

# **B9822 Mathematical Methods II**

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Class hours: Tuesday 4-7:15pm.  
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## **Overview**

This is a first graduate course in mathematical statistics and data analysis. The course covers fundamental concepts of statistical inference that provide the foundations for data analysis and applied empirical work. The course combines theory of statistical inference, methods for analyzing data, and hands-on examples using statistical software packages. At the end of the course, students will be able to apply basic tools of data analysis on their research.

There will be homework assignments, a midterm and a final. The homework will include some computational problems on analyzing data. We will be using the statistical software package Stata throughout the course. The midterm and final will be open book. The grade will be based on a weighted average of the exams.

Although there is no required textbook for the course, there are three recommended texts: (1) John Rice, “Mathematical Statistics and Data Analysis” and (3) Jeffrey Wooldridge, “Introductory Econometrics”. Photocopies of other readings will be distributed in class

## **Lecture 1: Basic Concepts of Statistical Inference**

*Readings:* Rice [6, 7.1-7.3.2]

### *Topics:*

- Estimating population parameters (e.g. population mean): Unbiased estimators, Standard Errors.
- Sampling from a Normal distribution. Distributions derived from the Normal distribution. Inference based on the sample mean.
- Confidence Intervals.

## **Lecture 2: Asymptotics**

*Readings:* Rice [5, 7.1-7.4]

*Topics:*

- Convergence in probability, Consistent estimators.
- Law of Large Numbers.
- Convergence in distribution. Central Limit Theorem.
- Some useful limit results: Slutsky's Theorem, Delta Method.
- Using asymptotics to construct confidence intervals.

## **Lecture 3: Hypothesis testing.**

*Readings:* Rice[11.1-11.3]

*Topics:*

- Introduction to hypothesis testing.
- Comparing 2 samples: test of proportions, test of means, test of std. deviations, non-parametric tests.
- Examples in Stata.

## **Lecture 4: ANOVA and Introduction to Linear Regression**

*Readings:* Rice[12]; Angrist and Pischke, Chapter 3.1

*Topics:*

- one and two-way ANOVA
- Conditional expectation and regression.

## **Lecture 5: Linear regression**

*Readings:* Wooldridge, [2-3]

*Topics*

- Linear regression.
- Sampling distribution of the OLS estimator.

## **Lecture 6: Linear regression (2)**

*Readings:* Wooldridge [4-5]

*Topics:*

- Hypothesis testing in the linear regression model.
- Regression diagnostics: outliers, leverage, influential points, multi-collinearity, heteroscedasticity.
- Applications of regression.
- Stata: linear regression exercise.

## **Lecture 7: Parametric Estimation**

*Readings:* Rice[8.1-8.5]

*Topics:*

- Intro to parametric estimation
- Method of Moments.
- Maximum likelihood.
- Sampling distribution of estimators: exact, bootstrapping and asymptotics.
- Computational example on ML.

## **Lecture 8: Maximum Likelihood (continued)**

*Readings:* Rice[8.6-8.8]

*Topics:*

- Asymptotic properties of MLE.
- Mean Square Error (MSE).
- Cramer-Rao lower bound, efficiency of MLE.

*Other activities:*

- Read Fader, Hardie and Lee (2005)

## **Lecture 9: Hypothesis testing in parametric estimation**

*Readings:* Rice [9.1-9.5]

*Topics:*

- Power and size of test
- Likelihood ratio (LR) test
- Neyman-Pearson lemma
- Generalized LR test
- Chi-square goodness of fit test

## **Lecture 10: Examples of MLE**

*Readings:* Wooldridge [17.1, 17.3]

*Topics:*

- Binary dependent variables: logit and probit
- Models for counting variables: Ordered logit, Poisson regression.
- Examples in Stata

## References:

Readings (from textbooks):

- [R]: Rice, John "Mathematical Statistics and Data Analysis" Second Edition, Duxbury Press.
- Goldberger, Arthur (1991). "A Course in Econometrics", Cambridge University Press.
- Joshua Angrist and Jorn-Steffen Pischke, Mostly Harmless Econometrics. Chapter 3.
- Casella, George and Roger Berger (2002), "Statistical Inference" Second Edition, Duxbury Press.
- Jeffrey Wooldridge, Introductory Econometrics: A Modern Approach.
- Freedman, David, Robert Pisani and Roger Purves. (1998) *Statistics*, 3<sup>rd</sup> Ed. W.W.Norton, 1998. Chapter 9

Papers:

1. Gilovic, Thomas, Robert Vallone and Amos Tversky. (1985) "The Hot-hand in Basketball". *Cognitive Psychology* 17, 295-314
2. Fader, Peter, Bruce Hardie and Ka Lok Lee (2005). "Counting your customers the easy way: An alternative to the Pareto/NBD model. *Marketing Science* 24 (2) 275-284.
3. Auerbach, Alan, Kevin Hassett and Stephen Oliner (1994). "Reassessing the Social Returns to Equipment Investment", *Quarterly Journal of Economics* 109 (3) 789-802.
4. Brant, Rollin (1996). "Digesting Logistic Regression", *The American Statistician* 50 (2) 117-119.
5. Krueger, Alan (1993). "How Computers Have Changed the Wage Structure: Evidence from Microdata. ", *Quarterly Journal of Economics* 108 (1), 33-60
6. Di Nardo, John and Jorn-Steffen Pischke (1997). "The Returns to Computer Use Revisited: Have Pencils Changed the Wage Structure Too?", *Quarterly Journal of Economics* 112 (1). 291-303.