MSc in Statistics - Student Handbook

Department of Mathematics
Imperial College London

2013/14

Contents

1 Introduction

Welcome to the MSc in Statistics at Imperial. The course is run by the Statistics Section of the Department of Mathematics. The main webpage for the course is imperial.ac.uk/statistics/msc.
Most course material will be made available in a virtual learning environment (VLE) at bb.imperial.ac.uk.

Aims/Objectives/Learning Outcomes

Here is what you can broadly expect from the course:

You will improve your understanding of the probabilistic background to statistics. This will be mainly achieved through one of the compulsory courses.

You will learn about the theoretical and methodological foundations of statistics. Besides a compulsory course, you can choose to specialise in methodological aspects of statistics through appropriate choice of optional courses as well as through the choice of project.

You will become proficient in modern computational methods for statistics. A minimal level will be achieved through a compulsory course, which will be improved upon by the optional courses as well as the project.

You will become confident in using statistical methods to solve practical problems. This will be achieved through the compulsory course Applied Statistics, through the use of the statistical software R throughout the course, through the range of optional courses and through the individual project. You will get proficient in the statistical language R.

You will learn about the breadth of statistical applications. This will be achieved through the wide range of optional courses, which allow you to specialise in more methodological aspects as well as in a diverse range of modern applications. Furthermore, there will be talks by practising statisticians, called Statistics in Practice, in the summer term. This will you with your career choice.

You will learn to tackle, analyse and solve realistic statistical problems independently. This will be mostly achieved through the research project.

About the Department of Mathematics (imperial.ac.uk/mathematics)

The Department of Mathematics at Imperial College London is an internationally renowned department within one of the world's most prestigious universities. The principal aim of the Department is to train professional mathematicians to pursue the study of scientific and technological problems by mathematical methods, and to undertake research in various branches of the subject, for which it has achieved outstanding results in the most recent government research assessment exercise.

About the Statistics Section (imperial.ac.uk/statistics)

The Statistics Section, part of the Department of Mathematics, has an international reputation for conducting methodological and applied statistical research at the highest level. Particular areas of current activity include statistical genetics and biostatistics, statistical methods in retail financial services, time series, core statistical methodology, classification and data mining, with many interactions and overlaps between these areas of research.

The Section is one of the leading statistics groups in UK. In the 2008 RAE, Imperial was ranked third nationally.

You can find a list of academic staff in the Statistics Section at imperial.ac.uk/statistics/people/staff.

Key contacts:

- Head of Department: Prof Richard Craster
- Head of the Statistics Section: Prof Alastair Young

- Postgraduate Tutor: Dr John Gibbons
- Course Director MSc Statistics: Dr Axel Gandy
- Course Administrator: Ms Anna Lisowska
  (`statsmsc@imperial.ac.uk`; Office: 652 Huxley; Tel: 020 7594 2843)

Each student will be assigned a course advisor (sometimes also called personal tutor), who

- advises on course choice and project choice,
- provides pastoral support.

Graduate School (imperial.ac.uk/graduateschool)

As soon as you begin your postgraduate studies at Imperial you automatically become a member of the Graduate School. Membership means you become part of a wider community, broadening and enriching your academic experience. The Graduate School also provides transferable skills training for Master's students, see imperial.ac.uk/graduateschool/transferableskillsprogramme.

2 Programme Structure

Autumn Term

week 1	Induction week	
week 2-11	M5MS01 Probability for Statistics	M5MS02 Fundamentals of Statistical Inference
	M5MS03 Applied Statistics	M5MS04 Computational Statistics

All of the courses in the above table are compulsory.
Week 1-11 M5S8 *Time Series*. This is an optional course and is equivalent to 30 hours of lecturing.

Spring Term

All courses in this term are optional. You have to take optional courses equivalent to 120 hours of lecturing, e.g. 8 courses of 15 hours each. This may include M5S8 in the Autumn term.

week 1	exams for M5MS01, M5MS02	
week 2-6	M5MS05 Advanced Statistical Theory	M5MS06 Bayesian Statistics
	M5MS07 Non-parametric Smoothing and Wavelets	M5MS11 Statistics for Extreme Events
	M5MS13 Pricing and Hedging in Financial Markets	M5MS17 Medical Statistics
	M5MS18 Official Statistics	
week 7-11	M5MS08 Multivariate Analysis	M5MS09 Graphical Models
	M5MS10 Machine Learning	M5MS12 Financial Econometrics
	M5MS15 Statistics in Retail Finance	M5MS16 Principles of Bayesian Inference
	M5MS19 Further Topics in Statistics	

All of the optional courses mentioned in the above table are equivalent to 15 hours of lecturing.
Week 1-11: M5S14 *Survival Models and Actuarial Applications*, equivalent to 30 hours of lecturing.

Summer Term

week 1-2	Written exams for optional 15 hour courses	
week 3-10	Project	Talks: Statistics in Practice
9 or 10	Project - Poster presentation	

The exams for M5S8 and M5S14 are in the Summer Term. The precise dates will be announced in due course.

July-September

Work on Project. Projects have to be handed in by the middle of September. Presentation on the project shortly afterwards. The precise dates are listed in Section 3.

3 Calendar of Important Dates

Monday, 30 September 2013 Begin Autumn Term
Friday, 13 December 2013 End Autumn Term
Monday, 13 January 2014 Begin Spring Term
Friday, 28 March 2014 End Spring Term
Monday, 28 April 2014 Begin Summer Term
Friday, 27 June 2014 End Summer Term
Friday, 5 September 2014, noon Deadline for handing in projects
Thursday, 11 September 2014 (TBC) Project presentation
May 2015 (TBC) Graduation Ceremony

A detailled timetable will be made available electronically.

