MTH 503–Mathematical Statistics II
Course Syllabus

Course description: Sufficient and complete statistics, likelihood and moment estimation, properties of estimators, interval estimation and hypothesis tests.

Credit hours: 3

Course Prerequisites and Corequisites: MTH 502

Course outline: Approximate time spent

- **Sampling Distributions** 10%
  - Properties of the Sample Mean and Sample Variance
  - Convergence Concepts
  - Central Limit Theorem
- **The t and F sampling distributions** 5%
  - Properties of t and F random variables
  - The role of t-statistics and F-ratios in statistics
- **Order Statistics** 5%
- **Methods of Point Estimation for Parameters** 25%
  - Method of Moments
  - Maximum Likelihood Estimation
    - Utilizing calculus
    - Utilizing graphical methods
  - Bayes' Estimation
    - Bayesian v. Frequentist Philosophy
    - Prior and Posterior Distributions
- **Properties of Estimators** 20%
  - Mean Squared Error and Unbiasedness
  - "Best" Estimation
    - UMVUE via Cramer-Rao Inequality
    - Sufficiency and Completeness
    - Rao-Blackwell Theorem
    - UMVUE via Lehmann-Scheffe Theorem
    - Best Invariant Estimation
- **Theory of Tests of Hypotheses** 25%
  - Simple v. Composite Hypotheses
  - Simple Likelihood Ratio Tests
    - Neyman-Pearson Results
  - General Likelihood Ratio Tests
  - Monotone Likelihood Ratios
  - Karlin-Rubin Theorem
  - Bayes' Tests
  - Properties of Hypothesis Tests
    - Unbiasedness and Consistency
    - Type I and II errors, Power
- **Confidence Intervals** 10%
  - Relationship to Hypothesis Tests
  - Pivotal Quantities
  - Test Statistic Inversion
  - Coverage and Assessing/Interpreting Confidence Intervals

Student Learning Outcomes (SLO): At the end of MTH 503, a student who has studied and learned the material should be able to:

1. State and apply the Central Limit Theorem and discuss its importance in statistical inference techniques. [MTH-PLO: 3, 4], [STA-PLO: 1, 5]
2. Estimate parameters of probability models via several methods and compare and contrast the properties of each method. [MTH-PLO: 2, 4], [STA-PLO: 2]
3. Assess the quality of an estimator for a parameter, specifically addressing the issue of mean-squared error. [MTH-PLO: 2, 4], [STA-PLO: 1]
4. Explain and consider both a frequentist and Bayesian approach to statistical inference. [MTH-PLO: 3, 5], [STA-PLO: 1, 5]
5. Carry out a test of hypotheses for the parameters of a probability model, specifically being familiar with likelihood ratio methodology. [MTH-PLO: 2, 4], [STA-PLO: 1, 2]
6. Explain the dual relationship between hypothesis tests and confidence intervals. [MTH-PLO: 3, 5], [STA-PLO: 1, 2 5]
7. Calculate and properly interpret an interval estimate for parameters from a specified probability model. [MTH-PLO: 2, 5], [STA-PLO: 2, 5]
8. Apply the major theorems related to hypothesis tests and discuss the overall philosophy of testing. [MTH-PLO: 2, 3, 5], [STA-PLO: 1, 5]
9. Explain the meaning of Type I and II errors along with have a firm understanding of the role of power as it pertains to hypothesis tests. [MTH-PLO: 3, 5], [STA-PLO: 1, 5]

Program Learning Outcomes (MTH - PLO):

Students graduating from SFASU with a M.S. degree and a major in mathematics will:

2. **[*Skills*]** Execute advanced mathematical procedures and build upon these standard procedures. (learning of new skills, applying or extending skills in new situations)
3. **[*Concepts*]** Demonstrate knowledge of core mathematical concepts. (definitions and theorems in analysis, definitions and theorems in linear or abstract algebra, definitions and theorems in theoretical statistics)
4. **[*Problem Solving*]** Demonstrate initiative in using various mathematical tools, including technology, to formulate, represent, and solve problems. (implement algorithms or definitions, discuss algorithmic proficiency, find numerical approximations)
5. **[*Communication*]** Demonstrate proficiency in communicating mathematics in a format appropriate to expected audiences. (written, visual, oral)

Program Learning Outcomes (STA - PLO):

Students graduating from SFASU with an M.S. degree and a major in statistics will demonstrate:

1. A command of core probability and statistical concepts through major definitions and theorems. **[*Concepts*]** (Probability and Statistical Inference)
2. Strategic competence in formulating a standard probabilistic/statistical model for a given problem. **[*Modeling*]** (Model Choice and Model Interpretation)
5. Proficiency in communicating probability and statistics in a format appropriate to expected audiences. **[*Communication*]** (Written Communication, Oral Communication)

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