ACTL5101

Probability and Statistics for Actuaries

Course Outline
Semester 1, 2014

Part A: Course-Specific Information

Please consult Part B for key information on ASB policies (including those on plagiarism and special consideration), student responsibilities and student support services.
Dear Students,

Welcome to ACTL5101 Probability and Statistics for Actuaries. This course is one of eight courses covering the Core Technical subjects of the Institute of Actuaries offered in Master of Actuarial Studies. Many of you will also be completing ACTL5102 Financial Mathematics for Actuaries. In the early weeks of the courses you will find that you will have to adjust to the study load in the courses and also take some time to note the links between these courses.

Probability is the branch of science concerned with the mathematical models and techniques for making quantitative inferences about uncertainty. Statistics deals with the collection and the analysis of data. Together, these two disciplines provide us with fundamental tools to analyse risk and manage the financial consequences of future uncertainties. This course provides you with a foundation in the probability models and statistical techniques required for analysing risks in modern financial markets. It provides a foundation for courses in your actuarial major in the final years of undergraduate study at UNSW. I hope you find the course challenging and interesting.

This course outline has details of the course requirements, course aims and learning outcomes, content, teaching methods, assessment tasks, texts and readings, and expectations. Please read it carefully and thoroughly, as it will be assumed that you are familiar with the contents.

If you have any questions about the course at any time then please contact us.

Brian Chu (lecturer in charge)
Katja Ignatieva (course coordinator)
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1 **STAFF CONTACT DETAILS**

The Lecturers of this course are:

<table>
<thead>
<tr>
<th>Staff</th>
<th>E-mail</th>
<th>Room</th>
<th>Telephone</th>
<th>Consultation times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brian Chu (lecturer in charge)</td>
<td><a href="mailto:brian.chu@unsw.edu.au">brian.chu@unsw.edu.au</a></td>
<td>Quad 2064</td>
<td>9385 2647</td>
<td>By appointment</td>
</tr>
<tr>
<td>Katja Ignatieva (course coordinator)</td>
<td><a href="mailto:k.ignatieva@unsw.edu.au">k.ignatieva@unsw.edu.au</a></td>
<td>Quad 2068</td>
<td>9385 6810</td>
<td>By appointment</td>
</tr>
</tbody>
</table>

Brian is responsible for lectures and related teaching and learning.
Katja is responsible for the administration and final assessment of the course.

**Who should I contact?**

- Questions about the lectures: Brian Chu by appointment or per email;
- Administrative enquiries about the course: Katja Ignatieva by appointment or by e-mail;
- Enquiries about coursework programs in Actuarial Studies: the director of Postgraduate Actuarial Programs (Prof. Michael Sherris m.sherris@unsw.edu.au)
- Enrolment: ASB Student Centre: [http://www.asb.unsw.edu.au/currentstudents/resources/businessstudentcentre/Pages/default.aspx](http://www.asb.unsw.edu.au/currentstudents/resources/businessstudentcentre/Pages/default.aspx)
2 COURSE DETAILS

2.1 Teaching Times and Locations
This course will consist of three hours of lectures.

Lecture times and locations are as follows:

**Wednesday 6:00 p.m. – 9:00 p.m.** Australian School Business 119 (K-E12-119)

Timetables and locations are correct at time of printing. A full timetable of lectures and topics is provided later in this course study guide. Any alterations to the lecture times or locations will be advised in lectures and via Moodle.

Students should consult Moodle on a regular basis, since assignment questions and other course materials will be placed there. The web address is: http://moodle.telt.unsw.edu.au/

2.2 Units of Credit
6

2.3 Summary of Course
This course covers probability and statistics topics relevant to actuarial studies. Topics covered include univariate/multivariate random variables, moments, moment generating functions, marginal and conditional distributions, sampling distributions, estimation methods, hypothesis tests, and linear regression. Examples relevant to actuarial studies, finance and insurance are used to illustrate the application of the topics covered.

2.4 Course Aims and Relationship to Other Courses
At the end of the course you should be able to:

A. Demonstrate an understanding of probability theory;
B. Demonstrate an understanding of statistical theory;
C. Express your views on, and understanding of parameter estimation for parametric distributions.
D. Express your views on, and understanding of hypothesis testing.
E. Express your views on, and understanding of linear regression.