4 Assessment / Requirements for Programme Completion

4.1 General

The programme specification will be made available at

imperial.ac.uk/mathematics/admissions/msccourseinformation

The entire MSc course will be worth 90 ECTS. It consists of two elements. The first element consists of the taught courses and is worth 67.5 ECTS. The second, the project, is assigned 22.5 ECTS.

The individual courses taken by the students will be assessed through coursework or individual exams. The compulsory courses *M5MS03 Applied Statistics* and *M5MS04 Computational Statistics* will be examined through coursework only. Some of the optional courses in the second term will also be examined through coursework. All other courses will be examined through written papers in the first week of the spring term or in the summer term. 30 hour courses will normally be examined by a 2 hour exam, 15 hour courses by a 1.5 hour exam.

The second course element, the project, will be examined as follows. Students have to submit a thesis, a substantial written report normally not exceeding 12000 words. The thesis must be submitted no later than 16 September. The thesis is worth 90% of the project mark. An integral part of the project will be an oral examination, consisting of a 20 minute presentation and 10 minute questioning on the project. The oral examination will be worth 10% of the total project mark.

MSc degrees are awarded only once each year, following the Examiners' Meeting which is normally held by the end of October.

In line with usual practise, the MSc in Statistics has an external examiner, meaning an examiner external to the university whose main role it is to uphold standards and to ensure that the assessment process is fair and rigorous. More details of the role of the external examiner are available from the website of the registry. Registry is currently developing a central internal webpage which should list external examiners and their affiliations.

4.2 Degree Classifications

To obtain a *pass* mark, students will have to:

- Register for, and take the examination in courses equivalent to 240 lecture hours, including the 4 compulsory 30 hour lecture courses. They must earn a pass mark (i.e., a score of at least 50%) in courses equivalent to 180 lecture hours with no mark below 40%, and score a weighted average mark of at least 50%. Courses will be weighted by their nominal lecture hours. A student who earns below 40% in a course examined by a paper will have to re-sit that paper. A student who earns below 40% in a course examined by coursework will be given a re-sit coursework.

- Earn a pass mark (i.e., a score of at least 50%) in the project.

A *merit* mark will be awarded to students who gain a weighted average mark of 60% or above in courses equivalent to 240 lecture hours, including the 4 compulsory 30 hour lecture courses, with no mark below 50%, and who score 60% or above on the project.

A *distinction* mark will be awarded to students who gain a weighted average mark of 70% or above in courses equivalent to 240 lecture hours, including the 4 compulsory 30 hour lecture courses, with no mark below 50%, and who score 70% or above on the project.

Students are usually only offered one re-sit opportunity for failed courses in the following academic year. Marks for re-sits are capped at 50%.

4.3 Release of Results

The exam board, which will take place after the course has finished, will have final authority to decide your results. This board will, among other things, consider borderline cases and take mitigating circumstances into account. You will receive your final results from registry (in October/November after your course has finished).

During the year, you will receive indications of your performace in the various courses you have taken - these are provisional and subject to confirmation by the exam board. Specifically, in Blackboard, under the "course" M5MS00, you will find rough indications of your results on the College Scale (under "My Grades"). The following code will be used:

A+:	a high distinction [80,100]
A:	in the distinction range [70,80)
A-B:	Borderline between merit and distinction (around 70).
B:	in the merit range [60,70).
B-C:	Borderline between pass and merit (around 60).
C:	in the pass range [50,60).
C-D:	Borderline between fail and pass (around 50).
D:	in the fail range [40,50).
F-D:	Borderline between fail and a bad fail (around 40).
F:	Bad Fail (<40)

4.4 Mitigating Circumstances

If you want mitigating circumstances to be taken into account, you need to fill in the appropriate mitigating circumstances form and submit it to the MSc Administrator **within 5 working days of the examination or coursework submission date**.

Below are the links to these forms on the registry webpage. During term time they are also available in front of the Undergraduate Maths Student office.

Request for Mitigation for Minor pieces of coursework Form
Request for Mitigation for Examinations and Major pieces of coursework Form

4.5 Plagiarism / Examination Offences

The College and Department are against all forms of plagiarism. While discussing among fellow students and consulting relevant literature and internet resources to gain genuine understanding are accepted as part of your learning process, producing coursework (or parts of coursework) identical, or nearly identical, to others, or using materials from published literature and/or web sites without proper acknowledgement will be viewed as plagiarism and will be investigated. Once an act of plagiarism is established, all students involved will be penalised, which may include marks for coursework or project being zeroed and/or disciplinary actions by the Department and the College. Records of plagiarism and penalty imposed may be kept in the student records.

The penalties for plagiarism and examination offences can be very severe, including effectively expulsion from the College. Further information is in Appendix A of this document.

The library has some information concerning plagiarism at

imperial.ac.uk/library/subjectsandsupport/plagiarism.

5 Facilities

5.1 Your College E-Mail

You will be getting an individual Imperial e-mail account. This will be our primary way of contacting you. It is your responsibility to check this e-mail account regularly.

Furthermore, please use this e-mail address (and not any other e-mail address) to send e-mails to your lecturers or any other member of staff at Imperial.

5.2 Virtual Learning Environment (VLE)

Most course material will be made available in a virtual learning environment, see learn.imperial.ac.uk. At the start of the year the VLE may be at bb.imperial.ac.uk instead.

5.3 Where to find us

Teaching will mainly take place in the Huxley building on the South Kensington Campus. The MSc Administrator's office is on the 6th floor. Most academics involved in the programme have their offices on the 5th floor of the Huxley building.

5.4 MSc Room

There is a dedicated room for MSc students (Huxley 215). This room is reserved for students of the MSc in Statistics, the MSc in Pure Mathematics and the MSc in Applied Mathematics. You can also use the Mathematics Learning Centre (level 4 Huxley), in particular over the summer.

