Note The electronic copy of this PDF has http links embedded (i.e. “Scottish Credit and Qualifications Framework”). These links may not work properly in all .pdf readers, but the links should appear if a cursor is placed over them.

Disclaimer Every effort has been made to ensure the contents of this document are accurate at the time of printing. Unforeseen circumstances may necessitate changes to the procedures, curricula and syllabus described.

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National Degree Standards

All the undergraduate and taught postgraduate programmes offered by the Department of Actuarial Mathematics and Statistics (School of Mathematical and Computer Sciences), Heriot-Watt University, are compliant with the requirements of the Scottish Credit and Qualifications Framework (SCQF).
1 Introduction

This programme has been designed to develop the skills and knowledge required for a successful career in modern asset management and investment banking.

Financial Engineering involves the creation of financial products that are aimed specifically at the needs of investors, rather than the conventional approach of defining assets on the basis of borrowers’ requirements. Central to Financial Engineering are relative value (sometimes called arbitrage) trading strategies and the structuring of financial products, and the closely associated process of securitisation. Structuring involves the transformation of cash flows derived from an asset and improving the risk profile of the resulting structured product. The modern derivative markets are driven by the process of structuring, both in terms of transforming cash flows through ‘swaps’ and credit enhancement through credit derivatives.

The emphasis in modern finance is on understanding the relationships between asset values in a dynamic and uncertain environment, and on the basis of this understanding, creating profitable investment strategies. This means that mathematics is an essential part of a successful Financial Engineer’s skill set.

The programme in Quantitative Financial Engineering develops the skills and knowledge required by the modern investment and asset management industry. The emphasis is on developing a range of practical skills useful in the workplace, rather than expertise in abstract mathematics or theoretical economics that is not relevant to the problems encountered in modern financial markets.
2 Programme Administration

The administration for the programme is handled by the Department of Actuarial Mathematics and Statistics at Heriot-Watt University, which is part of the School of Mathematical and Computer Sciences.

Students should contact staff in the School Office (EM1.25) in the first instance for any enquiries in relation to the programme. The School Office is open week days from 1000 to 1600. The School Office can also be contacted by e-mail: macs-schooloffice@macs.hw.ac.uk or telephone: 0131 451 3432.

Programme Director

Dr Tim Johnson,
Department of Actuarial Mathematics and Statistics,
Room CMG05, Heriot-Watt University,
tel: 0131 451 8343
email: T.C.Johnson@hw.ac.uk

Tim will act as a first point of contact for students who require advice or assistance for both academic and non-academic matters.

Programme Administrator

Jill Gunn,
Department of Actuarial Mathematics and Statistics,
Room EM 1.17,
tel: 0131 451 3334
email: J.P.Gunn@hw.ac.uk

Jill is responsible for all programme administrative matters, is a member of the Programme Committee and is the secretary to the Board of Examiners.

Students can also get advice on a range of Finance, Hospitality Services and Academic Registry issues from the Student Service Centre (http://www1.hw.ac.uk/studentcentre/) which is situated in the Hugh Nisbet Building along from the Bank (email: studentcentre@hw.ac.uk)

3 Introductory Information

3.1 Enrolment

All student enrolment is completed on-line. You are responsible for ensuring your enrolment details are correct, and that you have enrolled for all courses that you wish to take. Information to assist with course selection will be provided at the Pre-Enrolment meeting. If you have any questions about enrolment you should speak to the Programme Administrator. Students are advised to enrol for all courses which they might be interested in taking in the first instance. Your choice of courses can be finalized at a later date.

You must enrol for either the PG Diploma in QFE or the MSc in QFE. If you change your mind and wish to change programme you may only do so before 30 September 2015 by advising the Programme Administrator in writing. International students should be aware that any programme changes will be notified to the UK Border Agency and this may have implications for your student visas.

No refunds of programme fees will be provided to students who leave the University without completing the programme for which they are registered for any reason (i.e. regardless of whether this departure is voluntary or because students have failed to qualify for the desired award).

3.2 Note from the Programme Director

The programme is demanding. In order to be successful you will have to work extremely hard, the Scottish Qualifications Authority state that each “credit” should be achieved after 10 hours effort, this means students are expected to spend 150 hours to achieve a pass (not an ‘A’) in, for example, Financial Markets. Typically there will be 40-60 hours lectures on a 15 credit course, so students need to be spending as much time working on a topic outside the classroom as they do in the classroom. Also, poor attendance at classes is likely to lead to poor performance.

We recommend that most students take Statistical Methods as their option in semester 1, since Credit Risk Modelling in semester 2 relies on a foundation in statistics. Financial Markets is offered as an option to students with a good foundation in statistics.

Anyone who finds they are struggling with any aspect of a course should alert the course lecturer at the first available opportunity. Staff are always happy to help but cannot do so if they are not aware that there is a problem. Your academic mentor (see Section 3.5) is also available during the year to provide support when needed. It is a programme requirement to meet with your mentor at least once a semester.
3.3 Important Dates

Semester Dates

<table>
<thead>
<tr>
<th>Activity</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1 teaching</td>
<td>14 September 2015 – 7 December 2015</td>
</tr>
<tr>
<td>Semester 1 exams</td>
<td>7 December 2015 – 18 December 2015</td>
</tr>
<tr>
<td>Break</td>
<td>21 December 2015 – 8 January 2016</td>
</tr>
<tr>
<td>Semester 2 teaching</td>
<td>11 January 2016 – 1 April 2016</td>
</tr>
<tr>
<td>Break</td>
<td>4 April 2016 – 22 April 2016</td>
</tr>
<tr>
<td>Semester 2 exams</td>
<td>25 April 2016 – 20 May 2016</td>
</tr>
<tr>
<td>Dissertation (to be confirmed)</td>
<td>6 June 2016- 19 August 2016 (an 11 week period)</td>
</tr>
<tr>
<td>Graduation</td>
<td>17 November 2016 – 18 November 2016</td>
</tr>
</tbody>
</table>

Between the end of the Semester 2 exams and the beginning of the Dissertation period the Exam Board is held. The Exam Board has the authority to change grade boundary points and approve any re-scaling of marks, for this reason lecturers are unable to give any indication as to a student’s achievement on a course until after the Board. Within an hour or so of the Exam Board completing, decisions on students’ progression to dissertation are given. Exam results will come later after processing.

