th>Academic Session:</th>
<th>2016-17</th>
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<tbody>
<tr>
<td>Course Title:</td>
<td>Inference</td>
<td>Course Value:</td>
<td>200 hr</td>
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<tr>
<td>Course Code:</td>
<td>MT5432</td>
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<td>G350</td>
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<td>(Please contact Data Management for advice)</td>
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<tr>
<td>Availability:</td>
<td>Term 2</td>
<td>Status:</td>
<td>Optional Condonable</td>
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<tr>
<td>(Please state which teaching terms)</td>
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<tr>
<td>Pre-requisites:</td>
<td>-</td>
<td>Co-requisites:</td>
<td>-</td>
</tr>
<tr>
<td>Aims:</td>
<td>This is a graduate level course intended to provide the mathematical theory underlying the main principles and methods of statistics, in particular, to introduce the mathematical theory of parametric estimation and hypotheses testing.</td>
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<tr>
<td>Learning Outcomes:</td>
<td>On completion of the course, students should be able to demonstrate a deep understanding of some of the advanced concepts and results of the theory of estimation and hypothesis testing with main emphasis on the general methodology rather than special models occurring in applications; formulate statistical problems in rigorous mathematical terms; select and apply appropriate tools of mathematical statistics and advanced probability to analyse and solve the problems; understand and construct mathematical proofs of some of the main theoretical results of mathematical statistics; understand the concepts and results in asymptotic theory of estimation.</td>
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<tr>
<td>Teaching &amp; Learning Methods:</td>
<td>44 hours of lectures and examples classes. 156 hours of private study, including work on problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.</td>
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</tr>
<tr>
<td>Key Bibliography:</td>
<td>Statistical Inference – G Casella and R L Berger (Duxbury 2001) Library reference 518.1 CAS</td>
<td></td>
<td></td>
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<tr>
<td>Formative Assessment &amp; Feedback:</td>
<td>Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts.</td>
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<tr>
<td>Summative Assessment:</td>
<td>Exam: 100% Written exam. Two hours. Coursework:</td>
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</table>
# COURSE SPECIFICATION FORM

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<tr>
<th>Department/School:</th>
<th>Mathematics</th>
<th>Academic Session:</th>
<th>2016-17</th>
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</thead>
<tbody>
<tr>
<td><strong>Course Title:</strong></td>
<td>Applied Probability</td>
<td><strong>Course Value:</strong></td>
<td>(UG courses = unit value, PG courses = notional learning hours)</td>
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<tr>
<td><strong>Course Code:</strong></td>
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<td><strong>Availability:</strong></td>
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<td><strong>Co-requisites:</strong></td>
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</table>

**Aims:** This is a graduate level course intended familiarise students with the principal methods of the theory of stochastic processes and to introduce a range of examples of probabilistic methods used to model systems that exhibit random behaviour.

**Learning Outcomes:** On completion of the course the student should be able to:
- use the method of conditioning and the method of conditional expectation;
- use the method of generating functions;
- understand the structure and concepts of discrete and continuous time Markov chain with countable state space;
- construct a probability model for a variety of problems;
- understand the structure of diffusion processes;
- understand the concept of Brownian motion.

**Course Content:** Preliminaries: Conditional expectation; generating functions; Distribution of random sums; Stochastic processes - basic Notions.
- Poisson Process: Inter-arrival and waiting times; Conditional distribution of the waiting times; Nonhomogeneous processes; Compound Poisson process.
- Renewal theory: Renewal processes; Some limit theorems; Alternating renewal processes; Delayed renewal processes; Cumulative renewal processes.
- Markov processes: Markov chains, classification of states, Some limit theorems; Stationary distributions; Absorption probabilities.
- Diffusion Processes: Forward and backward diffusion equations; Brownian motion, Wiener processes, Ito’s Formula.

**Teaching & Learning Methods:** 44 hours of lectures and examples classes. 156 hours of private study, including work on problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.