5.5 Health and Safety

There will be a health and safety induction in the first week. Further information is available at

imperial.ac.uk/mathematics/healthandsafety
imperial.ac.uk/facilitiesmanagement/healthandsafety

5.6 The Library (imperial.ac.uk/library)

We strongly encourage you to make heavy use of the library: It has extensive print and electronic mathematics collections, which support related research and teaching within the College. The statistics material forms one of the most significant parts of this collection and the holdings have been developed by the library in close liaison with staff within the department's statistics section. The collection of statistics books contains more than 8,000 volumes and gives comprehensive coverage of all topics within the field. The library's journal holdings in statistics are nearly all available electronically and include several hundred current journals and complete runs of major titles, such as all the Royal Statistical Society journals, Annals of Statistics, Journal of the American Statistical Association and Biometrika. Students within the department are also able to contact Jenny Evans, the Mathematics Librarian, who can provide support and tuition throughout their studies.

5.7 Lockers

There is a (limited) number of lockers in the basement of the Huxley building. You can try to reserve one of them, see

`https://workspace.imperial.ac.uk/mathematics/Public/students/ug/generalinformation/LockersSign.pdf`

6 Pastoral Support, Student Representative, College Tutors

Every student is assigned a Course Advisor who should be the first point of contact for any problems. Students can also approach the course director, the course administrator or the postgraduate tutor directly.

Students will elect a representative of the MSc in Statistics, who will be a member of the departmental postgraduate staff-student committee, which meets three times a year.

All students also have confidential access - independent of department or division - to the College Tutors regarding academic issues, and all aspects of pastoral care and discipline within the College.

imperial.ac.uk/students/collegetutors imperial.ac.uk/students/welfareandadvice

7 Evaluation and Quality Assurance

Students will obtain feedback via:

- Marked coursework
- Meetings with research project supervisors.
- Meetings with course advisor.
- Meetings with course director.

Feedback from students via:

- Departmental Postgraduate Staff-Student Committee (meets three times a year).
- Individual Course Survey (PGSole).
- Research project supervisors meeting their students.
- Course advisors meeting their students.
- Meetings between course director and students, particularly their elected representative.
- The Postgraduate Tutor being approached by students.

It is very important that you provide us with your feedback (I am sure you are aware of the bias that can be caused by missing data):

- If something is great we definitively want to know.
- If something does not work well - we can only fix it if we know about it.

An annual course review will take place taking into account the student feedback.

7.1 Student Surveys

Your feedback is important to your department, the College and Imperial College Union.

Whilst, there are a variety of means to give your feedback on your Imperial experience, the following College-wide surveys give you regular opportunities to make your voice heard:

- PG SOLE lecturer/module
- Student Experience Survey (SES)
- Postgraduate Taught Student Experience (PTES)

The PG SOLE lecturer/module survey runs at the end of the Autumn and Spring Terms. This survey is your chance to tell us about the modules you have attended and the lecturers who taught them. Run at the same time as the Autumn Term PG SOLE is the Union's Student Experience Survey (SES). This survey will cover your induction, welfare, pastoral and support services experience. During December you will receive an email in your Imperial College account with a link to the survey.

The Postgraduate Taught Experience Survey (PTES) is the only national survey of Masters level (MSc, MRes, MBA and MPH) students we do and so the only way for us to compare how we are doing against the national average and to make changes that will improve our Masters students experience in future. PTES covers topics such as motivations for taking the programme, depth of learning, organisation, dissertation and professional development. During the spring term you will receive an email in your Imperial College account with a link to the survey. All these surveys are anonymous and the more students that take part the more representative the results so please take a few minutes to give your views.

If you would like to know more about any of these surveys or see the results from previous surveys, visit:
`http://www3.imperial.ac.uk/registry/proceduresandregulations/surveys`
For further information on surveys please contact the Registrys Surveys Team on
`surveys.registrysupport@imperial.ac.uk`

8 Core Courses

M5MS01 Probability for Statistics (Prof N Bingham)

Review of axiomatic probability theory: probability spaces, distributions and their characteristics [including generating functions], conditional distributions.
Asymptotic theorems and convergence. Convergence modes and stochastic orders, convergence of transformations, laws of large numbers, central limit theorem, martingales.
Multivariate normal distribution. Gaussian processes.
Markov chains. Markov processes, classification of chains, stationary distributions, continuous-time Markov chains.

M5MS02 Fundamentals of Statistical Inference (Prof A Young)

Approaches to inference: Bayesian, Fisherian, frequentist.
Decision theory: risk, criteria for a decision rule, minimax and Bayes rules, finite decision problems.
Bayesian methods: fundamental elements, choice of prior, general form of Bayes rules. Empirical Bayes, hierarchical modelling. Predictive distributions, shrinkage and James-Stein estimation.
Data reduction and special models. Exponential families, transformation models. Sufficiency and completeness. Conditionality and ancillarity.
Key elements of frequentist theory. Hypothesis testing: Neyman-Pearson, uniformly most powerful tests, two-sided tests, conditional inference and similarity. Optimal point estimation. Confidence sets.
Introduction to likelihood theory. Asymptotic properties of maximum likelihood estimators, testing procedures. Multiparameter problems.

M5MS03 Applied Statistics (Dr N Kantas)

Statistical Models and modelling illustrated with real examples. Data pre-processing. Simple and multiple linear regression. Model diagnostics and iterative modelling. Handling messy data, such as missing values. Sparsity and Lasso. Experimental Design. Generalised linear models: logistic, log-linear. Basic linear time series models, e.g. ARMA. Multi-level models and repeated measures. Classification and discrimination.

M5MS04 Computational Statistics (Prof D Stevens and Dr D Mortlock)

Statistical Computing: R programming: data structures, programming constructs, object system, graphics.
Numerical methods: root finding, numerical integration, optimisation methods such as EM-type algorithms.
Simulation: generating random variates, Monte Carlo integration.
Simulation approaches in inference: randomisation and permutation procedures, bootstrap, MCMC, Sequential Monte Carlo/particle filtering.