3.4 Timetable

Timetables can be found at: http://www.macs.hw.ac.uk/timetable/. Copies will also be available for reference on the notice boards along from the School Office. Occasionally it is necessary to make adjustments to the timetable, such as rescheduling a class – all changes will be notified on the class VISION pages or by email. Classes are timetabled to start and finish at 15 minutes past the hour. The standard Heriot-Watt practice is that classes start at 20 minutes past the hour and finish at 10 minutes past. Please be courteous to staff and fellow students by ensuring you arrive on time to all your classes.

3.5 Attendance Requirements

In order to achieve course and programme learning outcomes, students are expected to attend all scheduled course learning sessions (e.g. timetabled lectures, tutorials, lab sessions, etc). Should you have to missed a timetabled session due to ill health or other legitimate reasons, you should submit a self-certification or medical certification or an application for consideration of Mitigating Circumstances (http://www1.hw.ac.uk/committees/ltb/resources/mc-policy.pdf). Students who fail to satisfy course attendance requirements may, after due warning, be disallowed from presenting themselves for examination in the course (see http://www.hw.ac.uk/students/doc/withdrawalprocedures.pdf).

3.6 Student Mentors

All Heriot-Watt students are allocated an academic Mentor. By default, the Programme Director will normally be assigned as your Mentor. If there are any changes to this default situation you will be informed early in first semester.

If you have any academic, personal or financial problems during the year your Mentor will be willing to advise or help you, but your Mentor has limited competence and for more serious problems they will advise who you should speak to for more expert advice.

You are advised to meet with your mentor at least once each semester. For international students
this meeting is regarded as a required contact point for UK Borders Agency attendance monitoring purposes.

3.7 Other Students

You share your courses with students on other degrees and occasionally a PhD student will attend lectures.

3.8 Staff-Student Liaison

All students on the MSc should feel free to discuss aspects of the running of the programme directly with the Programme Director. However, issues which are relevant to the whole of the class should normally be raised with the Programme Director through a student representatives – ‘Class Rep(s)’ sitting on the AM&S Department’s Postgraduate Staff Student Liaison Committee.

At least one Class Rep (classes of less than 15 students normally need only one Rep) will be elected at the start of the year. Class Reps will engage with the Programme Director to monitor and review all aspects of the programme and act as the main communication channel between students on a Programme (the MSc) and the Programme Director. If an issue emerges with the Programme, the Programme Director will ask the Class Reps to discuss the issue with the class and report back.

3.9 Feedback

Feedback is a two-way process. Feedback is provided to students in a variety of ways in order to help you to reflect on and to evaluate your progress and to assist you to take steps to improve before the next relevant assessment. For most courses, students can expect feedback on assessed coursework within three teaching weeks of the coursework due date.

Feedback is sought from students via Student-Staff Liaison Committees and various surveys so that the School can continue to enhance the student learning experience. Your feedback is valued by the School, so please be sure to provide feedback whenever it is sought.

3.10 Teaching Accommodation and Staff Accommodation

Classes may be held in any teaching rooms on campus. Students on other postgraduate programmes may join the class for certain courses or lectures. The academic staff of the Department of Actuarial Mathematics and Statistics all have their offices in the Colin Maclaurin (CM) building. Administrative staff and the MACS School Office are nearby in that section of the Earl Mountbatten building close to the CM building.

3.11 Computer Facilities

All enrolled students are issued with accounts on the University Desktop Service. This will give you an email account, and access to word-processing facilities and various packages which will be needed for some of the Diploma programmes and for the MSc projects.

There are details of computer lab locations and availability in the IT Help portal.

Students are expected to use the computing facilities in an appropriate and considerate way. Abuse of the facilities is subject to various disciplinary measures, ranging from a ban on access to the facilities to,
in extreme and flagrant cases, expulsion from the University. Examples of abuse include monopolising a terminal for non-academic related purposes, running excessively long or inappropriate print jobs, and displaying, circulating or printing offensive material on or from the internet. Computer games and relay chat are specifically forbidden. Further information on policy regarding the abuse of computing facilities is available from Information Technology (IT).

You will be credited with a printing quota for use over the year. While an additional allocation will be made in the summer for those proceeding to the MSc, you are advised to use your quota sparingly.

3.11.1 On-line enrolment

You can usually work through a on-line enrolment by finding a vacant PC and logging on. The Computer Centre may not have details of all students. For these people the quick enrolment will not be possible and you should go to Student Services.

3.11.2 Contacting You

The Programme Director, Programme Administrator and lecturers and will regularly communicate with you by email. All emails will be sent to your Heriot-Watt email address (e.g. abc123@hw.ac.uk) and NOT to any personal email address you may have. It is your responsibility to find out what arrangements have been made and what information has been sent to you. You are expected to check your Heriot-Watt email in-box regularly and to make sure that there is always space in it for incoming messages - so remember to clear it out on a regular basis. You should also check the class VISION and website pages regularly for announcements and updates.

3.12 Student mail

Mail arriving for all students in the School is put in pigeon holes in the School Office.

3.13 Mobile phones

The use of mobile phones is strictly forbidden in all lectures, tutorial sessions and computer lab sessions. All mobile phones must be switched completely off during these times.

Mobile phones may not be taken into exam rooms during examinations.

3.14 Finance

Students are reminded that invoices are issued prior to or at enrolment and are payable immediately. Anyone who is experiencing difficulty in meeting their repayments should contact the Finance Office immediately.

The University has a strict policy regarding the payment of invoices and students who fail to meet this will have their student privileges withdrawn and may in some cases be subject to legal proceedings. If you are experiencing difficulties in meeting your payments it is essential that you contact the Finance Office at the first available opportunity. You may also wish to seek advice from your Student Welfare.

