Syllabus – STOR 654, Statistical Theory I

Fall 2018 (August 21 – December 5)
Section 001, TuTh 11:00am – 12:15pm
Hanes 107

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Target Audience: First year Ph.D. students in the Department of Statistics and Operations Research. It is assumed that students have taken statistics at an advanced undergraduate level and are familiar with mathematical ideas such as proofs.

Required Text:

- "Theoretical Statistics: Topics for a Core Course" by Keener, Springer, Download from SpringerLink.

Optional Texts:

- Casella and Berger: *Statistical Inference*, Duxbury 2/e
- Bickel and Doksum, *Mathematical Statistics, Vol 1*, 2/e, Prentice Hall

Course Objective: This is the first course in mathematical statistics. The main objective of the course is to rigorously develop basic statistical ideas such as point estimation, confidence intervals, and hypothesis testing together with appropriate technical tools such as concentration inequalities. This course will be followed by STOR 655, which covers asymptotical (large sample) approaches to mathematical statistics.

Course Format: Traditional lecture

Assessment: Your grade will be based on a midterm exam (30% of the grade), a final exam (50% of the grade) and weekly homework sets (20% of the grade).

Important dates:

- Final Exam: see the published university schedule
- Midterm exam: Tuesday, October 16
- Homework: Homework sets will be usually assigned on Tuesdays and due in one week at the beginning of the class. Late/missed homework will receive a grade of zero. Students are encouraged to discuss the homework problems with other members of the class, but should prepare their final answers on their own.

Course Outline: We plan to cover the following topics. Notice that the order is different than in the book.

1. Background
    a. Probability spaces, r.v.'s, expectation, variance, covariance.
    b. Transformations, CDF method, Jacobian method
    c. Basic inequalitites (Jensen, Holder, Markov, and Chebyshev)
    d. Moment generating function, Chernoff and Hoerfding's inequality.
    e. Statistical model and identifiability
    f. Properties of sample mean and variance
    g. Order statistics
2. Data Reduction
    a. Scale and location families
    b. Exponential families
    c. Sufficiency. Definition and Factorization theorem.
    d. Minimal sufficiency, sufficient condition
    e. Ancillary statistics
3. Point Estimation
    a. Method of Moments
    b. Maximum likelihood
    c. Bayes estimators: prior, posterior, conjugacy
    d. MSE, bias, and bias-variance decomposition
    e. Bayes risk, Bayes rule
    f. Comparing risk functions
4. Hypothesis Testing
    a. Basic Definitions
    b. Likelihood ratio tests
    c. Error probabilities and power function: size and level of test
    d. Neyman-Pearson lemma
    e. *p*-values
    f. Multiple testing adjustment (Bonferroni, Benjamini-Hochberg)
5. Interval Estimation
    a. Basic Definitions
    b. Derivation: Inverting test statistic, Pivotal quantities, Pivoting the CDF
    c. Credible intervals
    d. Evaluating interval estimators
6. Practical Issues of Bayesian Statistics (time permitting)
    a. Prior selection (conjugate, objective vs subjective, hierarchical models)
    b. Basic Bayes computations (Metropolis Hastings and Gibbs sampler).

Note: The instructor reserves the right to make any changes he considers academically advisable. It is your responsibility to attend classes and keep track of the proceedings.