This course covers probability and statistics at an introductory yet mathematically rigorous level with a strong foundation in mathematics. The assumed knowledge of the course is a good understanding of mathematics as covered in a full year of university calculus and linear algebra. There is a document on Moodle with some assumed knowledge of mathematics and linear algebra. Consult the Course Coordinator if you do not have the required mathematical background.

ACTL5101 Probability and Statistics for Actuaries will have applications in other courses in the actuarial major. More advanced models are covered in ACTL5103 Foundations of Actuarial Models. The course is necessary knowledge for the more advanced coverage in ACTL5105 Life Contingencies and ACTL5106 General Insurance Techniques.

The course corresponds to the actuarial professional subject CT3 Probability and Mathematical Statistics. Students achieving Credit or higher grades will be recommended for exemption from the professional examination. Exemptions from
professional actuarial examinations require above average performance in the equivalent University course.

Students should have a solid background in mathematics and are assumed to be able to use a computer to analyse financial problems. You should be able to use a word processing package (such as WORD) and a spreadsheet (such as EXCEL).

2.5 Student Learning Outcomes
The aims of Section 2.4 (A to D) have been broken down into the following learning outcomes. At the end of the course students should be able to:

A1. Explain the concepts of probability.
A2. Explain the concepts of random variable, probability distribution, distribution function, expected value, variance and higher moments, and calculate expected values and probabilities associated with the distributions of random variables.
A3. Define a moment generating function, derive it in simple cases, and use it to evaluate moments.
A4. Define basic discrete and continuous distributions, be able to apply them and simulate them in simple cases.
A5. Explain the concepts of independence, jointly distributed random variables and conditional distributions, and use generating functions to establish the distribution of linear combinations of independent random variables.
A6. Explain the concepts of conditional expectation and compound distribution, and apply them.
A7. State the central limit theorem, and apply it.
B1. Summarise the main features of a data set (exploratory data analysis).
B2. Explain the concepts of random sampling, statistical inference and sampling distribution, and state and use basic sampling distributions.
C1. Describe the main methods of estimation and the main properties of estimators, and apply them.
C2. Construct confidence intervals for unknown parameters.
D1. Test hypotheses.
E1. Investigate linear relationships between variables using correlation analysis and regression analysis.

2.6 Coverage of IAAUST Learning Outcomes
This course corresponds largely with the actuarial professional subject CT3 Probability and Mathematical Statistics.

The course’s Learning Outcomes relate to the aims of this Institute of Actuaries course in the following way:

<table>
<thead>
<tr>
<th>Course Learning Outcomes</th>
<th>Institute of Actuaries aims</th>
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<tbody>
<tr>
<td>A1</td>
<td>CT3: ii</td>
</tr>
<tr>
<td>A2</td>
<td>CT3: iii</td>
</tr>
<tr>
<td>A3</td>
<td>CT3: iv</td>
</tr>
<tr>
<td>A4</td>
<td>CT3: v</td>
</tr>
</tbody>
</table>
3 Learning and Teaching Activities

3.1 Approach to Learning and Teaching in the Course

The philosophy underpinning this course and its Teaching and Learning Strategies are based on “Guidelines on Learning that Inform Teaching at UNSW. These guidelines may be viewed at: www.guidelinesonlearning.unsw.edu.au. Specifically, the lectures, exercises and assessment have been designed to appropriately challenge students and support the achievement of the desired learning outcomes. A climate of inquiry and dialogue is encouraged between students and teachers and among students (in and out of class). The lecturers and tutors aim to provide meaningful and timely feedback to students to improve learning outcome. This is not a course where you can become proficient just by observing.

You will need to get involved in class - evaluating information, asking and answering questions. You must also learn to organize your independent study and practice enough problems to gain a thorough understanding of concepts and how to apply them.

This course is very condensed and the subjects each week require that you know the material of past weeks. Therefore, falling behind will lead to less effective lectures and exercises and is thus not recommended.

