1. General course information

- SS9030B: Statistical Inference
- 2018–2019 Winter term: January 7 – April 9, 2019
- Lecture room: MC204
- Day and time: Tuesday 11:30–12:30 & Friday 10:30–12:30

Requirements

- Basic Calculus and Linear Algebra
- Probability
- Mathematical and Computational Statistics

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

2. Instructor information

- Office: WSC 274
  Office hours are to be used for sorting out individual bureaucratic issues, and not for individual tutoring. Subject-matter questions, discussions, and consultations are very much welcome during the class time, so that everybody would be treated equally and benefit equally.
- E-mail: zitikis@stats.uwo.ca or rzitikis@uwo.ca
  When contacting by email, students must use their Western (@uwo.ca) email addresses.

3. Course description

Objectives

- Study of statistical methods with a view toward their manifold uses
- Enhancement of statistical intuition and technical prowess
- Increased confidence when facing statistical challenges
- Auxiliary preparation for the PhD comprehensive exam

Learning outcomes

- A bird’s view of statistical inference
- Familiarity with modern, application-driven methods and techniques of statistics

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1To accommodate feedback from students and administrators, the course outline is subject to revision up till and including the first class. This version was prepared on December 6, 2018.
4. Detailed lecture descriptions

Chapter 1.
Lecture 1a: Probability and random variable
- random variable, measurable function, sample space, event, \( \sigma \)-algebra, filtration, probability, cdf, continuity
Lecture 1b: Probability and dependence
- independent events and rv's, pairwise independent events and rv's, conditional probability, Bayes's theorem, conditional independence

Chapter 2.
Lecture 2a: Random variables and their classification
- discrete, continuous, cdf, quantile, value at risk, bivariate rv, marginals, conditionals
Lecture 2b: (SUPPLEMENT)\(^2\) Value-at-risk in insurance and finance
- VaR and V@R, relationship, interpretation, computation, Acerbi and Tasche’s example, portfolio diversification
Lecture 2c: (SUPPLEMENT) Distributional transform
- quantile function, properties and issues, distributional transform, properties, conditional cdf of the distributional transform
Lecture 2d: (SUPPLEMENT) Copula
- bivariate cdf and copula, uniqueness and non-uniqueness, five properties, QD, independence, Fréchet, survival

Chapter 3.
Lecture 3a: Expectation
- mean, variance, covariance, loaded insurance premiums, distortion functionals, conditional mean, variance and covariance
Lecture 3b: (SUPPLEMENT) Average value at risk
- an optimization problem, value at risk, AVaR and AV@R, stop-loss transform, subadditivity and diversification
Lecture 3c: (SUPPLEMENT) Tail conditional expectation
- AVaR as tail expectation, the role of continuity and distributional transform, AV@R as tail expectation

Chapter 4.
Lecture 4a: Inequalities
- Markov, Chebyshev, Hoeffding, Jensen, Grüss, Hölder, negotiating insurance premiums, acceptance sets
Lecture 4b: Covariance, QD, and co-monotonicity
- covariance via survival probabilities, covariance without mentioning the means, quadrant dependence, co-monotonicity, weighted premiums, non-negative loading

\(^2\)Those lectures with “(SUPPLEMENT)” will not be covered. They are designed (and uploaded on OWL) for those who wish to see connections of this course to two of the core streams in the department: Act Science and Fin Modelling.
Chapter 5.
Lecture 5a: Convergence of random variables
- modes of convergence, Slutsky’s theorem, transformed sequences, the delta method, variance stabilization

Chapters 6.
Lecture 6a: Models and inference
- estimators, confidence intervals, pointwise, simultaneous, based on limits and probability bounds, linear and non-linear functionals, CI’s for cdf’s and quantiles

Chapters 7.
Lecture 7a: Statistical functionals
- Linear and non-linear functionals, L-functionals, M-functionals, R-functionals, plug-in estimators
Lecture 7b: (SUPPLEMENT) Classification of risk measures
- classification of risk measures, properties of the value at risk, properties of the average value at risk

Chapter 8.
Lecture 8a: Bootstrap
- the idea of bootstrap, bootstrap based on limit theorems, bootstrap based on percentiles, jackknife

Chapter 9.
Lecture 9a: Parametric inference
- loss function approach, method of moments and its consistency, maximum likelihood method and its consistency

Chapter 10.
Lecture 10a: Hypothesis testing and p-values
- hypotheses and terminology, power, size, p-value, permutation test, multiple testing, FWER, Bonferroni procedure, FDP, FDR, Benjamini-Hochberg procedure

Chapters 11.
Lecture 11a: Bayesian inference
- Bayesian philosophy, prior, posterior

Chapters 12.
Lecture 12a: Decision theory
- loss, risk, maximal risk, minimax, Bayes risk, Bayes decision rule

Chapter 13.
Lecture 13a: Regression
- regression function, linearity, loss function and LSE, multiple regression, prediction, standard error, prediction interval
Chapter 14.
Lecture 14a: Multivariate models
• random vectors, their means and variances, multivariate normal, likelihood, MLE, portfolio selection, multivariate elliptical