**Key Bibliography:**
- Stochastic Processes – S M Ross (Wiley 1996) Library Ref. 519.2

**Formative Assessment & Feedback:** Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts.

**Summative Assessment:**
- **Exam:** Written exam 100% Two hour exam.
- **Coursework:**
### COURSE SPECIFICATION FORM

<table>
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<tr>
<th>Department/School:</th>
<th>Mathematics</th>
<th>Academic Session:</th>
<th>2016-17</th>
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<tr>
<td>Course Title:</td>
<td>Channels</td>
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<tr>
<td>Availability:</td>
<td>Term 1</td>
<td>Status:</td>
<td>Mandatory for MCC, Optional for MfA Condonable</td>
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<tr>
<td>(Please state which teaching terms)</td>
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<tr>
<td>Pre-requisites:</td>
<td>Undergraduate courses in probability and algebra.</td>
<td>Co-requisites:</td>
<td>-</td>
</tr>
<tr>
<td>Aims:</td>
<td>To investigate the problems of data compression and information transmission in both noiseless and noisy environments.</td>
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</tr>
<tr>
<td>Learning Outcomes:</td>
<td>1. state and derive a range of information-theoretic equalities and inequalities; 2. explain data-compression techniques for ergodic as well as memoryless sources; 3. explain the asymptotic equipartition property of ergodic sources; 4. understand the proof of the noiseless coding theorem; define and use the concept of channel capacity of a noisy channel; explain the noisy channel coding theorem; 5. understand a range of further applications of the theory; 6. Demonstrate independent learning skills</td>
<td></td>
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</tr>
<tr>
<td>Course Content:</td>
<td>Entropy: Definition and mathematical properties of entropy, information and mutual information. Noiseless coding: Memoryless sources: proof of the Kraft inequality for uniquely decipherable codes, proof of the optimality of Huffman codes, typical sequences of a memoryless source, the fixed-length coding theorem. Ergodic sources: entropy rate, the asymptotic equipartition property, the noiseless coding theorem for ergodic sources. Lempel-Ziv coding. Noisy coding: Noisy channels, the noisy channel coding theory, channel capacity. Further topics, such as hash codes, or the information-theoretic approach to cryptography and authentication.</td>
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</tr>
<tr>
<td>Teaching &amp; Learning Methods:</td>
<td>The total number of notional learning hours associated with this course are 200. 3 hours of lectures per week over 11 weeks. 33 hours in total. 167 hours of private study, including work on the mini-project, problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.</td>
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</tr>
<tr>
<td>Formative Assessment &amp; Feedback:</td>
<td>Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts.</td>
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</tr>
<tr>
<td>Summative Assessment:</td>
<td>Exam: 90% Written Exam. Two hour written exam. Coursework: 10% Individual unsupervised mini-project</td>
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</table>
**COURSE SPECIFICATION FORM**

<table>
<thead>
<tr>
<th>Department/School:</th>
<th>Mathematics</th>
<th>Academic Session:</th>
<th>2016-17</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Course Title:</strong></td>
<td>Quantum Information and Coding</td>
<td><strong>Course Value:</strong> (UG courses = unit value; PG courses = notional learning hours)</td>
<td>0.5 unit</td>
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<tr>
<td><strong>Course Code:</strong></td>
<td>MT5445</td>
<td><strong>Course JACS Code:</strong></td>
<td>G100</td>
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<tr>
<td><strong>Availability:</strong></td>
<td>Term 2</td>
<td><strong>Status:</strong></td>
<td>Optional Condorable</td>
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<tr>
<td>(Please state which teaching terms)</td>
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</tr>
<tr>
<td><strong>Pre-requisites:</strong></td>
<td>Undergraduate courses in probability and linear algebra.</td>
<td><strong>Co-requisites:</strong></td>
<td>-</td>
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</tbody>
</table>

**Aims:**

‘Anybody who is not shocked by quantum theory has not understood it’ (Niels Bohr). This course aims to provide a sufficient understanding of quantum theory in the spirit of the above quote. Many applications of the novel field of quantum information theory can be studied using undergraduate mathematics.

**Learning Outcomes:**

On completion of the course the student should be able to:
- demonstrate a comprehensive understanding of the principles of quantum superposition and quantum measurement;
- use the basic linear algebra tools of quantum information theory confidently;
- manipulate tensor-product states and use and explain the concept of entanglement;
- explain applications of entanglement such as quantum teleportation or quantum secret key distribution;
- describe the Einstein-Podolsky-Rosen paradox and derive a Bell inequality;
- solve a range of problems involving one or two quantum bits;
- discuss Deutsch's algorithm and its implications for the power of a quantum computer;
- understand and apply Grover's search algorithm.