9 Optional Courses

9.1 Course Choice

You will be asked to indicate a preliminary course choice at the beginning of the Autumn Term and to update this choice at the end of the Autumn Term. This is only a preliminary indication.

You have to make a final choice for optional courses in the Spring Term by 4pm on the Monday of the second week the course is running.

You have to register for optional courses exactly equivalent to 120 lecture hours (not more, not less).

9.2 Courses Equivalent to 15 Lecture Hours

M5MS05 Advanced Statistical Theory (Prof A Young)

Likelihood theory: pseudo-likelihood, composite likelihood, principles and techniques of likelihood-based inference, with emphasis on multi-parameter problems.
Statistical asymptotics: Laplace approximation, Edgeworth, saddlepoint and related approximations for densities and distribution functions.
Higher-order statistical methods: Bartlett correction, the modified signed root statistic, parametric bootstrap methods and comparisons with analytic approaches, objective Bayes.
Introduction to high-dimensional inference. Topics to be covered from: sparse inference, regression, multiple testing (control of FDR etc.), semi-parametric inference.
Written exam in the Summer Term.

M5MS06 Bayesian Statistics (Prof D van Dyk)

Bayesian modeling, conjugate families, types of prior distributions, averaging over nuisance parameters, large-sample and frequency properties, hierarchical and multi-level models, model checking, comparison, and improvement (Bayes factors, p-values, and posterior predictive p-values). Bayesian analysis of surveys, experiments, and observational studies. Bayesian analysis of linear regression, hierarchical linear, and generalized linear models.
Written exam in the Summer Term.

M5MS07 Non-parametric Smoothing and Wavelets (Dr B Missaoui)

Kernel estimators: window width, adaptive kernel estimators. Roughness penalties: Cubic splines; Spline smoothing, Reinsch algorithm; alternative penalties: lasso, ridge regression. Basis function approach: B-spines, wavelets: discrete wavelet transform; wavelet filters; the maximal overlap discrete wavelet transform; wavelet variance, wavelet shrinkage, thresholding. Generic Model choice: AIC, BIC, cross-validation.
Written exam in the Summer Term.

M5MS08 Multivariate Analysis (Dr E Cohen)

Key topics of linear algebra. Standard multivariate notations. The covariance matrix. Linear and non-linear multivariate transformations. The multivariate normal distribution. The central and non-central chi-square distributions. The Kronecker product. The Wishart distribution. The F-distribution and Hotellings T^2 statistic. Selected likelihood ratio tests. Ordinary, multiple and partial correlation coefficients.
Written exam in the Summer Term.

M5MS09 Graphical Models (Dr C Anagostopoulos)

Introduction (belief networks). Graph theoretic prerequisites. Conditional independence and Markov properties: undirected, directed acyclic, chain graphs. The junction tree algorithm for exact inference. Approximate inference (to include the EM algorithm). Applications to HMMs for speech recognition. Gaussian Graphical Models. EM for the Kalman Filter for target tracking. Graphical model selection: Bayesian and penalized likelihood methods. Basic principles of causal inference via graphical modelling.
Written exam in the Summer Term.

M5MS10 Machine Learning (Dr B Calderhead)

This course will provide an introduction to statistical pattern recognition and machine learning. The lectures will focus on different techniques including methods for feature extraction, dimensionality reduction, data clustering and pattern classification. State-of-art approaches such as support vector machines and ensemble learning methods will be introduced. Real-world applications will illustrate how the techniques are applied to real data sets.
Continuous assessment through coursework.

M5MS11 Statistics for Extreme Events (Dr A Veraart)

This course introduces extreme value theory. We focus on statistical methods for extreme events and study applications in insurance and finance. The main topics are as follows: Extreme value theory: Fluctuations of maxima; fluctuations of upper order statistics; Statistical Methods: Probability and quantile plots; mean excess function; Gumbels method of exceedances; parameter estimation for the generalised extreme value distribution; estimating under maximum domain of attraction conditions; fitting excess over a threshold.
Written exam in the Summer Term.

M5MS12 Financial Econometrics (Dr A Veraart)

Financial econometrics is an interdisciplinary area focusing on a wide range of quantitative problems arising from finance. This course gives an introduction to the field and presents some of the key statistical techniques needed to deal with both low and high frequency financial data. Main topics: Discrete time framework: ARCH, GARCH models and their estimation; Continuous time framework: Brownian motion, stochastic integration and stochastic differential equations, Its formula, stochastic volatility, realised quadratic variation and its asymptotic properties, Lévy processes, testing for jumps, volatility estimation in the presence of market microstructure effects.
Written exam in the Summer Term.

M5MS13 Pricing and Hedging in Financial Markets (Dr C Barnett)

The fundamentals of no-arbitrage theory and risk neutral valuation of contingent claims in the setting of the trinomial model will be explained. The most commonly traded contingent claims in the financial markets (vanilla and forward starting options, barrier and volatility derivatives, American options) will be described in detail and their pricing discussed in the context of trinomial models.
Written exam in the Summer Term.

M5MS14 Statistical Bioinformatics and Genetics

Will not be offered in 2013/14.

M5MS15 Statistics in Retail Finance (Dr B Missaoui)

Overview of credit scoring: Retail credit and default; credit scorecards; classification; probability of default; application of logistic regression; testing and performance measures (ROC/AUC)
Segmentation: interaction terms, data segmentation and classification trees
Behavioural models: static models, application of survival models, Markov transition models
Capital requirements: Basel Accord, loss distribution, VaR, capital and regulatory requirements, Merton-type one factor model
Asset correlation models: correlation in time, random effects model
Stress testing: historic, scenario and simulation approaches
Fraud detection: including unbalanced classes and neural networks.
Continuous assessment through coursework.