No student with outstanding debt will be permitted to graduate from the University, and in some cases students with debt may be prevented from continuing to the MSc dissertation stage of the programme.
4 Programme Structure

The official description of the degree can be found at QFE Programme Structure

4.1 Components of the Degree

The taught component of the degree makes up 120 credits. There are five mandatory courses making up 75 credits and consisting of

- **Derivative Markets and Pricing** (15 credits, Semester 1) - an introduction to derivative markets and how derivative products are priced.
- **Modelling and Tools** (15 credits, Semester 1) - an introduction to applied mathematical modelling.
- **Financial Engineering** (15 credits, Semester 2) - a comprehensive treatment of the mathematics underpinning contemporary trading and securitisation.
- **Credit Risk Modelling** (15 credits, Semester 2) - a detailed treatment of the mathematics underpinning Basel Accord on banking supervision and Solvency II for insurance.

Students should choose **one of four optional courses in the first semester**

- **Statistical Methods** (15 credits, Semester 1) - a foundation course in probability and statistics.
- **Financial markets** (15 credits, Semester 1) - an introduction to the financial markets. This should be only taken by students confident in the syllabus of Statistical Methods.
- **Enterprise Risk Management** (15 credits, Semester 1) - a comprehensive treatment of financial risk management covering both quantitative and qualitative aspects.
- **Data Mining & Machine Learning** (15 credits, Semester 1) - an introduction to machine learning techniques, increasingly significant in finance.

and **two of four optional courses in the second semester**.

- **Time Series Analysis and Financial Econometrics** (two 7.5 credit courses taken and examined together, Semester 2) - analysis and modelling of financial data.
- **Modern Portfolio Theory** (15 credits, Semester 2) - the classical mathematical theory of portfolios.
- **Bayesian Inference & Computational Methods** (15 credits, Semester 2) - the theory and application of modern Bayesian statistical inference.
- **Stochastic Simulation** (15 credits, Semester 2) - a comprehensive course on the mathematical modelling of stochastic processes.

Courses are usually assessed by examination at the end of the semester in which they are taught, a notable exemption is that Enterprise Risk Management I is examined in the Summer, not at the end of Semester I. Some courses have an element of continuous assessment, whether a mid-term test or project work in addition to a written exam while Special Topics in Risk Management has no exam and is assessed through coursework.

Students opting for the MSc, rather than the Diploma, will also write a Dissertation.
• **Dissertation** (60 credits) - an extended project that can be either theoretical, undertaken with an academic supervisor, or more practical, delivered by industry professionals through the Scottish Financial Risk Academy (www.sfra.ac.uk). Companies offering dissertations through the SFRA include Aviva, Moody’s Analytics, J.P. Morgan Chase, Kames Capital (AEGON), Lloyd’s Banking Group, RBS and Standard Life Investments. Access to an industrial dissertation is competitive across a number of masters degrees offered by Scottish Universities and students are selected solely by the company offering the project.

### 4.2 Creating your own Programme

Students on this degree come from a variety of backgrounds and have a large number of choices in the courses they take. The following are **suggested optional course combinations for guidance**.

**Student’s with good statistics but no finance background**  Financial Markets and Enterprise Risk Management then any two in Semester 2.

**Student’s with some statistics and some finance background**  Statistical Methods and Enterprise Risk Management then any two in Semester 2.

**Student’s with no statistics but some finance background**  Statistical Methods and Financial Markets then any two in Semester 2.

**Student’s with no statistics and no finance background**  Statistical Methods and Financial Markets then any two in Semester 2.

**Student’s with some statistics and some computing but no finance background**  Statistical Methods and Data Mining & Machine Learning then Time Series Analysis and Financial Econometrics and Bayesian Inference & Computational Methods in Semester 2.

### 4.3 Personal Computing Resources

What follows is advice only, we do not provide support. You are advised to familiarise yourself with computational tools in advance of having to use them in projects.

An objective of the Programme is for students to develop their computational skills. This is done by exposing students to a number of computational platforms in taught courses, rather than presenting computing in a standalone course; the idea is you learn the skill in the context of an application.

Specifically you will have the opportunity to use MATLAB in Modelling and Tools (F11MT) and R in Enterprise Risk Management (F71ER) while in Financial Engineering (F71FE) you will be encouraged to use PYTHON as an alternative to MATLAB or R.

MATLAB is available to you via the University’s computers or you can install it on a personal computer and obtain a licence from ithelp@macs.hw.ac.uk. See Matlab instructions for details.

R is also available via the University’s computers and can be easily, and freely, downloaded and installed on your own computer.

PYTHON is not available on the University’s computers but can be easily, and freely, downloaded and installed on your own computer.
5 Progression and Degree Classifications

Students can register for a Masters or Diploma in Quantitative Financial Engineering. Students registered for the MSc degree need to satisfy certain progression criteria, enabling them to proceed onto the Dissertation. If they fail to meet these criteria, given below, they will graduate with a Diploma or Certificate, according to the circumstances.

All decisions related to course awards and progression are made by the Exam Board that sits, firstly, between the end of exams and the start of the Dissertation Period and then after the Dissertation. The Exam Board comprises of all lecturers on the Programme, School management, an examiner from outside the university (the ‘external examiner’) and a representative of the University's Dean from outside the School of Mathematical and Computer Sciences.

The University operates the Heriot Watt Assessment and Progression System (HAPS) which specifies minimum progression requirements. Schools have the option to apply progression requirements above the minimum University requirement, which are approved by the Studies Committees. Students should refer to the programme specific information on progression requirements. This information is detailed below.

Note that grade boundaries are set by the School offering the course, in particular Financial Markets typically sets the E grade boundary at 35%, not 30% which is usual in the School.

5.1 Masters Degree in QFE

To proceed to the Dissertation students need to

- Pass all 120 credits at grade A-D (40% –100%).
- Achieve an average grade of at least 50% across the best 120 credits.

Students will then be awarded a Masters if they achieve a grade A-C (50%–100%) on the Dissertation. Students will be awarded a distinction in the Masters if they

- Achieve an average grade of at least 70% the best 120 taught credits and pass all credits at grade A–C.
- Achieve a grade A (70%–100%) in the Dissertation.

5.2 Postgraduate Diploma in QFE

Students who choose not to progress to the Masters or do not meet the progression requirements after the April/May exams may be awarded the Postgraduate Diploma in QFE. The requirement for this degree is an average mark of over 40% in 120 credits all passed at grades A–E. Student’s will achieve a distinction in the Diploma if they achieve an average mark of over 70% in their best 120 credits and pass all courses at grades A–C.