**Course Content:**

**Linear algebra:** Complex vector space, inner product, Dirac notation, projection operators, unitary operators, Hermitian operators, Pauli matrices.

**One qubit:** Pure states of a qubit, the Poincaré sphere, von Neumann measurements, quantum logic gates for a single qubit.

**Tensor products:** 2 qubits, 3 qubits, quantum logic gates for 2 qubits, Deutsch's algorithm, the Schmidt decomposition.

**Mixed states:** Partial trace, probability, entropy, von Neumann entropy.

**Entanglement:** The Einstein-Podolsky-Rosen paradox, Bell inequalities, quantum teleportation, measures of entanglement, decoherence.

**Grover's search algorithm,** and applications.

**Further applications,** such as e.g. the quantum Fourier transform, Shor's factoring algorithm, the BB84 key distribution protocol, quantum channel capacity, the Holevo bound.

**Teaching & Learning Methods:**

33 hours of lectures and examples classes.

167 hours of private study, including work on problem sheets, the self-study module on Grover's algorithm, and examination preparation. This may include discussions with the course leader if the student wishes.

**Key Bibliography:**

M A Nielsen and I L Chuang – Quantum Computation and Quantum Information (Cambridge 2000). Library Ref. 001.64 NIE

**Formative Assessment & Feedback:**

Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts.

**Summative Assessment:**

Exam: Two hour written exam (100%)

Coursework: None

The information contained in this course outline is correct at the time of publication, but may be subject to change as part of the Department's policy of continuous improvement and development. Every effort will be made to notify you of any such changes.
## COURSE SPECIFICATION FORM

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<th>Academic Session:</th>
<th>2016-17</th>
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<tbody>
<tr>
<td><strong>Course Title:</strong></td>
<td>Advanced Financial Mathematics</td>
<td><strong>Course Value:</strong></td>
<td>20 credits</td>
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<tr>
<td>(UG courses = unit value, PG courses = notional learning hours)</td>
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<tr>
<td><strong>Course Code:</strong></td>
<td>MT5448</td>
<td><strong>Course JACS Code:</strong></td>
<td>G100</td>
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<td>(Please contact Data Management for advice)</td>
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<tr>
<td><strong>Availability:</strong></td>
<td>Term 2</td>
<td><strong>Status:</strong></td>
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<tr>
<td>(Please state which teaching terms)</td>
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<tr>
<td><strong>Pre-requisites:</strong></td>
<td>An undergraduate course in financial mathematics</td>
<td><strong>Co-requisites:</strong></td>
<td>-</td>
</tr>
<tr>
<td><strong>Aims:</strong></td>
<td>To investigate the validity of various linear and non-linear time series occurring in finance;</td>
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<td></td>
<td>To extend the use of stochastic calculus to interest rate movements and credit rating;</td>
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<tr>
<td><strong>Learning Outcomes:</strong></td>
<td>1. make use of some of the ARCH (autoregressive conditionally heteroscedastic) family of models in time series;</td>
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<td>2. appreciate the ideas behind the use of the BDS test and the bispectral test for time series.</td>
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<td>3. understand the partial differential equation for interest rates and the assumptions that lead to it;</td>
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<td>4. be able to model forward and spot rates;</td>
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<td></td>
<td>5. see how to model the prices for certain exotic options.</td>
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<td>6. Demonstrate independent learning skills</td>
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<tr>
<td><strong>Teaching &amp; Learning Methods:</strong></td>
<td>The total number of notional learning hours associated with this course are 200. 3 hours of lectures per week over 11 weeks. 33 hours total. 167 hours of private study, including work on the miniproject, problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.</td>
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<td><strong>Formative Assessment &amp; Feedback:</strong></td>
<td>Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts.</td>
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<tr>
<td><strong>Summative Assessment:</strong></td>
<td>Exam: 90% Two hour written exam. Coursework: 10% Unsupervised mini project</td>
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# COURSE SPECIFICATION FORM