M5MS16: Principles of Bayesian Inference (Dr D Mortlock)

Fundamentals: logical propositions, probability (in everyday life and of mathematical quantities), [Bayes's theorem], Cox proofs of self-consistency
Parameter estimation: [marginalisation], improper priors and limits, choice of priors, approximate Bayesian computation
Model comparison: Bayes factors and the model-averaged likelihood (aka evidence), Occam's razor and extra parameters, nested models and the Savage-Dickey density ratio, model averaging, quasi-Bayesian model comparison techniques (AIC, BIC, DIC, etc.)
Multi-level models: [conditional distributions and Gibbs sampling], histograms and density estimation, empirical Bayes
Experimental design: the posterior predictive distribution, information content of a distribution (i.e., Shannon entropy), maximum entropy distributions, future measurements and information gain, degree of difference between distributions
Continuous assessment through coursework.

(Items in square brackets will have been covered already in M5MS06: Bayesian Data Analysis and will not be covered in detail during the lectures; however they will be included in the notes for completeness.)

M5MS17 Medical Statistics (Dr L Bottolo)

The objective of the course is to provide a broad range of statistical techniques to analyse biomedical data that are produced by pharmaceutical companies, research units and the NHS. Besides a general introduction to linear, generalised linear models and survival analysis, the course will focus on clinical trials (study design, randomisation, sample size and power, covariates and subgroups adjustment) to examine the effect of treatments on the disease process over time and longitudinal data analysis from the perspective of clinical trials. The statistical theory and the derivation and estimation of model parameters will be illustrated as well as the application of longitudinal models on real case studies drawn from biomedical and health sciences. The analysis of the real examples will be performed using standard statistical software. At the end of the course, students will be able to plan basic clinical trials, analyze longitudinal data and interpret the results. The course will cover the following models and topics:
- Introduction to linear/generalised linear models and survival analysis
- Introduction to clinical trials
- Treatment allocation, monitoring and effect estimation
- Introduction to longitudinal data and repeat measures
- General and generalised linear model for longitudinal data
- Random and mixed-effects models

Continuous assessment through coursework.

M5MS18 Official Statistics (Dr C Anagostopoulos)

Survey methods (SRS, probability sampling, stratified sampling, cluster sampling, multistage sampling, systematic sampling, contrast with YouGov), national accounts (GDP and its constituents, GNP), demographic methods (population structures, standardisation, life tables, lexis diagrams, cohorts), index numbers (axiomatic, economic, hedonic, chain linking, divisia, Laspeyres, Paasche, CPI, RPI). Brief overview of time series models for official statistics. This course will be illustrated using data and series from the ONS.
Written exam in the Summer Term.

M5MS19 Further Topics in Statistics (Prof E Moodie)

This course covers varying current topics in Statistics. In 2013/14, the following will be offered:
Longitudinal data methods

Semi-parametric methods for continuous outcomes: weighted least squares, sandwich estimators of the variance. Specification & estimation of covariances, inference. Linear mixed effect models. Generalized Estimating Equations. Time permitting, the following will also be covered: Estimation in the presence of time-varying confounding. Extensions to discrete outcomes.
Examination by coursework only.

9.3 Courses equivalent to 30 lecture hours

The following courses are from the general course offering of the Mathematics Department. These courses can be taken as optional courses if the student has not taken these courses or their equivalents for undergraduate students (M3S8/M4S8,M3S14/M4S14) as part of a previous degree.

M5S8 Time Series with Advanced Study (Prof A Walden)

An introduction to the analysis of time series (series of observations, usually evolving in time) is given which gives weight to both the time domain and frequency domain viewpoints. Important structural features (e.g.

reversibility) are discussed, and useful computational algorithms and approaches are introduced. The course is self-contained.

Discrete time stochastic processes and examples. ARMA processes. Trend removal and seasonal adjustment. General linear process. Invertibility. Directionality and reversibility in time series. Spectral representation. Aliasing. Generating functions. Estimation of mean and autocovariance sequence. The periodogram. Tapering for bias reduction. Parametric model fitting. Forecasting.

Additional material: From long-memory processes, Autoregressive parametric spectrum estimation, Harmonic analysis, Multichannel time series modelling and analysis.
Written exam in the Summer Term.

M5S14 Survival Models and Actuarial Applications with Advanced Study (P Ginzberg)

Survival models are fundamental to actuarial work, as well as being a key concept in medical statistics. This course will introduce the ideas, placing particular emphasis on actuarial applications. Explain concepts of survival models, right and left censored and randomly censored data. Describe estimation procedures for lifetime distributions: empirical survival functions, Kaplan-Meier estimates, Cox model. Statistical models of transfers between multiple states, maximum likelihood estimators. Binomial model of mortality. Estimation of transition intensities which depend on age. Testing crude estimates for consistency. Counting processes.
Additional material: Extension of on e or more of the above topics.
Students obtaining a grade of 60% or higher in this course unit will gain an exemption from the Actuarial Profession Core Technical exam CT4.
Written exam in the Summer Term.

10 The Project

10.1 Allocation

You will receive a list of available projects in the Spring Term. We aim to get this list to you very early in the Spring Term.

By a certain fixed date in the Spring Term (which will be announced in due course), you have to submit a ranked list of preferences from the list of available projects.

We will then allocate projects, taking relevant factors (including your preferences and your performance in the compulsory courses) into account. We aim to announce the allocation before the end of the Spring Term.

10.2 Working on the project

The work on the project is done under the direction of a Supervisor, who need not be your Course Advisor. In case of projects done with external partners, you will still have a supervisor from within the Mathematics Department, who has overall responsibility.

You should start with initial work on the project as soon as the topic is allocated. Aim to meet your supervisor before the Easter break. Particularly, try to resolve any issues with regards to access to data as soon as possible.

You should work essentially full-time on the project after the exams for the 15-hour optional courses are finished. During the Summer Term, immediately after the exams, the project should be defined and refined, so that the scope is clear by the end of the Summer Term. Make use of this time period during which your supervisor will be generally available for meetings in person.