5.3 Postgraduate Certificate in QFE

Students who do not meet the requirements for the award of the Postgraduate Diploma after the April/May exams may be awarded the Postgraduate Certificate in QFE. The requirement for this degree is an average mark of over 40% in the best best 60 credits, passing courses and passing courses at grade A-E.
5.4 Resit examinations

Students who do not automatically satisfy the requirements for immediate progression onto the MSc dissertation may be permitted to resit up to three courses. The opportunity to resit a further specified paper will be granted at the discretion of the Exam Board. If all requirements for progression are met after the re-assessment, the MSc dissertation may then be undertaken in the following summer.

There will be one opportunity to resit a given examination. Modules taught by the School of Management and Languages can sometimes be re-sat in June, at the start of the Dissertation Period. However in general the resit examination will be at the next available opportunity (that is, at in their usual assessment diet in the following academic year.)

5.5 Degree Certificates

On successful completion of the degree (MSc or Postgraduate Diploma) you will receive a Heriot-Watt degree certificate. Normally this is presented at the graduation ceremony at Heriot-Watt University in November although you can receive it by post if you are unable to attend in person.

6 Information on Assessment Procedures

Generally speaking, immediately you feel that there are issues (health, financial, family, personal) that may prevent your successful completion of the degree you should inform someone. Normally you should contact the Programme Director but if the matter is of a personal nature you can contact Student Welfare in confidence, who will then inform the Programme Director that you have issues of a personal nature without giving details.

All problems can be resolved successfully and students graduate providing the student informs someone in good time.

It is the students’ responsibility to ensure that they adhere to the University’s regulations with regard to examinations (Section 9).

6.1 Disability and Special Needs

Some of you on the MSc may have some form of disability or have special needs. Examples include students with hearing, eyesight problems or physical disabilities. We are very happy to make special arrangements to help you as much as we can to make your year here a successful one.

The University has a special needs adviser. If you do think there is something that we can help with then you should first make contact with the Special Needs adviser.

The special needs adviser is also a useful person to contact during the year for some problems that might arise during the year, such as if you break a bone.

6.2 Notification of Mitigating Circumstances and Medical Certificates

It is very important that you notify the Programme Director as soon as possible of any mitigating (special) circumstances (such as illness or death of a close relative) which could adversely affect your studies and/or examination performance. Details of the Policy are at Special Circumstances Policy at

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1These were previously known as ‘Special Circumstances’ and some forms may still refer to ‘Special Circumstances’.
http://www.hw.ac.uk/registry/resources/special-circumstances-policy.pdf and the form at: http://www.hw.ac.uk/registry/forms.htm (under ‘Find a Form’). In the case of illness, a medical certificate must be supplied as soon as possible to the Programme Administrator. The Examiners will always take such circumstances into account where appropriate, but the later the notification, the less scope there is to do so. Notification of special circumstances must be given before the examination diet concerned.

*Late notification will normally mean that no account can be taken of the circumstances.* With regards to submission of project work, students are required to take reasonable precautionary measures to keep their work in progress safe such as regular backups of computer files. For further details, see the University Regulations.

Issues relating to individual loss of data/computer failures are unlikely to be classed as ‘Mitigating Circumstances’. It is therefore up to the student to ensure they have taken adequate backups and the software they rely on is secure.

### 6.3 Dictionaries in Examinations

No translation dictionaries are permitted in any of the University’s examinations. The only exception to the policy is in the case of individual students who had been assessed by the University’s Disability Service as requiring access to a translation dictionary.

### 6.4 Calculators in Examinations

Where a calculator is required for the completion of an examination, a student may use any basic scientific calculator, except the following: graphics calculator, programmable calculator and a calculator which features text storage or retrieval facilities (see http://www.hw.ac.uk/registry/resources/approvedcalculatorguidance.pdf).

### 6.5 Unauthorised Material

You must not have any unauthorised electronic devices or pre-printed materials in the examination room. Cheating in an examination is treated very seriously by the University. If you do have any material relevant to the exam which you have brought in by mistake, you must hand it over to an invigilator before the start of the examination. Invigilators will carry out checks on authorised materials and calculators.

### 6.6 Plagiarism

The University has a strict policy on Plagiarism – passing off as one’s own the ideas or writing of another. All students should be familiar with the University’s policy on plagiarism (English/Chinese).

Plagiarism undermines every academic principle. Plagiarism is cheating and the Department, the School, and the University treat it very seriously indeed. This is relevant for all students and has implications for course work, exams and the writing of MSc dissertations. The sanctions for plagiarism range from the discounting of the plagiarised work, the course or dissertation completely, withholding of the degree or Diploma concerned, or ultimately to expulsion from the University.

Anyone indulging in plagiarism of any kind can expect no sympathy or understanding from the University. Typically plagiarised work is discounted and will normally result in the student failing the
relevant course.

We will automatically assess work which we feel is plagiarised, the system is extremely powerful in employing the Internet to identify source documents. Copying text verbatim from any electronic source (or book or journal article that is available electronically) without attribution will be identified as plagiarism.

If you have the slightest doubt about any aspect of this matter and of how your own work relates to it, you must discuss it with the Programme Director before submitting any work.
7 Synopses of Taught Courses

Derivatives Markets and Pricing (F71DV)
(15 credits, semester 1, mandatory)

Lecturers: Dr A. Wiese

Aim

The aims of this course are:

- To provide a thorough grounding in the operation of derivative markets
- To provide an introduction to the methods of hedging using option and forward contracts, with particular emphasis on bond (interest rate) markets
- To provide students with a good understanding of the principles of no-arbitrage pricing
- To introduce mathematical concepts related to stochastic processes
- To teach students the CRR (discrete time binomial) model for derivative pricing
- To introduce the Wiener process and the BSM option pricing model

Syllabus

- Introduction and Forward Contracts
- Options
- Hedging with Futures and Options
- Interest Rate Derivatives and Swaps
- No–Arbitrage Pricing of Forwards
- Single Period Derivative Pricing
- Mathematical Foundations of Multi-Period Derivative Pricing
- The Binomial Model
- Continuous Time Models

Texts


Modelling and Tools (F11MT)
(15 credits, Semester 1, mandatory)

Lecturers: Prof. S. Malham

Aim The course aims to provide postgraduate students with fundamental techniques of deterministic and probabilistic mathematical modelling. Model problems will be used to develop and illustrate these techniques. To investigate the problems, Matlab programs will be developed and implemented. The course is taught in the format of bi-weekly 2 hour sessions which combine the presentation of theoretical material in lecture style and practical analytical and numerical studies of application problems.

