PROPOSED COURSE OUTLINE TEMPLATE FOR STUDENTS AT NTU

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>2017/2018</th>
<th>Semester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Coordinator</td>
<td>Bernhard Schmidt</td>
<td></td>
</tr>
<tr>
<td>Course Code</td>
<td>MH3500</td>
<td></td>
</tr>
<tr>
<td>Course Title</td>
<td>Statistics</td>
<td></td>
</tr>
<tr>
<td>Pre-requisites</td>
<td>MH2500</td>
<td></td>
</tr>
<tr>
<td>No of AUs</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Contact Hours</td>
<td>Lecture: 39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tutorial: 12</td>
<td></td>
</tr>
<tr>
<td>Proposal Date</td>
<td>28/07/2017</td>
<td></td>
</tr>
</tbody>
</table>

Course Aims
This course aims to develop your understanding of the statistical concepts of parameter estimation and hypothesis testing that are fundamental for real life applications of statistics as well as for numerous further courses in the curriculum of the statistics track.

Intended Learning Outcomes (ILO)
By the end of this course, you (as a student) would be able to:

1. Apply basic probability concepts such as PMF, PDF, CDF, expected values, variance, and moments in a statistical context and perform the involved computations of series and integrals.
2. Use standard probability distributions to model statistical scenarios and to derive useful conclusions from computations based on these distributions.
3. Explain the relevance of the Central Limit Theorem for statistics.
5. Rigorously assess the quality of parameter estimators.
6. Analyse the asymptotic properties of parameter estimators.
7. Construct exact and approximate confidence intervals.
8. Explain the purpose and philosophy of hypothesis testing, as well as the meaning of \( p \)-values.
9. Given a dataset, create and apply a useful hypothesis test based on these data.
10. Compute the size and power of a hypothesis test.
11. Construct most powerful tests using the Neyman-Pearson Lemma.

Course Content
Review of probability
- PDF, CDF, PMF, mean, variance, moments
- Common probability distributions
- Upper percentage points of distributions
- Moment generating functions
- Probability distributions of functions of random variables
- Distribution of maximum and minimum of random variables

Random samples, sample mean and sample variance
- Distributions derived from the normal distribution
- Chi-Square distribution
- t-distribution
- F-distribution

Central Limit Theorem and its significance for Statistics

Parameter estimation
- Introduction
- Parameter estimation as part of statistical inference
- Examples for the procedure of parameter estimation
- Discrete and continuous parametric models

Criteria for quality of estimators
- Bias, standard error, mean squared error
- Estimated standard error
- Consistency of estimators

Constructing good estimators
- Method of moments
- Maximum likelihood method

Asymptotic properties of estimators
- Review of Law of Large Numbers
- Consistency of method of moments and maximum likelihood estimators
- Fisher information
- Asymptotic normality of maximum likelihood estimators
- Cramer-Rao bound and efficient estimators

Confidence intervals for estimators
- Review of concept of confidence intervals
- Large sample confidence intervals for maximum likelihood estimators
- Pivotal quantities
- Construction of exact confidence intervals
- Asymptotically pivotal quantities
- Construction of approximate confidence intervals

Hypothesis testing
- Purpose and philosophy of hypothesis testing
- Role of hypothesis testing in statistical inference
- Null hypothesis and its interpretation
- Simple and composite hypotheses

Fisher-type tests
- p-values and critical values
- Connection between confidence intervals and Fisher-type tests

Neyman-Pearson tests
- Alternative hypothesis
- One-sided and two-sided tests and their p-values
- Type I and type II errors
- Power and size of a test
- Constructing good tests: Neyman-Pearson lemma
- Overview of frequently used tests

Assessment (includes both continuous and summative assessment)

<table>
<thead>
<tr>
<th>Component</th>
<th>Course LO Tested</th>
<th>Related Programme LO or Graduate Attributes</th>
<th>Weighting</th>
<th>Team/Individual</th>
<th>Assessment rubrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Final Examination</td>
<td>1-11</td>
<td>A1, A2, A3, B2, B4, C1</td>
<td>60%</td>
<td>Individual</td>
<td>Point-based marking (not rubrics based)</td>
</tr>
<tr>
<td>2. Continuous Assessment Component 1: Midterm</td>
<td>1-5</td>
<td>A1, A2, A3, B2, B4, C1</td>
<td>20%</td>
<td>Individual</td>
<td>Point-based marking (not rubrics based)</td>
</tr>
<tr>
<td>3. Continuous Assessment Component 2: Weekly Quizzes</td>
<td>1-11</td>
<td>A1, A2, A3, B2, C1</td>
<td>20%</td>
<td>Individual</td>
<td>Point-based marking (not rubrics based)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Formative feedback

Learning and Teaching approach
Component 2: Feedback on common mistakes and the level of difficulty of the problems is given.
Component 3: Students will receive individual feedback on their performance in the quizzes during the tutorial sessions.

Reading and References
John A. Rice: Mathematical Statistics and Data Analysis, Third Edition

Course Policies and Student Responsibilities

Absence Due to Medical or Other Reasons
If you are sick and not able to attend a quiz or midterm, you have to submit the original Medical Certificate (or another relevant document) to the administration to obtain official
leave. In this case, the missed assessment component will not be counted towards the final grade. There are no make-up quizzes or make-up midterm.

### Academic Integrity & Collaboration Policy

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU’s shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [academic integrity website](#) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Collaboration is encouraged for your homework because peer-to-peer learning helps you understand the subject better and working in a team trains you to better communicate with others. As part of academic integrity, crediting others for their contribution to your work promotes ethical practice.

You **must write up your solutions by yourself and understand anything that you hand in.**

If you do collaborate, **you must write on your solution sheet the names of the students you worked with.** If you did not collaborate with anyone, please **explicitly write, “No collaborators.”** Failure to do so constitutes plagiarism.

Use of materials outside the course is strongly discouraged. If you use outside source, **you must reference it in your solution.**

### Course Instructors

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Office Location</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bernhard Schmidt</td>
<td>SPMS-MAS-05-24</td>
<td>65132009</td>
<td><a href="mailto:bernhard@ntu.edu.sg">bernhard@ntu.edu.sg</a></td>
</tr>
</tbody>
</table>

### Planned Weekly Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Course LO</th>
<th>Readings/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Review of probability</td>
<td>1</td>
<td>Study lecture notes</td>
</tr>
<tr>
<td>3</td>
<td>Random samples, sample mean and sample variance, distributions derived</td>
<td>2,3</td>
<td>Study lecture notes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td></td>
<td>from the normal distribution, Central Limit Theorem and its significance for statistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Introduction to parameter estimation, quality criteria for parameter estimators</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5-7</td>
<td>Constructing good estimators: method of moments and maximum likelihood method</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>8-9</td>
<td>Asymptotic properties of estimators, Cramer-Rao bound and efficient estimators</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Confidence intervals for estimators</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Introduction to hypothesis testing and Fisher-type tests</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>12-13</td>
<td>Neyman-Pearson tests and Neyman-Pearson Lemma</td>
<td>9, 10, 11</td>
<td></td>
</tr>
</tbody>
</table>

Study lecture notes