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<th>2016-17</th>
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<tr>
<td>Course Title:</td>
<td>Combinatorics</td>
<td>Course Value: (UG courses = unit value, PG courses = notional learning hours)</td>
<td>20 credits</td>
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<tr>
<td>Course Code:</td>
<td>MT5454</td>
<td>Course JACS Code: (Please contact Data Management for advice)</td>
<td>G100</td>
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<td>Availability:</td>
<td>Term 1</td>
<td>Status:</td>
<td>Optional Condonable</td>
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<tr>
<td>Pre-requisites:</td>
<td>An undergraduate course in discrete mathematics</td>
<td>Co-requisites:</td>
<td>-</td>
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<tr>
<td>Aims:</td>
<td>To introduce some standard techniques and concepts of combinatorics, including methods of counting including the principle of inclusion and exclusion; generating functions; probabilistic methods; permutations, Ramsey theory.</td>
<td></td>
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</tbody>
</table>
| Learning Outcomes: | 1. Perform simple calculations with generating functions.  
2. Understand Ramsey numbers and calculate upper and lower bounds for these (where practical).  
3. Calculate sets by inclusion and exclusion and understand the applications to number theory;  
4. Use simple probabilistic tools for solving combinatorial problems.  
5. Demonstrate independent learning skills |
| Teaching & Learning Methods: | The total number of notional learning hours associated with this course are 200.  
3 hours of lectures per week over 11 weeks. Total 33 hours.  
167 hours of private study, including work on the mini-project, problem sheets and examination preparation. This may include discussions with the course leader if the student wishes. |
| Key Bibliography:  | Discrete Mathematics – N L Biggs (Oxford UP) 510 BIG.  
Combinatorics: Topics, Techniques, Algorithms – P J Cameron (Cambridge UP) 512.23 CAM.  
Invitation to Discrete Mathematics = J Matoušek and J Nešetřil (Oxford UP) 512.23 MAT |
| Formative Assessment & Feedback: | Formative assignments in the form of 8 problem sheets.  
The students will receive feedback as written comments on their attempts. |
| Summative Assessment: | Exam: 90% Two hour written exam.  
Coursework: 10% unsupervised miniproject |
**COURSE SPECIFICATION FORM**

<table>
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<th><strong>Department/School:</strong></th>
<th>Mathematics</th>
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<th>2016-17</th>
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<tr>
<td><strong>Course Title:</strong></td>
<td>Theory of Error-Correcting Codes</td>
<td><strong>Course Value:</strong></td>
<td>(UG courses = unit value, PG courses = notional learning hours) 20 credits</td>
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<tr>
<td><strong>Course Code:</strong></td>
<td>MT5461</td>
<td><strong>Course JACS Code:</strong></td>
<td>(Please contact Data Management for advice)</td>
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<tr>
<td><strong>Availability:</strong></td>
<td>Term 2</td>
<td><strong>Status:</strong></td>
<td>Mandatory for MCC MSc</td>
</tr>
<tr>
<td><strong>Pre-requisites:</strong></td>
<td>Undergraduate courses on linear algebra and finite fields</td>
<td><strong>Co-requisites:</strong></td>
<td>-</td>
</tr>
<tr>
<td><strong>Aims:</strong></td>
<td>To provide an introduction to the theory of error-correcting codes employing the methods of elementary enumeration, linear algebra and finite fields.</td>
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<tr>
<td><strong>Learning Outcomes:</strong></td>
<td>On completion of the course, students should:</td>
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<tr>
<td></td>
<td>- calculate the probability of error or the necessity of retransmission for a binary symmetric channel with given cross-over probability, with and without coding;</td>
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<td>- prove and apply various bounds on the number of possible code words in a code of given length and minimal distance;</td>
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<td>- use MOLSs and Hadamard matrices to construct medium-sized linear codes of certain parameters;</td>
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<td>- reduce a linear code to standard form, finding a parity check matrix, building standard array and syndrome decoding tables, including for partial decoding;</td>
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<td>- know/prove/apply the theorem that a cyclic code of length $n$ over a field consists of all multiples of any factor of $x^n - 1$;</td>
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<td>- understand the structure of BCH codes.</td>
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<tr>
<td><strong>Course Content:</strong></td>
<td>Basic theory of coding: Words, codes, errors, t-error detection and t-error correction. The Hamming distance in the space $V(n,q)$ of $n$-tuples over an alphabet of $q$ symbols (with emphasis on $(\mathbb{Z}_2)^n$). Probability calculations.</td>
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<tr>
<td></td>
<td>Linear codes: Linear codes as linear subspaces of $V(n,q)$. Generator and parity check matrices, standard array and syndrome decoding. Dual of a code. Hamming codes.</td>
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<td></td>
<td>Cyclic codes: Structure of $GF(q)$ relevant to coding theory, minimal polynomial of an element of $GF(q)$; generator polynomial, check polynomial; BCH codes, RS codes.</td>
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<tr>
<td><strong>Teaching &amp; Learning Methods:</strong></td>
<td>44 hours of lectures and examples classes.</td>
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<td></td>
<td>156 hours of private study, including work on problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.</td>
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<tr>
<td><strong>Key Bibliography:</strong></td>
<td>A First Course in Coding Theory – R Hill (Oxford UP) 001.539 HIL</td>
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<tr>
<td></td>
<td>Coding Theory – a First Course – S Ling and C Xing (Cambridge UP) 001.539 LIN</td>
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<tr>
<td></td>
<td>The Theory of Error-Correcting Codes – F J MacWilliams and N J A Sloane (North-Holland) 512.23 MAC</td>
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</tr>
<tr>
<td><strong>Formative Assessment &amp; Feedback:</strong></td>
<td>Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts.</td>
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<tr>
<td><strong>Summative Assessment:</strong></td>
<td>Exam: Two hour written exam. 100% Coursework:</td>
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COURSE SPECIFICATION FORM