Syllabus

1. **Introduction to Matlab:** Providing/reviewing the basics of Matlab. This will include lab work. This will allow the development of appropriate Matlab programs in the following sessions. (15 lectures)
2. **Data fitting and calibration:** Least squares data approximation, Accuracy and goodness of fit, More general models. Using Matlab. (6 lectures)

Texts TBC

Assessment 50% by coursework, 50% by end of semester exam.
Enterprise Risk Management I (F71ER)
(15 credits, semesters 1 optional)

Lecturer: Prof A. McNeil

Aim

To provide: an introduction to the advanced statistical methods underpinning Enterprise Risk Management (ERM), including credit risk; a thorough grounding in the wide range of risks facing a company. To develop key risk assessment skills.

Summary

Much of the course will focus on a small number of financial risks that banks and insurers are exposed to. We will discuss how these risks can be analysed and the methods discussed in lectures will be implemented in the weekly computer labs.

At the end of the course you should be able to:

- Demonstrate an understanding of the different reasons for measuring financial risk.
- Describe and apply the different measures of financial risk.
- Define what is meant by a coherent measure of risk.
- Determine the main characteristics of a univariate financial time series.
- Use appropriate statistical and computational methods to determine the fatness of the tails of returns data.
- Describe and apply the main univariate and multivariate distributions to financial data.
- Describe and apply the fundamental concepts and theorems in Extreme Value Theory (EVT).
- Describe how analysis of financial data using EVT differs from traditional statistical methods.
- Describe and apply the main statistical methods in EVT to financial data.
- Demonstrate how multivariate returns can be described using marginal distributions and copulas.
- Describe and apply the main copulas.
- Explain how the use of different copulas can affect the returns distribution on a portfolio containing two assets.
- Describe some empirical techniques that can be applied to financial time series data to establish the presence of stochastic volatility.
- Describe some simple time series models for stochastic volatility and explain how these affect the distribution of returns over time.
- Use appropriate statistical software to analyse problems involving financial risk.
Syllabus In this course we will cover the following topics

- **Introduction**
  - What is ERM and why is it worthwhile
  - Direct and indirect stakeholders in an enterprise
  - Different types of risk

- **Quantitative analysis of financial data**
  - Quantifiable and non-quantifiable risks
  - Modelling univariate financial time series; model fitting and diagnostic tests
  - Extreme value theory
  - Econometric models for stochastic volatility
  - Modelling multivariate risks including the use of copulas
  - Different measures of correlation and dependency
  - Risk measures; coherent risk measures
  - Scenario analysis and stress testing
  - Model and parameter risk

**Texts** The required reading for the lecture course will be a set of printed lecture notes that I will provide.

For additional reading, an excellent textbook is that by McNeil, Frey and Embrechts (2015).


The majority of the topics covered in the lecture course are discussed in detail in this book.

The book by Crouhy, Galai and Mark (2006) is also an excellent one (modestly priced!) covering the non-quantitative parts of the course.


**Assessment**

20% of the mark will be from coursework during Semester 1. 80% will be based on a 2 hour exam in the Summer exam diet.

Further information and course materials are available on VISION.
Statistical Methods (F71SM)

(15 credits, semester 1, optional)

Lecturer: Prof. D. Clancy

Aim

This course aims to provide postgraduate students taking the MSc in Actuarial Science, the MSc in Financial Mathematics, and other programmes with a broad knowledge of the principal areas of mathematical statistics and statistical methods widely used in insurance and finance.

Summary

At the end of studying this course, students should be able to:

- Summarise and display data.
- Perform basic probability calculations.
- Calculate moments and the expected values of other functions of random variables.
- Apply the central limit theorem.
- Obtain estimators of parameters of certain common distributions.
- Determine properties of estimators: efficiency,
- Cramèr-Rao lower bound, (approx. large-sample) distribution.
- Perform inference on parameter estimates: obtain confidence intervals and carry out hypothesis testing.
- Fit a linear regression model.

Syllabus

- Summary and display of data
- Introduction to probability
- Random variables
- Models for count data
- Models for measurements
- Jointly distributed random variables
- Linear combinations of random variables
- The central limit theorem
- Sampling distributions
- Estimation of parameters
- Hypothesis testing
- Linear regression

Main Texts

*John E Freund’s Mathematical Statistics:*(7th Ed. or later), Miller & Miller, Prentice-Hall
*New Cambridge Statistical Tables:*(2nd Ed.), Lindley & Scott, C.U.P.

Other Reading

*Essential Statistics:*(4th Ed. or later), Chapman Hall/CRC
*Introduction to Probability and Statistics:* (8th Ed.), W. Mendenhall and R.J.Beaver, PWS, Kent

Assessment

Statistical Methods will be examined by a 2-hour examination at the end of the first semester.
Financial Markets (C31FM)
(15 credits, semester 1, optional)

Lecturer: Dr B. Xu.

Aims

This course is designed to give students a critical understanding of financial markets, the nature of the assets traded in them, and the price-setting process. The course concentrates on equity and bond markets.

Summary

After studying this course, students should:

- Understand the functions of financial markets.
- Understand the main asset classes and financial instruments.
- Understand the roles of the various participants involved in financial markets.
- Understand the logic of diversification and implications of this logic for share prices.
- Have the ability to critically evaluate the Efficient Markets Hypothesis.
- Understand many tests of market efficiency, and observed market anomalies.
- Understand technical and fundamental analysis of share prices.
- Identify the key errors made by individuals in processing information and biases.
- Understand the pricing, characteristics, and risk determinants of bonds.
- Have the ability to calculate yields and prices of various types of bonds.
- Have the ability to describe the major theories of term structure and the effects that the theories would have on observed term structure.
- Have the ability to critically evaluate the investment performance.