The course puts emphasis on statistics, i.e., parameter estimation, hypothesis testing and linear regression (week 5-12). In order to understand statistics one should have some knowledge about probability (week 1-4). The probability part of the course is taught in only four weeks, which means that the workload in those weeks might be larger than in the second part of the course. To ease the workload, you are expected to do exercises every week. The number of examples in the lecture notes has increased substantially. In the lecture you are required to make attempts to these examples, some of them are to do at home.
3.2 Learning Activities and Teaching Strategies
The examinable content of the course comprises the material covered in lectures, video lecture, and exercises.

Students are expected to develop the skills and ability to derive the results on their own. Memorizing formulae and final results will not be of a great help in the exams; only a proper ability to develop these results will ensure success.

Lectures
The purpose of lectures is to provide a logical structure for the topics that make up the course; to emphasize the important concepts and methods of each topic, and to provide relevant examples to which the concepts and methods are applied.

A required learning strategy for the lectures (on which provision of the course materials is based) is:
1) Prior to attending a lecture view the video lecture (week 1-5). Links are available on the Moodle website.
2) Prior to attending a lecture download and read the lecture notes for your lecture and bring them with you to the lecture. The lecture notes are available for downloading on the Moodle website.
3) Attend the lecture. The lecture notes form the basis for the lecture. Key concepts will be emphasized and demonstrated through worked examples. You should take your lecture notes, pen and paper (to make lecture exercises) to the lecture.
4) After the lecture you should complement your lecture notes with the assigned readings and ask questions from the lecturer or your tutor if some issues are still unclear.

Exercises
The more you read the more you know, but the more you practice the more you learn and understand. So the key to the understanding of this course is problem solving.

The purpose of exercises is to enable you to raise questions about difficult topics or problems encountered in their studies. Students must not expect another lecture, but must attempt the questions themselves in groups and the tutor will answer questions to the group, not to the whole class.

The object of the exercises is to attempt the assigned exercises and topics covered in the course. Each week a document will be posted containing the exercises, which students should attempt. The schedule for the questions is attached in section 7: Course Schedule. Exercises are an integral component of the course; and successful completion of exercises is crucial for your successful completion of the course.

The teaching strategy (including the feedback loop) in this course is:

Get introduced  Try it out  Get feedback  Try again

The “Get introduced” (explanation of course concepts in the lecture) and “Try it out” (examples in the lecture) are part of the lecture. If you are not able to make satisfactory
attempt to the examples in the lecture, this is feedback that you should revise the lecture material in depth after the lecture. The “Try again” (exercises) and “Get feedback” (answers from lecturer/solutions posted on Moodle) are part of the exercises. Exercises are designed to attempt the questions in groups (typically of 3-4 students). This collaborative working is advised since it allows learning from peers and allows the more advanced student with a possibility to test whether s/he knows the material in depth and is thereby able to explain it to peers. If the group is unable to solve a question, it can ask for help from the lecturer or solutions posted on Moodle. It will only be posted at the end of the week to give you time to attempt the questions without a solution manual. The solution manual should not be part of attempting a question, but to verify whether your attempt was correct.

A required learning strategy for the exercises (on which provision of the course materials is based) is:

1) Prior to make an attempt of the exercises, review your lecture notes.
2) If you have questions about the exercises, ask them from your lecturer. If you think you have a good understanding of the material, you should try and answer the questions of your peers. This will give you feedback on your ability to explain the material and hence how well you know the material.
3) Check your answer using the solutions posted on Moodle.

3.3 Learning and Teaching Technologies

The course ACTL 5101 Probability and Statistics for Actuaries is a condense course. To optimize the learning experience we will use several learning and teaching technologies.

Moodle
This course will use Moodle for communication with students. Moodle will contain the course outline, lecture notes, homework and exercises, assessment information, and any notices relevant to this course. It is important that you visit the site regularly to see any notices posted there by the course coordinator. The site can be accessed at: http://moodle.telt.unsw.edu.au/

Video Lectures
In the first five weeks you are expected to view the videos on Moodle before attending the lecture, see course schedule. The material covered in the videos will not be covered in the lectures, except when there are clarification questions from students. The lecture will provide exercise style examples (i.e., using collaborative group work in lecture) of the material covered in the video lectures. Therefore, it is essential that you study this material before the lecture.