You can expect regular face-to-face interaction during terms, usually every two weeks. After the Summer Term, you can only expect less frequent interactions (not necessarily face-to-face).

Continued documentation is good practice and it will help greatly when the final thesis is being prepared. Appropriate referencing is essential.

The purpose of the project is largely to train and test your ability to work independently. The supervisor will give general guidance on the work for the project and the writing of the thesis. You are strongly advised to pass a first draft of the thesis to the supervisor at least a month before the submission deadline. Advice on the suitability or otherwise of particular sections of the thesis cannot be expected.

10.3 Poster Presentation

At the end of the Summer Term, you are expected to present a poster. The poster should clearly state and describe the underlying question and the scope of your project. This is an excellent opportunity to get feedback, both from members of staff as well as from your fellow students. This is a compulsory, but non-assessed part of the course.

There is no need to spend a lot of time dressing up the poster, and no need to overload the poster with material. It is mainly intended to encourage you to clarify (and to explain) the scope of the project. It may very well be that you cannot present any results of your own yet, but you may want to address what results you hope to achieve.

On a practical side: A template for posters will be available in Blackboard. The Department owns a poster printer which can be used for this. Precise details and timings will be circulated in due course.

10.4 The Thesis

You have to submit a thesis, a substantial written thesis normally not exceeding 12000 words. This is a guideline: the appropriate length is a function of the project itself and its subject matter. Excess length disproportionate to the content may be penalised.

The thesis should be on A4-sized paper and typed (ideally using LaTeX), and words or paragraphs must not be crossed out. They should be in a simple binding; a ring or springback binder is sufficient. It is important that students sign the declaration "The work contained in this these is my own work unless otherwise stated". Each thesis should include (i) a brief summary, (ii) an introduction (iii) the main body of the thesis, and (iv) a bibliography.

Two printed copies of the thesis must be submitted to the MSc Administrator before the deadline listed in Section 3. An electronic copy of the thesis (one PDF document) must also be submitted via the Virtual Learning Environment. Late submission may be penalised and will normally delay consideration of the thesis to the following year.

The thesis is worth 90% of the project mark.

10.5 Oral Presentation

An integral part of the project will be an oral examination, consisting of a 20 minute presentation and 10 minute questioning on the project. The oral examination will be worth 10% of the total project mark.

The presentation will usually take place shortly after the submission deadline of the thesis, precise dates are listed in Section 3. The audience will consist of two faculty members.

You are strongly advised to prepare your oral presentation carefully, as it is an integral part of your training. Bear in mind that you only have 20 minutes, and that you should not assume or expect that the audience are experts in the area of your project. The purpose of the oral is not only to test your technical mastery of the material, but also to see how you can convey main ideas and results in your work to a general statistical public.

A few more suggestions:

- Spend enough time at the beginning on setting the scene to make sure that the audience is on board. They have not been working on this for the last 4 months.

- Be selective about what you present. You can always add a slide at the end ("other things I have been doing"). Having more slides than minutes is usually never a good idea (imagine sitting through a few high-speed talks in a row).
- The presentation aims at a reasonably educated statistician - essentially your fellow students. You do not have to introduce very basic material.
- Switch off your mobile phone during the presentation (including yours!) - last year somebody's phone rang during their own talk....

10.6 Guide to the Presentation of the Thesis

The following are guidelines only and need to be taken with common sense and adapted for the needs of your particular presentation.

The recommended structure consists of an abstract, a Table of Contents (Chapter/Section numbers), an introduction, a middle section presenting the results and a conclusion and summary section followed by a bibliography. Sections should be numbered, as should pages, graphs/tables, equations. The graphs and tables should appear at their natural location in the text. Any long program listings should be put in appendices at the end.

It is important that references to other research work consulted or results borrowed or shared should be properly documented and you should copy the style of reference of one of the research articles you consult, i.e. with referencing also included within the text as well as at the end. It is also a good idea to acknowledge the help that your supervisor has given you!

The **abstract** should be a brief statement of the aims and outcomes of the project, to summarise/advise even for a casual reader!

The **introduction** should attempt to set your work in the context of other work done in the field. It should demonstrate that you are aware of what you are doing, and how it relates to other work. It should show that you have referenced other work.

The main sections should guide the reader through your results, analysing them and explaining them. It should show both your successes and your failures in trying to solve your problem (your unsuccessful attempts should be discussed, especially if you have ideas or explanations as to why they failed). Graphs and simple diagrams (especially when they are neat) can sometimes be far more effective in presenting results than lots of numbers and/or lots of words.

The **conclusion** section should summarise what you have learned. If you would have done more, given more time, you should indicate where your effort would have gone. If your work has raised any unsettled questions, you should address them and indicate what further work needs doing.

Any programs in the appendices should be representative. A copy of every single version of every code is unnecessary. Programs should be documented with many comment lines and a discussion of the input necessary to drive them and the output resulting from them as appropriate. Large tables of results should be organised in reference form (as should large sets of graphs) with indices and tables of contents to guide the interested reader through them. Appendices do not count towards the word limit.

The **title page** is your own design however it should include your name, CID, project title, supervisor's name. You may want to include the wording: "Submitted in partial fulfilment of the requirements for the MSc in Statistics of Imperial College London". You should not be using the Imperial crest, but you can use the Imperial logo:

`http://www3.imperial.ac.uk/graphicidentity/applyingthegraphicidentity/usingthecrest`
`http://www3.imperial.ac.uk/graphicidentity/applyingthegraphicidentity/usingthelogo`

The second page must contain a **signed and dated plagiarism statement, "The work contained in this thesis is my own work unless otherwise stated"**. It is sufficient if you sign the hard copies.

While the exact form of binding is unimportant, it should be neat and robust so that your work may be read many times by several people. You should use generous margins and line spacings and least an 11pt font.

Before submitting the thesis, make sure you read the thesis in its entirety. There should be no half-finished sentences. Also, use a spell-checker.