Syllabus

1. Financial Markets
   - The logic and underlying problems of financial markets
   - Main types of assets classes and financial instruments
   - Participants in financial markets

2. Equity Investment
   - Diversification and the Capital Asset Pricing Model
• The total return concept
• The efficient markets hypothesis
• Technical and fundamental analysis
• Behavioural biases

3. Bond Investment

• Types of bond
• The term structure of interest rates
• Bond risk
  – Default risk and bond rating agencies
  – Interest rate risk: duration: converting
• Theory of immunisation.

4. Portfolio management

• Passive vs. active portfolio management approaches
• Investment Performance Measurement

**Recommended Texts**


**Assessment**

20% of the overall assessment will be based on a ‘mid-term’ at the end of October/beginning of November.

There will be a 2 hour examination counting towards the remaining 80% of the course assessment during the Semester 1 Assessment Period (December).
Data Mining and Machine Learning (F21DL)
(15 credits, Semester 1, optional)

Lecturers: Prof. D. Corne

Aim

- To introduce students to the fundamental concepts and techniques used in data mining and machine learning.
- To develop a critical awareness of the appropriateness of different data mining and machine learning techniques.
- To provide familiarity with common applications of data mining and machine learning techniques.

Syllabus

1. **Data Mining**: Basic concepts (datasets, dealing with missing data, classification, statistics), regression analysis, cluster analysis (k-means clustering, hierarchical clustering), unsupervised learning, self-organising maps, naïve Bayes, k-nearest-neighbour methods

2. **Machine Learning**: decision tree learning, ensemble methods (bagging and boosting, random forests), deep learning architectures, support vector machines

Texts TBC

Assessment 100% coursework.
Financial Engineering (F71FE)
(15 credits, semester 2, mandatory)

Lecturers: Dr T. Johnson

Aim The aims of this course are:

- To provide a thorough grounding in financial engineering (the including non-vanilla derivatives, securitisation and structuring)
- To introduce mathematical concepts hedging and pricing derivatives
- To provide students with a good understanding of developing the BSM model to different asset classes,
- To provide students with an understanding of pricing American options
- To provide students with a good understanding of exotic options
- To provide students with a good understanding of modelling interest rates, including Libor Market Models and valuing swaptions
- To introduce the student to securitisation
- To provide students with an understanding of managing a complex portfolio of assets

Syllabus

1. Stochastic Calculus applied to financial markets
   - The Martingale Approach to asset pricing, including Cameron-Martin-Girsanov Theorem, the concept of the Radon-Nikodym derivative, the Martingale Representation Theorem
   - Self-financing portfolios in continuous time and the construction of replicating strategies using the martingale approach
   - OU and Feller processes and derivation of a BSM like PDE
   - The role of the market price of risk in the transfer between the real-world and the risk-neutral probability measures
   - Hedging derivatives and the Greeks in continuous time models and to structures

2. Volatility
   - The role of the volatility parameter in the valuation of options
   - Estimation of volatility from market data
   - The “smile” effect and volatility surfaces

3. Exotic options, derivative portfolios and securitisation
   - Description of exotic options (including Quanto, Chooser, Barrier, Binary, Lookback Asian, Exchange, Basket options)
• Swaps and swaptions
• Securitisation, Structured Derivatives and Synthetic Securities
• Risk Management of portfolios/securitised assets.

4. Modelling the Term Structure of Interest Rates
• The Black, Hull & White Vasicek and Cox-Ingersoll-Ross models (Ho & Lee, Black, Derman & Toy, Black & Karasinski)
• HJM framework.
• Libor Market Models
• Implementation and calibration of models

5. Financial Engineering Project
• Extended project synthesising knowledge in a practical setting.

Texts


Assessment 40% through coursework, 60% through end of semester exam.
Credit Risk Modelling (F71CM)
(15 credits, semester 2, mandatory)

Lecturer: Prof A. McNeil

Aims

This course will introduce students to quantitative models for measuring and managing credit risk. It also aims to provide students with an understanding of the credit risk methodology used in the financial industry and the regulatory framework in which the credit risk models operate.

Syllabus

- Introduction to credit risk: credit-risky instruments, defaults, ratings
- Merton’s model of the default of a firm
- Common industry models (KMV, CreditMetrics, CreditRisk+)
- Modelling dependence between defaults with factor models
- Mixture models of default
- The Basel regulatory capital formula
- Calculating the portfolio credit loss distribution
- Introduction to credit derivatives: CDS and CDOs

Texts


Assessment

Credit Risk Management will be examined by a 2-hour exam.
Portfolio Theory (F71PT)
(15 credits, semester 2, optional)

Lecturers: Prof. A. Cairns / TBC

Aim To provide postgraduate students with the necessary skills in asset pricing and portfolio selection models

Summary At the end of studying this course, students should be able to:

- Derive the properties of a utility function. Apply the concept of utility theory on investment.
- State the conditions for absolute dominance, first and second order stochastic dominance.
- Demonstrate whether investments have dominance over each other.
- Calculate some important measures of risk: variance, semi-variance, shortfall probability and mean shortfall and Value at Risk.
- Calculate the mean and variance of return on a portfolio of assets.
- Demonstrate an understanding of methods used to select portfolios of assets, including utility theory, stochastic dominance and mean-variance analysis.
- Describe the purpose and calculation of the following: opportunity set, efficient frontier, indifference curve, separation theorem.
- Develop a critical understanding on the theory of mean-variance model and understand its modifications using other risk measures.
- Describe the properties of single-factor and multi-factor models. Show how to fit a single-factor model to market price data.
- Discuss the assumptions underlying and applications of the Capital Asset Pricing Model. Derive the capital market line and the security market line.
- Understand the concept of risk premium in Arbitrage Pricing Theory.
- State the weak, semi-strong and strong forms of the efficient market hypotheses and discuss their economic implications.
- Discuss the topics in prospect theory: framing, reference points, probability estimates.
Syllabus

• Utility theory
• Stochastic dominance
• Measures of investment risk
• Mean-variance portfolio theory
• Models of asset returns
• Capital asset pricing model
• Efficient market hypothesis and behavioural finance


Assessment  There will be a 2 hour examination at the end of the semester.
Bayesian Inference & Computational Methods (F79BI)
(15 credits, semester 2, optional)

Lecturers: Prof. G. Gibson

Aim To provide students with a knowledge of modern Bayesian statistical inference, an understanding of the theory and application of stochastic simulation methods including MCMC, and experience of implementing the Bayesian approach in practical situations.

