STEPHEN F. AUSTIN STATE UNIVERSITY

Department of Mathematics and Statistics

STA 523 – Stochastic Processes
Course Syllabus

Course description: Markov chains, Poisson and renewal Processes, continuous time Markov processes including birth and death processes, queueing theory.

Credit hours: 3

Course Prerequisites and Corequisites: MTH 502

Course outline: Approximate time spent

- **Introduction to Stochastic Modeling** 5%
  - Review of Probability Laws
  - Review of Distribution Theory
  - Markov dependence
  - State Space and Parameter Space Classifications
- **Markov Chains**
  - N-step transition matrices 30%
  - Classification of States
    - Irreducible chains
    - Recurrence and Transience
    - Periodicity and Ergodicity
    - Canonical Forms of Transition Matrices
  - Finite Chains with Transient States
    - Fundamental Matrix
    - Mean/Variance Recurrence Times
    - First Passage Times
  - Irreducible Chains with Ergodic States
    - Transient Behavior
    - Limiting Behavior
    - First Passage Times with Difference Equations
    - Sojourn Times
- **Branching Processes and Special Topics** 10%
  - Branching
    - Mean and Variance of Generation Sizes
    - Probability of Ultimate Extinction
  - Higher Order Chains
  - Lumpable Chains
  - Time Reversibility
- **Statistical Inference for Markov Chains** 10%
  - Estimation of Transition Matrix Elements
  - Hypothesis Testing Issues for Markov Chains
- **Simple Markov Processes** 25%
  - The Poisson Process
    - Tie to Exponential Distribution
    - Tie to Uniform Distribution
  - Pure Birth Processes
  - Pure Death Processes
  - Simple Birth and Death Processes
    - Introduction to Queueing Terminology: M/M/1
  - Limiting Behavior of Markov Processes
  - Markovian Networks

- **Statistical Inference for Simple Markov Processes** 5%
  - Estimation: Poisson Processes and Birth and Death Process Parameters
  - Testing for Poisson Processes and Birth and Death Process
  - Statistical Inference for Queues
- **Additional Queueing Processes** 10%
  - Markovian Queues: M/M/1, M/G/1, M/M/1/K, M/M/∞
  - Other Models: Erlang distribution queues, G/G/1 models
  - Batch Arrivals and/or Service
- **Renewal Theory** 5%
  - Renewal Function and Density
  - Limiting Behavior
  - Recurrence Times (Backward and Forward)
  - Statistical Inference for Renewal Processes

Student Learning Outcomes (SLO): At the end of STA 523, a student who has studied and learned the material should be able to:

1. Classify the states of a Markov chain. [PLO: 2]
2. Compute the mean and variance of the recurrence times for Markov chains. [PLO: 1, 2]
3. List physical scenarios in nature in which a Markov chain would provide a good probability model. [PLO: 2, 5]
4. Investigate long-run limiting behavior of states in Markov chains and interpret their meanings. [PLO: 2, 3]
5. Compute the summary measures of branching processes and investigate the long-run survival or death of the branching. [PLO: 2]
6. Model physical systems using the Poisson process. [PLO: 2, 4]
7. Explain the connection between Birth and Death processes and queueing models. [PLO: 2, 4]
8. Model physical systems using a Birth and Death process. [PLO: 2, 4]
9. Discriminate between popular queueing models and calculate/analyze queueing characteristics of each of these popular models. [PLO: 1, 2, 4]
10. Recognize when a renewal process will provide an adequate model to a process which exists in nature. [PLO: 2, 4]
11. Perform statistical inference techniques on Markov chains, branching processes, selected Markov processes, queues and continuous time renewal processes. [PLO: 1, 2, 4]

Program Learning Outcomes (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)
3. Skill in using statistical software in order to process and interpret data. **[*Data Processing*]** (Computational Skills and Model Validation)
4. The ability to independently apply principles of probability and statistics to model and solve new or non-standard problems. **[*Independent Thinking and Application*]** (Existing Literature Comprehension, Independent Progression, Resourcefulness)
5. Proficiency in communicating probability and statistics in a format appropriate to expected audiences. **[*Communication*]** (Written Communication, Oral Communication)