Make sure that you have a proper introduction, that (1) describes the topic of your thesis (aiming at a reasonably educated statistician), (2) gives an overview of the thesis and, very crucially, (3) clearly points out what your main contribution is (what bits are your own doing / what is the best part).

When you present background material, make sure you reference the sources you have used. Try not to rely on Wikipedia - you are expected to go to the underlying textbooks/scholarly articles.

Include an acknowledgement.

Figures: The best place is at the top or at the bottom of a page. If this is not possible they should go on a separate page. In LaTeX this can be achieved by

```
\begin{figure} [tbp]
...
\end{figure}
```

When generating plots from R it is usually best to export them as pdf or eps for inclusion in LaTeX. To get Greek letters, sub and superscripts into labels use eg xlab=expression(alpha[5]).

List of references: Using author (year) style notation is good practice (the reader may know the paper, but she will definitively not know the number in your reference list. To achieve this in LaTeX you can use BibTeX together with the package natbib. If citing several references together, use..`\citep{ref1,ref2,ref3}` . Use a coherent style - either all authors get their first full names or none gets their full names. Books need the name of the publisher, journal articles need the name of the journal. When using BibTeX for generating references, make sure that appropriate capitalisation is used, eg it should be Monte Carlo and not monte carlo. To achieve this in BibTeX, use Monte Carlo.

Maths: In formulas use `\\exp` and not `exp`.

10.6.1 Submission

Two hard copies of the thesis must be submitted; a single copy will NOT be accepted. One of the copies will be returned to you.

You also have to submit an electronic copy of the thesis (in PDF format) through the online learning system (bb.imperial.ac.uk .. M5MS00 .. Project). Please name this file in the following format: "Surname_Firstname_Thesis.pdf". Note that this electronic copy may be checked for plagiarism via online plagiarism detection services (e.g. Turnitin).

The thesis submission deadline is a very hard deadline since the assessment process has then to be completed on a very short timescale.

10.6.2 Computing

The Mathematics Department has several research computing resources - discuss with your supervisor if you need to use those. See `http://www3.imperial.ac.uk/mathematics/staff/computing/research` for an overview.

10.6.3 Marking Guidelines

See separate document, available on Blackboard.

11 Further Elements of the Course

Introduction to R and LaTeX

There will be an introduction to R & LaTeX in the first week of the term. The goal is to enable you to use these tools with confidence and to produce reports as well as presentations.

Talks Statistics in Practice

These are talks given by statisticians from various industries (e.g. pharmaceutical, consulting, official statistics, academia) about their career in particular and about typical problems in their industry. This will show students the various career paths that are open to them.
Most of these talks will take place in the Summer Term. Attendance is expected, even though there will not be an examination on this.

The Statistics Research Seminar

The Statistics Section organizes regular research seminars. Seminars are advertised by e-mail and at

imperial.ac.uk/statistics/seminars.

Attendance is strongly encouraged. Speakers are specifically instructed to "start gently", to allow MSc students to follow at least parts of the talks.

12 Professional Skills Development

Working as a practical statistician will involve several skills, a lot of these will be trained during

Some of your lecturers may allow some of the coursework to be done in groups, which usually will be randomly assigned. This is supposed to train your teamwork abilities.

You will train your problem-solving skills throughout the course. In particular, it is very important that you work through the problem sheets that you will be given. Furthermore, the project will enable you to work thoroughly on a major problem.

Presentation skills are very important for your future career. You will have the opportunity to train these in the presentation of your project. Furthermore, some lecturers may require you to present your coursework.

13 Useful Links

Campus info

The MSc in Statistics is mainly run in the Huxley building at the South Kensington Campus. For maps and information about this campus see imperial.ac.uk/campusinfo/southkensington.

Past examination papers

Past examination papers will be made available for exam-based courses (precise location will be announced).

For courses which are shared with BSc/MSci students (M5S8, M5S14) past exam papers are available at imperial.ac.uk/mathematics/students/undergraduate/pastexampapers

Imperial Study Guide for Master's Students

This is an Imperial wide guide to help you with your studies.

imperial.ac.uk/students/studyguide
`https://workspace.imperial.ac.uk/college/public/pdfs/ISGMasters.pdf`

Academic and Examination Regulations

imperial.ac.uk/registry/proceduresandregulations/regulations

Registry (imperial.ac.uk/registry)

You get official results and transcripts from registry.

Student Hub (imperial.ac.uk/studenthub)

The Student Hub is the one stop shop for all key information and support that students need for everyday life at Imperial. All the student support departments are brought together here, so that you can get answers to your most frequent queries in one place, saving you from going all over the campus! The Hub provides a comprehensive information service run by knowledgeable staff who answer questions about university services available to students. As a student, you can obtain various letters (e.g. for opening a UK bank account).

The Student Hub is located at the west end of Level 3, Sherfield Building, South Kensington Campus.

Careers Service (imperial.ac.uk/careers)

The Careers Service provides a varied and comprehensive careers guidance, information and vacancy service for all students and alumni of Imperial College, from first to final year undergraduates and postgraduates.

Royal Statistical Society (rss.org.uk)

The Royal Statistical Society (RSS) is one of the world's most distinguished and renowned statistical societies. It is both a learned society for statistics and a professional body for statisticians.

It was founded in 1834 as the Statistical Society of London and became the Royal Statistical Society by Royal Charter in 1887. Today the Society has more than 7000 members around the world, of whom some 1500 are professionally qualified as Chartered Statistician. The RSS is active in a wide range of areas both directly and indirectly relevant to the study and application of statistics.

The RSS headquarters is located in 12 Errol street (about 50 minutes on public transport from the Mathematics Department).

Throughout the year, the RSS organizes Ordinary Meetings, at which statistical papers are being presented and discussed. The Young Statisticians Section organizes Pre-Ordinary Meetings, held just before the Ordinary Meetings, which are aimed at giving an introduction to the area of the paper presented at the Ordinary Meeting.

