



## 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