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<th>Department/School:</th>
<th>Mathematics</th>
<th>Academic Session:</th>
<th>2016-17</th>
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<tbody>
<tr>
<td>Course Title:</td>
<td>Advanced Cipher Systems</td>
<td>Course Value: (UG courses = unit value, PG courses = notional learning hours)</td>
<td>200 hr</td>
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<tr>
<td>Course Code:</td>
<td>MT5462</td>
<td>Course JACS Code: (Please contact Data Management for advice)</td>
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<tr>
<td>Availability: (Please state which teaching terms)</td>
<td>Term 1</td>
<td>Status: Mandatory for MCC MSc</td>
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<tr>
<td>Pre-requisites:</td>
<td>UG courses in linear algebra and probability</td>
<td>Co-requisites: -</td>
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<tr>
<td>Aims:</td>
<td>To introduce and study the mathematical and security properties of both symmetric key cipher systems and public key cryptography, covering methods for obtaining confidentiality and authentication.</td>
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<tr>
<td>Learning Outcomes:</td>
<td>On completion of the course the student should be able to: Understand the concepts of secure communications and cipher systems; Understand and use statistical information and the concept of entropy in the cryptanalysis of cipher systems; Understand the main properties of Boolean functions, and their applications and use in cryptographic algorithms; Understand the structure of stream ciphers and block ciphers; Know how to construct as well as have an appreciation of desirable properties of keystream generators, and understand and manipulate the concept of perfect secrecy; Understand the main mathematical and statistical properties of Feedback Shift Registers, and of FSR-based stream ciphers; Understand the modes of operation of block ciphers and their properties; Understand the main design principles and cryptographic techniques of modern symmetric cryptography algorithms; Understand the concept of public key cryptography, including the details of the RSA and ElGamal cryptosystems, both in the description of the schemes and in their cryptanalysis; Understand the concepts of authentication, identification and signature, be familiar with techniques that provide these, including one-way functions, hash functions and interactive protocols, and the Fiat-Shamir scheme; Understand the problems of key management, and be aware of key distribution techniques.</td>
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<tr>
<td>Teaching &amp; Learning Methods:</td>
<td>44 hours of lectures and examples classes. 156 hours of private study, including work on problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.</td>
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<tr>
<td>Formative Assessment &amp; Feedback:</td>
<td>Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts.</td>
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### COURSE SPECIFICATION FORM

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<tr>
<th>Summative Assessment:</th>
<th>Exam: Two hour written exam: 100%</th>
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### Department/School: Mathematics  
### Academic Session: 2016-17  
### Course Title: Public Key Cryptography  
### Course Value:  
(UG courses = unit value, PG courses = notional learning hours)  
20 credits  
### Course Code: MT5466  
### Course JACS Code: (Please contact Data Management for advice)  
G100  
### Availability:  
(Please state which teaching terms)  
Term 2  
### Status: Optional for MIA  
Mandatory for MCC  
Condonable  
### Pre-requisites: MT5462  
### Co-requisites:  

**Aims:**
- To introduce some of the mathematical ideas essential for an understanding of public key cryptography, such as discrete logarithms, lattices and elliptic curves;
- To introduce several important public key cryptosystems, such as RSA, Rabin, ElGamal Encryption, Schnorr signatures;
- To discuss modern notions of security and attack models for public key cryptosystems.

