STEPHEN F. AUSTIN STATE UNIVERSITY

Department of Mathematics and Statistics

MTH 359 – Probability Modeling
Course Syllabus

Course description: Elementary probability laws, conditional probability, the language of random variables and stochastic processes, modeling with discrete and continuous probability distributions, applications among various stochastic processes, methods of estimating parameters.

Credit hours: 3

Course Prerequisites and Corequisites: MTH 234.

Course outline: Approximate time spent

- **Introduction to Modeling** 5%
  - the modeling process
  - probability models vs. other models
  - a first model: the random walk
  - applications of random walks in science
- **Sets and Functions** 5%
  - Elementary set operations and theory
  - Definition of function and set function
  - Probability function and the axioms of probability
  - Equally likely sample spaces and the need for counting rules
- **Probability Laws Based on the Axioms** 10%
  - The Complement Rule
  - The Addition Rule
  - The Inclusion-Exclusion Principle and extensions to the Addition rule
- **Conditioning** 10%
  - Conditional Probability definition and the Multiplication Rule
  - Independent Events
  - The Theorem of Total Probabilities and Bayes' Rule
  - Extensions of the Multiplication Rule
  - Introduction to Markov Chains
- **Language of Random Variables and Stochastic Processes** 15%
  - Definition of random variable
  - Discrete v. Continuous random variables
  - Mass and density functions
  - Expected Value (Mean and Variance) of random variables
  - Moment Generating Functions
  - Roles, types and characteristics of stochastic processes
  - More on the random walk and more on Markov chains
- **Modeling with discrete distributions** 25%
  - Survey of popular models: Bernoulli, binomial, hypergeometric, Poisson, geometric, negative binomial
  - Relationships between discrete probability models
  - Investigation of settings in which each model is appropriate for use
  - Applications involving various stochastic processes
  - Estimating Parameters in Discrete Distributions: Method of Moments, MLE, bias, mean squared error

Approximate time spent

- **Modeling with continuous distributions** 30%
    - Survey of popular continuous distributions: uniform, exponential, gamma, normal
    - Using graphical methods to identify proper continuous models
    - Investigation of settings in which each model is appropriate for use
    - Applications involving various stochastic processes
    - Estimating Parameters in Continuous Distributions: Method of Moments, MLE, bias, mean squared error

Student Learning Outcomes (SLO): At the end of MTH 419, a student who has studied and learned the material should be able to:

1. Discriminate between mathematical, statistical and probabilistic models. [PLO: 1]
2. Explain and apply the axioms and major laws associated with the probability function. [PLO: 1, 2, 3]
3. Explain the difference between unconditional and conditional probabilities and how to compute each in physical settings. [PLO: 2, 3]
4. Model physical systems using popular discrete random variables. [PLO: 4]
5. Discriminate between popular discrete probability models based on physical scenarios that generate discrete data. [PLO: 1, 4]
6. Apply various stochastic models that are associated with discrete random variables to physical settings. [PLO: 2, 4]
7. Model physical systems using popular continuous random variables. [PLO: 4]
8. Apply various stochastic models that are associated with continuous random variables to physical settings. [PLO: 2, 4]
9. Discriminate between key features seen in data that lead to the choice of a particular continuous probability model. [PLO: 1, 4]
10. Estimate unknown parameters in order to complete the process of probability modeling. [PLO: 2, 4]
11. Compare and contrast methods of estimating parameters. [PLO: 2, 4]
12. Compare and contrast basic stochastic processes and provide illustrations of when they occur in nature. [PLO: 4]

Program Learning Outcomes (PLO):

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

1. Demonstrate comprehension of core mathematical concepts. [***Concepts***]
   (notion of theorem, mathematical proof, logical argument)
2. Execute mathematical procedures accurately, appropriately, and efficiently. [***Skills***]
   (calculus, algebra, routine, nonroutine, applied)
3. Apply principles of logic to develop and analyze conjectures and proofs. [L***ogical Reasoning***]
   (quantifiers, breaking down mathematical statements, counterexamples)
4. Demonstrate competence in using various mathematical tools, including technology, to formulate, represent, and solve problems. [***Problem Solving***]
   (calculus tools, algebra tools, applied tools, nonstandard problem solving)

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