Summary The course will review subjective and frequentist probability, the role of likelihood as a basis for inference, and give a comparative treatment of Bayesian and frequentist approaches. The key concepts in practical Bayesian statistics will be covered including: likelihood formulation; the incorporation of prior knowledge or ignorance in the prior; the interpretation of the posterior distribution as the totality of knowledge and its use in prediction. A range of stochastic simulation methods for investigating posterior distributions will be considered. Methods will include rejection sampling, and Markov chain methods such as the Metropolis-Hastings algorithm and the Gibbs sampler. The use of stochastic methods for inference for partially observed processes will be discussed and students will gain experience of implementing methods in computer laboratory sessions.

Texts


Assessment 2 hour exam (60%) and 2 practical assignments (20% each).
Time Series Analysis (F71TS)
(7.5 credits, Semester 2, optional, must be taken with C21FE)

Lecturer: Prof S. Foss

NOTE: F71TS runs in the first half of Semester 2 before C21FE.

Aims

This course will introduce students to the main concepts underlying the analysis of time series, the involved statistical and mathematical tools and their applications in finance and actuarial science.

Syllabus

- White noise series, univariate stationary and integrated non-stationary random series.
- Backwards shift operator, backwards difference operator, and the roots of the characteristic equation of a time series.
- Define a time series through a general linear filter of another stationary random series (particularly of a white noise series).
- Well known models for linear processes – stationary autoregressive (AR), moving average (MA), autoregressive moving average (ARMA); nonstationary integrated ARMA (ARIMA).
- Random walks with and without drift, particularly those with normally distributed increments.
- A short introduction to multivariate time series models, in particular VAR model.
- Cointegrated processes.
- Estimation, diagnosis and identification of time series models.
- Non-linear (e.g. TAR and GARCH), non-stationary (e.g. regression with stationary errors) time series models.
- Applications of time series models and forecasts from time series data using Box-Jenkins method and extrapolation.
- Smoothing techniques applied to time series and seasonal adjustment.

Recommended Texts


Assessment

Time Series Analysis and Financial Econometrics will be examined synoptically by a 3-hour exam.

Financial Econometrics (C21FE)
(7.5 credits, semester 2 optional, must be taken with F71TS)

Lecturers: Dr A. Christev (coordinator) and Prof. A. Bhattachrjee

Note: This information might be out of date. C21FE runs in the second half of Semester 2 and students should confirm with Dr Christev (A.Christev@hw.ac.uk) the precise time of the course start around week 5 of Semester 2.

Aim

To introduce the methods of econometrics and their application to financial data.

Syllabus

- Economic and financial data
- Basic econometric methods; simultaneity, identification
- Econometric methods
- Non-spherical disturbances
- ARCH models
- GARCH models
- Vector autoregression and Granger causality
- Unit roots
- Cointegration
- Error correction models
- State-Space Models and the Kalman Filter
- Applied studies in financial econometric methods

Texts


**Assessment**

Financial Econometrics and Time Series Analysis will be examined synoptically by a 3-hour exam.
Stochastic Simulation (F11SS)
(15 credits, semester 2, optional)

Lecturers: Prof G. Lord

Aim The aims of this module are to develop understanding of continuous random variables and numerical simulation. We examine Brownian motion and its properties and develop stochastic integrals and stochastic calculus. This is presented in a practical way with numerical simulations underpinning the analysis. We introduce numerical methods for SDEs and the different notions of convergence for numerical methods. We analyse convergence of Euler–Maruyama method. Monte-Carlo simulations and convergence is also be discussed. Typical example SDEs in the course are Langevin equations, Geometric Brownian motion and Ornstein-Uhlenbeck process.

Syllabus This will be focus on practical techniques with numerical simulations underpinning the analysis.

- Introduction to random number generation and Monte-Carlo simulations.
- Ito and Stratonovich Integral, SDEs and Numerics

Texts


Assessment 75% of the assessment will be through an end of semester exam, 25% through coursework
8 Dissertations

8.1 Choosing a Project

From the beginning of June, students on the QFE M.Sc. should begin working on their dissertations. These can be projects that are supervised internally, or they may be supervised externally in collaboration with a company (‘a placement’) arranged through the SFRA.

A list of possible projects will be distributed to students in Semester 2 (before the exams). The topics will vary from year to year, depending on the research or other interests of the staff and the priorities of the SFRA partner companies. The SFRA website lists previous Dissertation projects offered by industry (http://www.sfra.ac.uk/msc_placements.php).

We make the following suggestions for alternatives to those discussed above:

- Students are strongly encouraged, as they learn more in the first and in particular second semester, to devise projects on topics they are interested in. They should take their idea with the programme director to discuss it further and check its suitability, or to identify the most suitable supervisor.

- Students are also strongly encouraged to seek the opportunity to do their project in collaboration with an outside partner in a bank or financial institution (for example, a potential employer). The project will have to be devised again by the student and/or the contact in industry and must be approved by a member of academic staff. A number of good projects have been initiated in this way in the past.

- Obviously, as the programme proceeds, the more ideas you will have about what you would like to do. In theory the special topics are designed to get you to dip into the research literature to assist you in thinking up a suitable project.

- At the end of the second semester, students will be invited to nominate the four or five projects they would most like to do, in order of preference. We will then do our best to allocate projects to students in a fair way. If certain projects are over-subscribed, then relevant information may be taken into account (for example, rank order in the class in the examinations, performance in individual papers, or choice of special topics). Naturally, if you have already arranged a project/placement and supervisor this procedure will be unnecessary.