Turnitin
Turnitin will be used for handing in the assignment. More information will be given in the documentation for the assignment.
Some resources for help:
4 ASSESSMENT

4.1 Formal Requirements
In order to pass these courses, you must:

- achieve a composite mark of at least 50%; and
- make a satisfactory attempt at all assessment tasks.

Students who have an overall performance at the Credit level (65% and above) are eligible for exemption of the Institute of Actuaries CT3 examination.

4.2 Assessment Details
Assessment of your performance in the course will be done through a number of tasks. These are listed in the table below.

<table>
<thead>
<tr>
<th>Assessment Task</th>
<th>Weight</th>
<th>LO¹</th>
<th>Length</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term</td>
<td>20%</td>
<td>Weeks 1-4: A1-A6, B1</td>
<td>1 hour</td>
<td>Friday, 11 April, 4-5pm Location: TBA</td>
</tr>
<tr>
<td>Assignment</td>
<td>15%</td>
<td>A1-A7, B1, C1, D1</td>
<td>NA</td>
<td>Friday 30 May 11am sharp</td>
</tr>
<tr>
<td>Final examination</td>
<td>65%</td>
<td>All</td>
<td>2 hours</td>
<td>TBA</td>
</tr>
</tbody>
</table>

Mid-term
Technical skills are important in practice and this course provides foundation technical skills that will be useful throughout your working life.

In order to assess your understanding of the technical skills covered in the course there will be a 1-hour quiz during the session. The quiz will be closed book. Students will only be allowed to bring the textbook "Formulae and Tables for Actuarial Examinations" into the quiz, which should be fully unannotated!

Normal examination rules apply to the conduct of the quiz. Calculators will be allowed in the quiz and the final examination but a clear indication of all of the steps involved in your calculations must be shown. The University will not supply calculators to students for use in examinations where the provision of calculators has not been requested by the course examiner. It is the student's responsibility to be familiar with the rules governing the conduct of examinations.

The mid-term requires written responses, with students earning marks for correct mathematical working as well as part marks for incorrect responses with correct method and reasoning. They test not only your knowledge of the material, but also the depth of your understanding of it.

¹ Course Learning Outcome that is assessed
Assignment
There will be one assignment for this course. The assignment offers students the opportunity to engage in independent research, engage in critical analysis, self-reflection and problem-solving, as well as to demonstrate their understanding of the concepts and perspectives that are central to actuarial studies.

Students are reminded that the work they submit must be their own (see course outline part B). While we have no problem with students working together on the assignment problems, the material students submit for assessment must be their own.

Assignment Submission Procedure
Assignments must be submitted via the Turnitin submission box that is available on the course Moodle website. Turnitin reports on any similarities between their own cohort’s assignments, and also with regard to other sources (such as the internet or all assignments submitted all around the world via Turnitin). More information is available at: http://elearning.unsw.edu.au/turnitin/content/TurnItInStudentSupport.cfm?ss=0
Please read this page, as we will assume that its content is familiar to you. You will be able to make multiple submissions. You need to check your document once it is submitted (check it on-screen). We will not mark assignments that cannot be read on screen.

Students are reminded of the risk that technical issues may delay or even prevent their submission (such as internet connection and/or computer breakdowns). Students should then consider either submitting their assignment from the university computer rooms or allow enough time (at least 24 hours is recommended) between their submission and the due time. The Turnitin module will not let you submit a late report. No paper copy will be either accepted or graded.

In case of a technical problem, the full document must be submitted to the course coordinator before the due time by e-mail, with explanations about why the student was not able to submit on time. In principle, this assignment will not be marked. It is only in exceptional circumstances where the assignment was submitted before the due time by e-mail that it may be marked—and this only if a valid reason is established.

Avoid a 0 for your assignment (in the mildest case) because of plagiarism
Students are reminded that the work they submit must be their own (see section 5 above). While we have no problem with students working together on the assignment problems, the material students submit for assessment must be their own. This means that:

• The mathematical solutions you present are written up by you, without reference to any other student’s work.