You might be interested in joining the RSS, in particular the Young Statisticians section.

Our Principles

Imperial's Student Charter, which sets out the mutual expectations of universities and students, is available at imperial.ac.uk/students/ourprinciples.

Imperial Policy on Employment during Studies

https://workspace.imperial.ac.uk/registry/Public/Procedures%20and%20Regulations/Policies%20and%20Procedures/Student%20Employment%20During%20Studies.pdf

Examinations and Religious Obligations

https://workspace.imperial.ac.uk/registry/Public/Exams/Exams%20and%20religious%20obligations.pdf

College Procedures

The Colleges Regulations for Students:

imperial.ac.uk/registry/proceduresandregulations

Mitigation / extenuating circumstances policy and procedures:

imperial.ac.uk/registry/proceduresandregulations/policiesandprocedures/examinationassessment

Complaints and Appeals procedures:

imperial.ac.uk/registry/proceduresandregulations/policiesandprocedures/complaintsappeals

Academic integrity:

https://workspace.imperial.ac.uk/registry/Public/Procedures%20and%20Regulations/Policies%20and%20Procedures/Examination%20and%20Assessment%20Academic%20Integrity.pdf

Cheating offences policy and procedures:

imperial.ac.uk/registry/proceduresandregulations/policiesandprocedures/disciplinary

Further Examination and Assessment Regulations

imperial.ac.uk/registry/proceduresandregulations/policiesandprocedures/examinationassessment

Welfare and Support

Personal Development Planning and 'iPlan'

imperial.ac.uk/careers/staff/staff/pdp

Information for students with disabilities, including the Disability Advisory Service:

imperial.ac.uk/disabilityadvisoryservice

Other welfare and pastoral care /support resources

imperial.ac.uk/humanities/englishlanguagesupport
imperial.ac.uk/students/welfareandadvice
imperial.ac.uk/students/international

Imperial College Union (ICU)

www.imperialcollegeunion.org

Graduate Students' Association (GSA)

imperialcollegeunion.org/faculty-unions/gsaweb/index,457,ICS.html

Student representation how to become a student representative:

imperialcollegeunion.org/representation

Graduate School Open Day

In case you contemplate continuing at Imperial after the MSc, there is a Graduate School Open Day toward the end of the Autumn Term, see imperial.ac.uk/graduateschool/events/postgraduateopenday.

Alumni services (imperial.ac.uk/alumni)

This is Imperial's alumni community! The College has more than 150,000 alumni worldwide, and we look forward to keeping in touch with you after your degree, welcoming you back to campus and connecting you with classmates.

A Policy on Scientific Misconduct

The College considers any allegation of scientific misconduct to be a matter of great concern and will investigate any such allegation fully. Given its international reputation and status, the College has a responsibility to the scientific community and to the public at large and therefore, where appropriate, will make public the outcome of any such investigation.

Definitions

The College has adopted the Royal College of Physicians definitions of scientific misconduct as including piracy, plagiarism and fraud. The following definitions give indicative descriptions of the types of activity covered by this regulation. These descriptions are neither exclusive nor exhaustive:

1. Piracy is the deliberate exploitation of ideas and concepts from others without acknowledgement.
2. Plagiarism is the copying of ideas, data or text (or a combination of these) without permission or acknowledgement.
3. Fraud involves deceptionusually, but not exclusively, the invention of data. This could also include the omission from analysis and publication of inconvenient components of a data set.

Other types of scientific misconduct may be separately defined, but the College views them as combinations or sub-types of those defined above. In addition to scientific misconduct, these procedures will also apply to cases of scientific negligence. Procedures for the Investigation of Allegations of Scientific Misconduct See `https://www.imperial.ac.uk/publications/research/app_III.htm`.

Statement on Plagiarism

You are reminded that all work submitted as part of the requirements for any examination (including coursework) of Imperial College and the University of London must be expressed in your own words and incorporate your own ideas and judgements.

Plagiarism, that is, the presentation of another persons thoughts or words as though they were your own, must be avoided, with particular care in coursework, essays and reports written in your own time. Note that you are encouraged to read and criticise the work of others as much as possible. You are expected to incorporate this in your thinking and in your coursework and assessments. But you must acknowledge and label your sources.

Direct quotations from the published or unpublished work of others, from the internet, or from any other source must always be clearly identified as such. A full reference to their source must be provided in the proper form and quotation marks used. Remember that a series of short quotations from several different sources, if not clearly identified as such, constitutes plagiarism just as much as a single unacknowledged long quotation from a single source. Equally, if you summarise another persons ideas or judgements, figures, diagrams or software, you must refer to that person in your text, and include the work referred to in your

bibliography. Departments are able to give advice about the appropriate use and correct acknowledgement of other sources in your own work.

The direct and unacknowledged repetition of your own work which has already been submitted for assessment can constitute self-plagiarism. Where group work is submitted, this should be presented in a way approved by your department. You should therefore consult your tutor or course director if you are in any doubt about what is permissible. You should be aware that you have a collective responsibility for the integrity of group work submitted for assessment.

The use of the work of another student, past or present, constitutes plagiarism. Where work is used without the consent of that student, this will normally be regarded as a major offence of plagiarism.

Failure to observe these rules may result in an allegation of cheating. Cases of suspected plagiarism will be dealt with under the Colleges Examination Offences Policy and may result in a penalty being taken against any student found guilty of plagiarism.

Cheating Offences Policy and Procedures

imperial.ac.uk/registry/exams/examoffences

Plagiarism advice for postgraduate taught course (Master's) students

imperial.ac.uk/library/subjectsandsupport/plagiarism/pgtaught

TurnitinUK Plagiarism Detection Service at Imperial College

imperial.ac.uk/ict/services/teachingandresearchservices/elearning/plagiarism