- Joint, or group-work, projects are permitted. That is, if two or three students (not more) wish to conduct a piece of collaborative research together, but then proceed to write up individual dissertations, this is will be permitted. However, the proposal will be first scrutinized and then monitored by a member of staff and students will be heavily penalised if similar theses are submitted. Such proposals will only be considered if there is evidence that whilst students will work together and pooling ideas, there is sufficient scope for individuality.

Remember that this is only a rough guideline. It is up to you to talk with staff about possible ideas. Whilst staff will offer suggestions, it is better that the student becomes involved in this process too. Don’t forget the golden rule if you are suggesting your own project: everything is subject to approval, and the criteria for having approval is that you will have convinced a member of staff to supervise you!!

Students are required to ‘attend’ during their MSc project, this means that they need to be based at the same place as their supervisor. The SFRA might arrange a project supervised away from Edinburgh, in these cases the student is expected to work at the same place as the supervisor and live nearby.
It is possible to arrange for MSc projects to be supervised externally independently from the SFRA. However the external supervisor needs to be approved and this can take some time. If you would like to undertake an externally supervised project not organised through the SFRA you should contact the Programme Director in January.

8.2 Types of Dissertation

This list is not exhaustive, nor are its members mutually exclusive; it is just meant to give some ideas about what makes an acceptable dissertation.

- A subject review surveys a chosen area, summarising the research literature and providing an overview of its development, importance, methodology and outstanding problems.
- A theoretical essay describes, in considerable depth, some piece of mathematical theory relevant to finance. Papers in research journals are often very terse and assume a lot of prior knowledge on the part of the reader; and acceptable project could be to explain a recent paper, making its results more accessible and putting them in context.
- A numerical project would describe and implement one or more numerical methods for pricing, hedging or reserving for derivatives or portfolios, and perhaps aim to measure how well it performed using real or simulated data.
- A data-based project would analyse market or other data, fitting them to suitable models and drawing conclusions.
- A software project could aim to develop useful software for specific financial problems, perhaps as part of a placement with a financial institution.

8.3 Supervision

Arrangements need to be fluid, as staff have many other things to do beside project supervision (including holidays). Students should establish appropriate supervision arrangements with their supervisors at the start of the project. If you are involved in a pair of linked projects on the same area with the same supervisor, you should expect joint meetings with the supervisor in the early stages. Contact your supervisor as soon as possible to arrange a first meeting when you can discuss a rough timetable, in case he or she is about to leave town! Temporary substitute supervision may sometimes be arranged. If you have an external placement, you will need to make arrangements with both supervisors to ensure that you meet the requirements of the MSc degree.

As a matter of courtesy to your supervisor you should always arrive on time for your arranged meetings. You should never fail to turn up at a meeting without good reason. If you have to cancel an appointment then you should endeavour to contact your supervisor in advance.

8.4 Timetable

The dissertation period lasts 11 weeks, starting in early June. It is suggested that project work should be near completion by late July. This may vary depending on how much work is being written up as the project progresses. A first draft of the completed project should normally be ready in early August, but precise timing of this should be agreed with the supervisor.
As a rule of thumb, you have about four weeks to read around the subject; four weeks to do a piece of work; and three weeks to pull the dissertation together. That does not mean that you should wait for two months before drafting anything!

The deadline for handing in projects will be announced early in the summer by the programme director.

8.5 Format of the Dissertation

This section contains some guidance on what may be expected of a satisfactory dissertation.

- **The main text of the dissertation must not exceed 30 pages**, based upon a 12-point font size and 1.5-line spacing. The *main text* referred to here does not include such things as tables, graphs, figures, references, appendices and computer code. As a general rule the inclusion of computer code is not encouraged unless it is central to the aim of the project. If there is any doubt over any of these requirements then please consult your supervisor.

- Past experience suggests that the best dissertations are written up as the project progresses. This allows supervisors to comment, which can lead to improvements. Also many students don’t seem to realise just how time-consuming writing up can be! Past experience also suggests that taking too much time off does not lead to good dissertations. We suggest you take your longest holiday break in late September after submission.

- Past experience suggests that poor dissertations can often be the result of: a poor record of attendance at supervisions; writing the dissertation at the last minute, particularly where the supervisor has not even seen a first draft.

- Dissertations *must* contain:
  - a cover page which gives the title of the project, the name of the student, and the year;
  - an abstract;
  - a detailed list of contents at the start;
  - an introduction to the project and the dissertation;
  - proper structure in the main body of the text including section numbering;
  - conclusions;
  - a full and detailed list of references;
  - acknowledgement of all persons who have contributed to the development of the project.

Failure to comply with this structure may mean that, instead of being awarded a pass, a candidate is asked to resubmit the project after revision. This *will* result in a delay in the award of the MSc until June the following year.

- Dissertations *must* use consistent mathematical notation throughout.

- Some questions that the examiners will be asking:
  - Does the introduction say clearly what the dissertation is about?
  - How well has the student explained the area of work and summarised the relevant literature?
  - Does the dissertation show evidence of learning beyond the material of the taught courses and special topics?
– If the dissertation is mainly a survey, is it complete and up to date, and has the student shown clearly, by summarising and comparing the literature in their own words, that they have mastered the subject?

– If the dissertation involves numerical work, is it described clearly enough for someone else to reproduce the calculations, if required, and do the conclusions demonstrate that the student understands what he or she has done?

– Does the dissertation have a logical structure?

– Are books and journal articles adequately referenced?

– Where the results of numerical and other work are being discussed is this just a statement of what the results are or does the text contain real interpretation of the results. For example, does the text explain why the results are as they are?

• It is not necessary, and in fact would be quite uncommon, for a dissertation to contain truly original work that would be classified as research. What matters is that it shows the student’s own understanding of the chosen subject (not the supervisor’s!).

• Remember, it is your work that is being examined and not the supervisor’s. In particular, the supervisor is not there to proof-read your drafts or to teach you to write in English.

• Style and layout are up to the student subject to the constraints on structure detailed above. However, it is a good idea to look through a few journal articles and note the elements of good style. Remember, the examiners are researchers which means that they are, to a large extent, professional authors, and will not appreciate having to navigate a badly laid-out or sloppily-written dissertation.