



## COURSE SYLLABUS

Course: Probability Theory

Number: MAT 4180

Credit-Hours: 4 Credits

**Course Description:** An introduction to Calculus-based Probability theory and statistics. Topics include distributions, Monte-Carlo methods, probabilities, Markov's Inequality, Chebyshev Theorem; discrete and continuous random variables, Central Limit Theorem.

**Prerequisite:** MAT 3280 (Multivariable Calculus or equivalent) (may be taken concurrently)

Detailed Syllabus:

### 0. Getting Started

1. Email and Chat
2. Learning About the Course
3. Software Fundamentals

### 1. Simulations

- a. Uniform Distributions
- b. Monte Carlo Methods
- c. Random Walks
- d. Shooting craps; Iterated Fractals.

### 2. Data Analysis

- a. Frequency
- b. Expected Value
- c. Cumulative Distributions
- d. Variance
- e. Histograms
- f. Related formulas for Expected Values and Variance

### 3. Probabilities

- a. Calculating Probability
- b. Union and Intersection and Probability
- c. Conditional Probability Formula
- d. Independence
- e. Indicator functions

4. More Data Analysis
  - a. Markov's Inequality
  - b. Chebyshev's Theorem
  - c. Laws of Large Numbers
  - d. One-Sided Chebyshev Theorem
  
5. Normal and Exponential Distributions
  - a. Approximately Normally Distributed Sets
  - b. Normal Distribution
  - c. Approximately Exponentially Distributed Sets
  - d. Exponential Distribution
  - e. Memoryless Property of Exponential Distributions
  
6. Random Variables
  - a. "Random Variables"
  - b. Discrete Random Variables
  - c. Continuous Random Variables
  - d. Probability Density Functions
  - e. Cumulative Distribution Functions
  - f. Expected Values and Variance
  - g. Markov, Chebyshev, and Law of Large Numbers Revisited
  - h. Mean, Median, and Mode
  
7. Joint Distributions
  - a. Joint Probability Calculations
  - b. Discrete & Continuous
  - c. Expected Values, Covariance, and Correlation.
  - d. Conditional Probability Calculations
  - e. Conditional Expectations
  - f. The Law of Total Probability
  
8. Central Limit Theorem
  - a. Generating Functions for Discrete Random Variables
  - b. Generating Functions for Continuous Random Variables
  - c. Generating Functions and Independence
  - d. Central Limit Theorem
  - e. Fourier Transforms
  - f. Chi-squared and Gamma random variables

Additional Optional Modules:

9. Counting
  - a. Binomial and Poisson counting
  - b. Binomial and Poisson Distributions
  
10. Statistics
  - a. Sampling
  - b. Confidence Intervals
  - c. Hypothesis testing