Computational and Applied Mathematics 3307 – Probability & Statistics

Student Learning Outcomes

1. **Students will demonstrate factual knowledge of the mathematical notation and terminology used in this course.** Students will demonstrate the ability to read, interpret, and use the vocabulary, symbolism, and basic definitions of probability theory, including permutations and combinations, sample space, event, conditional probability, discrete and continuous random variables, expected value, mean, variance, probability density functions and distribution functions.

2. **Students will be able to describe the fundamental principles, laws, and theorems arising from the basic definitions of probability theory.** Students will be able to identify and use the postulates of probability, the basic properties of random variables, and laws and formulas that result from them, such as Bayes' Theorem, Chebyshev's Theorem, independence, mean and variance of linear combinations of random variables, and the Central Limit Theorem.

3. **Students will apply course material along with techniques and procedures covered in this course to solve problems.** Students will use the facts, formulas, and techniques learned in this course to solve problems involving elementary counting processes and ones related to special probability distributions, such as the binomial, hypergeometric, Poisson, exponential, and normal distributions.

4. **Students will develop specific skills, competencies, and thought processes sufficient to support further study or work in this field or related fields.** Students will acquire a level of proficiency in the fundamental concepts and applications necessary for further study in academic areas requiring a background in probability theory. These fields might include business, the social sciences, and the physical sciences and engineering, as well as mathematics.

Course Content

Textbook: *Fundamentals of Probability*, Third Edition, by Ghahramani. The following sections are covered.

Ch. 1, Axioms of Probability: Introduction, Sample Spaces and Events, Axioms of Probability, Basic Theorems, Probabilities 0 and 1, Random Selection of Points from Intervals.

Ch. 2. Combinatorial Methods: Introduction, Counting Principle, Permutations, Combinations.

Ch. 3, Conditional Probability and Independence: Conditional Probability, Law of Multiplication, Law of Total Probability, Bayes' Formula, Independence.

Ch. 4, Distribution Functions and Discrete Random Variables: Random Variables, Distribution Functions, Discrete Random Variables, Expectations of Discrete Random Variables, Variances and Moments of Discrete Random Variables, Standardized Random Variables.

Ch. 5, Special Discrete Random Variables: Bernoulli and Binomial Random Variables, Poisson Random Variable, Geometric Random Variable, Hypergeometric Random Variable.

Ch. 6, Continuous Random Variables: Probability Density Functions, Density Function of a Random Variable, Expectations and Variances.

Ch. 7, Special Continuous Random Variables: Uniform Random Variable, Normal Random Variable, Exponential R.V..

Ch. 8, Bivariate Distributions: Joint Distribution of Two Random Variables, Independent Random Variables.

Ch. 10, More Expectations and Variances: Expected Values of Sums of Random Variables, Covariance, Correlation.

Ch. 11, Sums of Independent Random Variables and Limit Theorems: Moment-Generating Functions, Sums of Independent Random Variables, Central Limit Theorem.

Optional Sections (one or more of these sections may be included as time permits)
Ch.1 – Continuity of Probability Function, Ch.2 – Stirling's Formula; Ch.5 – Negative Binomial Distribution; Ch.7 – Gamma Distribution, Beta Distribution; Ch.8 – Conditional Distributions, Transformations of Two Random Variables; Ch. 9 – Multinomial Distributions, Ch.10 – Conditioning on Random Variables, Bivariate Normal Distribution. Ch.11 –Markov and Chebyshev Inequalities, Laws of Large Numbers.