STAT-STATISTICS

STAT 3110. Statistics for Engineers and Scientists
3 Credits (3)
Modern probability and statistics with applications to the engineering sciences.
Prerequisite: C - or better in MATH 1521G or MATH 1521H.
Learning Outcomes
1. Apply probability concepts and statistical methods to analyze data relevant to engineering and scientific problems.
2. Interpret descriptive statistics, probability distributions, and inferential techniques in context-specific applications.
3. Construct confidence intervals and perform hypothesis tests to support decision-making in engineering contexts.
4. Use statistical software and tools to model, visualize, and communicate results from experimental and observational data.

STAT 4210. Probability: Theory and Applications
3 Credits (3)
Basic probability distributions including binomial, normal; random variables, expectation; laws of large numbers; central limit theorem.
Prerequisite(s): C- or better in MATH 2530G and C- or better in at least one-3000 level MATH or STAT course.
Learning Outcomes
1. Be able to compute discrete probabilities using combinatorial methods.
2. Understand and use conditional probability, independence and Bayes' Formula to compute probabilities.
3. Demonstrate understanding and use of discrete and continuous random variables including Bernoulli, Binomial, Poisson, Geometric, Normal, Exponential and Gamma.
4. Understand joint and conditional probability distributions and use them to compute probabilities.
5. Learn about basic limit theorems such as the Central Limit Theorem and the Laws of Large Numbers.

STAT 4220. Statistics: Theory and Applications
3 Credits (3)
Point and interval estimation; sufficiency; hypothesis testing; regression; analysis of variance; chi-square tests.
Prerequisite: C- or better in STAT 4210.
Learning Outcomes
1. Explain and apply the principles of point and interval estimation, including properties such as unbiasedness and consistency.
2. Analyze statistical models using concepts of sufficiency and likelihood to support inference procedures.
3. Conduct and interpret hypothesis tests, including those based on regression, ANOVA, and chi-square methods.
4. Evaluate the appropriateness of statistical techniques for real-world data and communicate results effectively in applied contexts.

STAT 5210. Probability: Theory and Applications
3 Credits (3)
Same as STAT 4210 with additional work for graduate students.
Learning Outcomes
1. Be able to compute discrete probabilities using combinatorial methods.
2. Understand and use conditional probability, independence and Bayes' Formula to compute probabilities.
3. Demonstrate understanding and use of discrete and continuous random variables including Bernoulli, Binomial, Poisson, Geometric, Normal, Exponential and Gamma.
4. Understand joint and conditional probability distributions and use them to compute probabilities.
5. Learn about basic limit theorems such as the Central Limit Theorem and the Laws of Large Numbers.

STAT 5220. Statistics: Theory and Applications
3 Credits (3)
Same as STAT 4220 with additional work for graduate students.
Learning Outcomes
1. Explain and apply the principles of point and interval estimation, including properties such as unbiasedness and consistency.
2. Analyze statistical models using concepts of sufficiency and likelihood to support inference procedures.
3. Conduct and interpret hypothesis tests, including those based on regression, ANOVA, and chi-square methods.
4. Evaluate the appropriateness of statistical techniques for real-world data and communicate results effectively in applied contexts.

STAT 5230. Elementary Stochastic Processes
3 Credits (3)
Markov chains, Poisson processes, Brownian motion, branching processes, and queuing processes, with applications to the physical, biological, and social sciences.
Prerequisite: STAT 5210 or consent of instructor.
Learning Outcomes
1. Apply conditional expectation and generating functions to analyze simple stochastic processes.
2. Describe and distinguish among key stochastic processes (Markov chains, Poisson processes).
3. Apply stochastic models to evaluate problems in the physical, biological, and social sciences.
4. Evaluate the long-term behavior of stochastic processes using transition probabilities and limiting distributions.
5. Analyze the Brownian motion process and its fundamental properties.

STAT 5310. Foundations of Probability
3 Credits (3)
Probability spaces, expectation and conditional expectation, limit theorems and laws of large numbers.
Prerequisite: MATH 5460.
Learning Outcomes
1. Define an abstract probability space via measure theory, regarding expectation as abstract integration and study its properties such as linearity and monotonicity.
2. Study the convergence of random variables and Weak and Strong Laws of Large Numbers.
3. Compare and employ almost sure convergence, convergence in probability, convergence in Lp, and convergence in distribution to analyze the behavior of sequences of random variables.
4. Define the weak convergence of probability measures, apply it to characterize the weak convergence on the set of real numbers, and study Central Limit Theorems.
5. Introduce the concept of stochastic process, define martingales and study the martin-gale convergence theorems.