Students should make sure they understand what plagiarism is (see Section 5 and do the quiz) — cases of plagiarism have a very high probability of being discovered. For issues of collective work, having different persons marking the assignment does not decrease this probability.

Students should consult the Turnitin section of the website accessible to all ACTL students well in advance, as this gives a (non exhaustive) list of things that could go wrong and explains how the policies above are implemented.

Final Examination
The final examination will assess students’ understanding of the concepts covered in the course and their ability to apply them to probability and statistics problems.
The final examination will be a two-hour written paper. The final examination will be closed book. Students will only be allowed to bring the text "Formulae and Tables for Actuarial Examinations" into the exam. This must not be annotated. Students may bring their own calculators. All calculators must be either UNSW or Actuarial Studies approved.

4.3 Late Submission
The School of Actuarial Studies has a policy of grading late assignments with a zero mark. Punctual submission of work is required in order to satisfy the requirements of the course. The assignment may be marked at the discretion of the course co-ordinator if there is a valid reason for late submission and used in cases where your final overall results are marginal.

Quality Assurance
The ASB is actively monitoring student learning and quality of the student experience in all its programs. A random selection of completed assessment tasks may be used for quality assurance, such as to determine the extent to which program learning goals are being achieved. The information is required for accreditation purposes, and aggregated findings will be used to inform changes aimed at improving the quality of ASB programs. All material used for such processes will be treated as confidential and will not be related to course grades.
5 COURSE RESOURCES

Textbooks
The prescribed textbooks for the course are:

- [FT] The Faculty of Actuaries and The Institute of Actuaries (2002), *Formulae and tables for examinations of the Faculty of Actuaries and The Institute of Actuaries*. (The formulae book you can use, if unannotated, in quizzes and exams for actuarial courses.)

Suggested textbooks for the course are:


You are advised to have one (or both) of these textbooks in this course. Depending on your mathematical background you should choose either [W+] or [JR].

Optional readings are:

- [CT] The Actuarial Education Company (2010), *CT3 Combined Materials Pack*, ActEd. (This is the Institute of Actuaries study material for the CT3 exam. Only the syllabus can be downloaded for free.)
- [H] Hossack, I., Pollard, J. & Zehnwirth, B. (1999), *Introductory Statistics with Applications in General Insurance*, Cambridge University Press, 2ed. (Want to see how statistics in used in the most statistical actuarial practice area, general insurance? Here’s your starting place.)

Formulae & Tables
Students will only be allowed to bring into the examinations for the Actuarial courses in the BCom the text "Formulae and Tables for Actuarial Examinations". This text must not be annotated. All students in the actuarial courses should purchase a copy of this text if they wish to use this in the final examinations for this course. The text is available from the UNSW bookstore, the UK Institute of Actuaries or from ActEd Australia. Visit the ActEd website at: [http://www.acted.com.au](http://www.acted.com.au).

6 INSTITUTE OF ACTUARIES OF AUSTRALIA
The Institute of Actuaries of Australia (IAAust) allows students to become IAAust University Subscribers free of charge. Full time undergraduates studying at an Institute accredited university who are members of a university student actuarial society are eligible. To sign up, go to [http://www.actuaries.asn.au/Membership/MembershipoftheInstitute/Subscriber.aspx](http://www.actuaries.asn.au/Membership/MembershipoftheInstitute/Subscriber.aspx)

The University Subscriber offer is not a membership of the IAAust but a subscription to receive information on career opportunities, invitations to selected IAAust events and online publications. You might also consider joining the IAAust – there are advantages in doing so while a full-time student. For membership information, go to [http://www.actuaries.asn.au/Membership/MembershipoftheInstitute.aspx](http://www.actuaries.asn.au/Membership/MembershipoftheInstitute.aspx)
### 7 COURSE SCHEDULE

This timetable below may change. Revisions will be advised as they occur through the course web site.