**Learning Outcomes:**
1. be familiar with the RSA and Rabin cryptosystems, the hard problems on which their security relies and certain attacks on them;
2. have a basic knowledge of finite fields and elliptic curves over finite fields, and the discrete logarithm problem in these groups; be familiar with cryptosystems based on discrete logarithms, and some algorithms for solving the discrete logarithm problem;
3. know the definition of a lattice and be familiar with the LLL algorithm and some applications of lattices in cryptography and cryptanalysis;
4. be able to define security notions and attack models relevant for modern theoretical cryptography, such as indistinguishability and adaptive chosen ciphertext attack.; be able to critically analyse cryptosystems;

**Course Content:**
- Background: Integers modulo n; Chinese remainder theorem; finite fields; fast exponentiation; public key cryptography and security; complexity theory.
- RSA/Rabin: Key generation; implementation; encryption and signatures; OAEP; the RSA problem and relationship with factoring; square roots modulo a prime; Hastad attack; Wiener attack.
- Discrete logarithms: Diffie-Hellman; ElGamal encryption; Schnorr signatures; Diffie-Hellman problem and decision Diffie-Hellman; methods to solve discrete logarithms such as baby-step-giant-step, Pollard rho and lambda, index calculus.
- Lattices: Definition of a lattice; GGH cryptosystem; LLL algorithm; lattice attacks on knapsack cryptosystems and variants of RSA.
- Elliptic curves: Group law; Hasse bound; group structure; point counting; ECC protocols; Maurer equivalence of DH and DL.

**Teaching & Learning Methods:**
The total number of notional learning hours associated with this course are 200.  
3 hours of lectures per week over 11 weeks. Total 33 hours.  
167 hours of private study, including work on the miniproject, problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.

**Key Bibliography:**
- Cryptography: an introduction – Nigel Smart (McGraw Hill) 001.5436 SMA  
- Cryptography theory and practice – Doug Stinson (CRC press, 2nd ed.) 001.5436 STI

**Formative Assessment & Feedback:**
- Formative assignments in the form of 8 problem sheets.  
The students will receive feedback as written comments on their attempts.
**Summative Assessment:**
- **Exam:** 90% Two hour written exam.
- **Coursework:** 10% unsupervised mini-project.