STAT 5320. Advanced Topics in Stochastic Processes
3 Credits (3)

Markov processes, martingales, Brownian motion, the Ito calculus, stochastic differential equations.
Prerequisite: STAT 5310.
Learning Outcomes
1. Analyze the structure and behavior of continuous-time Markov processes and martingales.
2. Derive the fundamental properties of Brownian motion and explain its role in stochastic modeling.
3. Apply Ito calculus to solve stochastic differential equations in theoretical contexts.
4. Formulate stochastic differential equations from applied problems.
5. Explain and apply the Feynman-Kac formula, the martingale problem, and the Girsanov formula.
6. Evaluate stochastic models arising in various disciplines.
7. Interpret the solutions of stochastic models using advanced probability theory.

STAT 5330. Continuous Multivariate Analysis
3 Credits (3)
Theory and applications of the multivariate normal distribution.
Prerequisite: STAT 5220, or consent of instructor.
Learning Outcomes
1. Explain the theoretical foundations and properties of the multivariate normal distribution.
2. Apply principal component analysis and linear discriminant analysis to solve multivariate problems.
3. Evaluate the structure and relationships among multiple continuous variables using matrix-based statistical methods.
4. Interpret results from multivariate analyses in real-world applications.
5. Communicate findings from multivariate analyses clearly in a written report.

STAT 5335. Linear Models
3 Credits (3)
Core topics include distribution of quadratic forms, theory of regression, analysis of variance and covariance in linear models. Advanced topics chosen from random and mixed linear models, generalized linear, growth curve, and nonlinear models, quartile and copula regression. May be repeated up to 6 credits.
Prerequisite: STAT 5330.
Learning Outcomes
1. Analyze linear models using the distribution of quadratic forms and the theory of least squares estimation.
2. Apply regression, ANOVA, and ANCOVA models to determine relationships among variables.
3. Evaluate the assumptions and limitations of linear modeling frameworks (random and mixed effects models).
4. Explain the theory behind generalized linear models, nonlinear models, and quantile regression.
5. Assess the applicability of advanced modeling techniques to complex data sets.

STAT 5340. Advanced Theory of Statistics I
3 Credits (3)
Testing hypotheses, probability and sufficiency, uniformly most powerful tests, unbiasedness, invariance, and minimax principle.
Prerequisite: STAT 5220 or consent of instructor.
Learning Outcomes
1. Explain foundational concepts in statistical inference (hypothesis testing, sufficiency).
2. Construct statistical tests using criteria such as unbiasedness and invariance.
3. Analyze the properties of statistical tests using the minimax principle.
4. Apply the Neyman-Pearson lemma to derive uniformly most powerful (UMP) tests.
5. Evaluate the theoretical properties of statistical procedures.
6. Justify the use of statistical procedures in complex inference problems based on theoretical properties.

STAT 5345. Advanced Theory of Statistics II
3 Credits (3)
Estimation of parameters; unbiased estimators; equivariance; Bayes properties; large sample theory and optimality.
Prerequisite: STAT 5340 or consent of instructor.
Learning Outcomes
1. Analyze methods for estimating parameters and their properties (unbiased, consistent, efficient).
2. Apply the principles of equivariance to construct and evaluate estimators.
3. Construct and evaluate Bayes estimators in various contexts.
4. Evaluate estimators using large sample theory and asymptotic optimality criteria.
5. Compare classical and Bayesian approaches to estimation.
6. Justify the selection of estimation methods based on theoretical and practical considerations.

STAT 5348. Topics in Probability and Statistics
3 Credits
Topics in modern probability and statistics. The material covered will reflect current research topics in the field and may vary each time the course is offered. To be taken up to 3 times. May be repeated up to 9 credits.
Learning Outcomes
1. Gain knowledge of advanced methods in the areas of probability and statistics.
2. Develop potential to explore literature in the areas of of probability and statistics.
3. Develop potential to conduct supervised research in the areas of of probability and statistics.