<table>
<thead>
<tr>
<th>Week</th>
<th>dd/mm</th>
<th>Topics</th>
<th>Suggested readings</th>
<th>Optional readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>05/03</td>
<td>Random Variables / Distributions</td>
<td>W+: Chap 1, 2, 3</td>
<td>D: Chap 3, 4</td>
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<tr>
<td></td>
<td></td>
<td>Expected Values</td>
<td>JR: Chap 1, 2, 4, 10</td>
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<td></td>
<td></td>
<td>Moments Moment Generating Functions</td>
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<td></td>
<td></td>
<td><strong>Online lecture:</strong> Probability</td>
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<tr>
<td>2</td>
<td>12/03</td>
<td>Special Distributions</td>
<td>W+: Chaps 3, 4</td>
<td>HPZ: Chap 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributions in Insurance</td>
<td>JR: Chap 2</td>
<td>D: Chap 3</td>
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<td></td>
<td></td>
<td><strong>Online lecture:</strong> Bernoulli, Binomial, Geometric,</td>
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<td></td>
<td></td>
<td>and Negative Binomial distribution</td>
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<td>3</td>
<td>19/03</td>
<td>Joint Distributions</td>
<td>W+: Chap 5</td>
<td>D: Section 6.4</td>
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<td></td>
<td></td>
<td>Multivariate Distributions</td>
<td>JR: Chap 3</td>
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<td></td>
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<td><strong>Online lecture:</strong> Summarising Data</td>
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<td>4</td>
<td>26/03</td>
<td>Distributions of Functions</td>
<td>W+: Chap 6</td>
<td>D: Chaps 1, 3</td>
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<td></td>
<td><strong>Online lecture:</strong> Property of sample mean and variance</td>
<td>JR: Chap 3</td>
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<td>with and without replacement</td>
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<td>5</td>
<td>02/04</td>
<td>Limit Theorems</td>
<td>W+: Chap 7</td>
<td>HPZ: Chap 5</td>
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<td></td>
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<td>Parameter Interference</td>
<td>JR: Chaps 5, 6</td>
<td>D: Chap 3</td>
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<td></td>
<td><strong>Online lecture:</strong> Application distributions of functions:</td>
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<td>Special Sampling Distributions</td>
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<td></td>
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<td>(Chi-squared, Student-t and Snedecor-F distribution)</td>
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<tr>
<td>6</td>
<td>09/04</td>
<td>Classical estimation theory: Cramer-Rao bound, UMVUE</td>
<td>W+: Chap 8, 9</td>
<td>HPZ: Chap 6</td>
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<td></td>
<td></td>
<td>Interval Estimation</td>
<td>JR: Chaps 7, 8, 9</td>
<td>D: Chap 3, 5</td>
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<tr>
<td></td>
<td></td>
<td>Asymptotic properties of ML estimators</td>
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<td><strong>Mid-Semester test Friday, 11 April 4-5pm Location: TBA</strong></td>
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<td>7</td>
<td>16/04</td>
<td>Hypothesis Testing</td>
<td>W+: Chap 10</td>
<td>D: Chaps 5, 9</td>
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<tr>
<td></td>
<td></td>
<td>Neyman-Pearson lemma, uniform most powerful, and</td>
<td>JR: Chaps 8, 9</td>
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<td>generalized likelihood ratio test</td>
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<td>23/04</td>
<td><strong>Mid-Semester Break</strong></td>
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<tr>
<td>8</td>
<td>30/04</td>
<td>Hypothesis Testing: power and Type I and II errors</td>
<td>W+: Chap 10</td>
<td>D: Chaps 5, 9</td>
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<tr>
<td></td>
<td></td>
<td>Jarque-Bera test, k-sample tests and analysis of variance</td>
<td>JR: Chaps 8, 9</td>
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<td>Testing methods: conditional test and bootstrap tests</td>
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<tr>
<td>9</td>
<td>07/05</td>
<td>Contingency tables and applications (independence &amp;</td>
<td>W+: Chap 10</td>
<td>D: Chaps 5, 9</td>
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<tr>
<td></td>
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<td>goodness of fit)</td>
<td>JR: Chaps 8, 9</td>
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<td>Non-parametric Hypothesis Tests (Binomial test, sign test</td>
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<td></td>
<td></td>
<td>and Wilcoxon test)</td>
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<td></td>
<td>&amp; overview of goodness of fit tests</td>
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