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</thead>
<tbody>
<tr>
<td><strong>Course Title:</strong></td>
<td>Applications of Field Theory</td>
<td><strong>Course Value:</strong></td>
<td>(UG courses = unit value, PG courses = notional learning hours)</td>
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<tr>
<td><strong>Course Code:</strong></td>
<td>MT5485</td>
<td><strong>Course JACS Code:</strong></td>
<td>(Please contact Data Management for advice)</td>
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<td><strong>Availability:</strong></td>
<td>Term 1</td>
<td><strong>Status:</strong></td>
<td>Optional Condonable</td>
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<tr>
<td><strong>Pre-requisites:</strong></td>
<td>An undergraduate course covering the elementary theory of groups, rings and fields.</td>
<td><strong>Co-requisites:</strong></td>
<td>-</td>
</tr>
<tr>
<td><strong>Aims:</strong></td>
<td>To introduce some of the basic theory of field extensions, with special emphasis on applications in the context of finite fields.</td>
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</tbody>
</table>
| **Learning Outcomes:**           | 1. understand simple field extensions of finite degree;  
2. classify finite fields and determine the number of irreducible polynomials over a finite field;  
3. state the fundamental theorem of Galois theory;  
4. compute in a finite field;  
5. understand some of the applications of fields.  
6. Demonstrate independent learning skills |
| **Course Content:**              | Extension theory: Polynomial factorisation. Field extensions. Simple extensions. The degree of an extension. Applications to ruler and compass constructions.  
Classifying finite fields: The number of irreducible polynomials. Existence and uniqueness of finite fields of a given size. Concrete representations of a finite field.  
| **Teaching & Learning Methods:** | The total number of notional learning hours associated with this course are 200.  
3 hours of lectures per week over 11 weeks. Total 33 hours.  
167 hours of private study, including work on the miniproject, problem sheets and examination preparation. This may include discussions with the course leader if the student wishes. |
| **Key Bibliography:**            | Introduction to Finite Fields and their Applications – R. Lidl and H. Niederreiter (Cambridge UP 1994); Library reference 512.4 LID.  
Galois Theory – I. Stewart (Chapman and Hall 2003); Library reference 512.4 STE. |
| **Formative Assessment & Feedback:** | Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts. |
| **Summative Assessment:**        | **Exam:** 90% Written Exam. Two hour paper.  
**Coursework:** 10% Individual unsupervised mini-project. |
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<th>Department/School:</th>
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<td><strong>Course Title:</strong></td>
<td>Topology</td>
<td><strong>Course Value:</strong></td>
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<td>(UG courses = unit value, PG courses = notional learning hours)</td>
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<td><strong>Course Code:</strong></td>
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<td><strong>Course JACS Code:</strong></td>
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<td>(Please contact Data Management for advice)</td>
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<tr>
<td><strong>Availability:</strong></td>
<td>Term 2</td>
<td><strong>Status:</strong></td>
<td>Optional Condonable</td>
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<tr>
<td>(Please state which teaching terms)</td>
<td></td>
<td>(i.e.: Core, Core PR, Compulsory, Optional)</td>
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<td><strong>Pre-requisites:</strong></td>
<td>Undergraduate real analysis</td>
<td><strong>Co-requisites:</strong></td>
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<td><strong>Aims:</strong></td>
<td>To introduce students to the basic concepts of metric and topological spaces, and to some aspects of low-dimensional topology.</td>
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<td><strong>Learning Outcomes:</strong></td>
<td>1. Understand what it means for knots and links to be equivalent, understand the concept of a knot invariant, and be able to use some invariants to distinguish knots and links.</td>
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<td>2. Understand the defining properties of a metric space, and determine whether a given function defines a metric; understand some basic concepts of metric spaces.</td>
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<td>3. Understand the definition of a topological space, and be able to verify the axioms in examples.</td>
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<td>4. Understand the concepts of subspace, product spaces, quotient spaces, Hausdorff space, homeomorphism, connectedness and compactness.</td>
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<td>5. Understand the notions of Euler characteristic, orientability and apply these to classify closed surfaces.</td>
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<td>6. Demonstrate independent learning skills</td>
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<td><strong>Course Content:</strong></td>
<td>Knot theory: knot and link diagrams, the Reidemeister moves, 3-colourings of knot diagrams, n-colourings of knot diagrams. Metric spaces: definition of metric spaces; examples of metric spaces, open and closed sets, further topics may include: compactness, Cantor set, continuous maps. Topological spaces: (motivated by properties of open sets in a metric space), examples of topological spaces, subspaces, connectivity, Hausdorff property, continuous functions, homeomorphisms, paths, path-connectedness, product topology, compactness, quotient spaces. Surfaces: identification spaces, connected sums, orientability, triangulations, Euler characteristic, standard examples including the sphere, the cylinder, the torus, the Möbius band, the projective plane, and the Klein bottle; the classification of surfaces. If time permits one or more of the following topics: homotopy, fixed point theorems, further knot theory</td>
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<td><strong>Teaching &amp; Learning Methods:</strong></td>
<td>The total number of notional learning hours associated with this course are 200. 3 hours of lectures per week over 11 weeks. Total 33 hours. 167 hours of private study, including work on the mini-project, problem sheets and examination preparation. This may include discussions with the course leader if the student wishes.</td>
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<td><strong>Formative Assessment &amp; Feedback:</strong></td>
<td>Formative assignments in the form of 8 problem sheets. The students will receive feedback as written comments on their attempts.</td>
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<td>Summative Assessment</td>
<td>Exam: 90% Written Exam. Two hour paper.</td>
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<td>Coursework: 10% Unsupervised miniproject</td>
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<td>Deadlines:</td>
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