Chapter 15.
Lecture 15a: Inference about independence
• binary and general discrete random variables, likelihood ratio test for independence, Pearson’s $\chi^2$ test, odds, odds ratio, relative risk

Chapter 16.
Lecture 16a: Causal inference
• counterfactuals, average causal effect, measuring association, conditional causal effect, conditional association, Simpson’s paradox and its resolution

Chapter 17.
Lecture 17a: Directed graphs and conditional independence
• conditional independence, directed graphs, basic terminology, directed acyclic graphs, probabilities on DAGs, d-connection and d-separation

Chapter 18.
Lecture 18a: Undirected graphs
• undirected graph, separation, complete graph, pairwise Markov graph, global Markov property, cliques, maximal cliques, probability specification

Chapter 19.
Lecture 19a: Log-linear models
• log-linear expansion, contingency tables, conditional independence, graphical, hierarchical, log-linear models, generators

Chapter 20.
Lecture 20a: Nonparametric density estimation
• error criteria, mean, bias, variance, risk, ISE, MISE, AMISE histogram estimator, bandwidth selection, cross validation
Lecture 20b: Kernel density estimation
• kernels, risk, MSE, AMSE AMISE, bandwidth selection, cross validation, Stone’s theorem, multivariate densities, curse of dimensionality
Lecture 20c: Nonparametric regression function estimation
• nonparametric regression, Nadaraya-Watson, weighted averages, bandwidth selection, cross-validation, linear smoother, general smoother, local polynomial regression
Chapter 21.

Lecture 21a: Smoothing using orthogonal functions

• $L_2$ space, orthonormal basis, Legendre, Laguerre, Hermite, density estimator, regression estimator, risk, Haar wavelets

5. Course materials

We shall closely follow the main textbook


“This book is for people who want to learn probability and statistics quickly. It brings together many of the main ideas in modern statistics in one place. The book is suitable for students and researchers in statistics, computer science, data mining and machine learning. This book covers a much wider range of topics than a typical introductory text on mathematical statistics. It includes modern topics like nonparametric curve estimation, bootstrapping and classification, topics that are usually relegated to follow-up courses.”

Other textbooks with useful for us material


“The goal of this text is to provide the reader with a single book where they can find a brief account of many, modern topics in nonparametric inference. The book is aimed at Master’s level or Ph.D. level students in statistics, computer science, and engineering.”


6. Methods of evaluation

• Assignments 20%

Every Tuesday, each student submits at least one problem and its solution related to any of the lectures covered during the previous week, so that a test bank would be created. The submission should be one page long at most, typed either in $\LaTeX$ or MS Word, and printed.

• First midterm 15% (late afternoon or early evening on Tuesday, January 29, 2019).

• Second midterm 15% (late afternoon or early evening on Tuesday, February 26, 2019)

Each of the two midterms is two-hour long and consists of four problems closely related, perhaps even identical, to those in the test bank.

• Final exam 50% (TBA, during the Final Examination period)

The exam is three-hour long and consists of six problems closely related, perhaps even identical, to those in the test bank.

No make-up exams, except for the final exam. The percentage of any legitimately\textsuperscript{3} missed midterm will be appended to the next evaluation (midterm or final exam, whichever comes next).

\textsuperscript{3}Legitimacy must be determined by a counsellor.
7. **ACCOMMODATION AND ACCESSIBILITY**

If documentation (medical or otherwise) is required, it can only be collected by the student’s Dean’s Office/Academic Counselling unit.

If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or supporting documentation to the Academic Counselling Office of your home faculty as soon as possible. If you are a Science student, the Academic Counselling Office of the Faculty of Science is located in WSC 140, and can be contacted at scibmsac@uwo.ca

For further information, please consult the university’s medical illness policy at http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf

If you miss the Final Exam, please contact your faculty’s Academic Counselling Office as soon as you are able to do so. They will assess your eligibility to write the Special Exam.

You may also be eligible to write the Special Exam if you are in a “Multiple Exam Situation” (see http://www.registrar.uwo.ca/examinations/exam_schedule.html)

8. **ACADEMIC POLICIES**

The website for Registrarial Services is http://www.registrar.uwo.ca

In accordance with policy, http://www.uwo.ca/its/identity/activatenonstudent.html, the centrally administered e-mail account provided to students will be considered the individual’s official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at his/her official university address is attended to in a timely manner.

No electronic devices will be permitted on tests and exams.

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at this website: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

9. **SUPPORT SERVICES**

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 ext. 82147 if you have questions.

The policy on Accommodation for Students with Disabilities can be found here: www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_disabilities.pdf

The policy on Accommodation for Religious Holidays can be found here: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

Learning-skills counsellors at the Student Development Centre (http://www.sdc.uwo.ca) are ready to help you improve your learning skills. They offer presentations on strategies for improving time management, multiple-choice exam preparation/writing, textbook reading, and more. Individual support is offered throughout the Fall/Winter terms in the drop-in Learning Help Centre, and year-round through individual counselling.

Students who are in emotional/mental distress should refer to Mental Health@Western for a complete list of options about how to obtain help http://www.health.uwo.ca/mental_health

Additional student-run support services are offered by the USC, http://westernusc.ca/services