Department of Mathematics and Statistics

2300 Engineering and Computational Sciences Building
Norfolk, VA 23529
757-683-3882
http://www.odu.edu/math (http://www.odu.edu/math/)

Gordon Melrose, Chair
Ruhai Zhou, Graduate Program Director
N. Rao Chaganty, Statistics Program Director

Graduate Study in Computational and Applied Mathematics

The master's and doctoral programs in computational and applied mathematics offered by the Department of Mathematics and Statistics are designed to produce applied mathematicians and statisticians who can meet the growing demand for analytical and computational skills in traditional scientific and multi-disciplinary fields. Students in the program can choose to pursue an option in either applied mathematics, mathematics of data science, statistics, or biostatistics.

Applied mathematics is the application of mathematics to the solution of non-mathematical problems. Such problems may originate in math-oriented fields (physics, chemistry, and engineering) as well as in such areas such as geology, oceanography, meteorology, biology, ecology, environmental health, economics, actuarial science, business (operations and market research), banking, and medicine. Students will learn to use methods of applied mathematics, machine learning, data analysis, probability, statistics, biostatistics, numerical analysis, and scientific computing in seeking solutions to such problems. For work in computational and applied mathematics, training in an additional field of application is a necessity.

The desire and ability to use mathematics to bring together various disciplines is the unique characteristic of an applied mathematician. Not only has mathematical modeling and solving of societal and scientific problems increased the demand for applied mathematicians, but the flexibility and breadth of knowledge inherent in this discipline make it attractive for those who do not want to become irreversibly specialized.

Old Dominion University is one of the few American institutions offering a program expressly in applied mathematics. There are approximately 26 graduate program faculty members in the Department of Mathematics and Statistics, and current enrollment in the program is about 50 students. Areas of faculty research include analytical and numerical modeling in oceanography and meteorology, computational fluid dynamics and stability theory, elasticity and fracture mechanics, combustion theory, magnetohydrodynamics, mathematical biology, numerical analysis and approximation, optimization, applied probability, statistical inference, reliability, multivariate statistics, generalized linear models, estimating equations, biostatistics, nonparametric statistics, bioinformatics, machine learning, data science and high performance computing.

Facilities within the metropolitan area include the NASA/Langley Research Center, the Virginia Modeling, Analysis and Simulation Center (VMASC), and the Eastern Virginia Medical School.

Program Financial Aid. The Department of Mathematics and Statistics offer graduate assistantships with stipends awarded to students after a competitive review process. The level of award is determined on the basis of previous experience and performance as a graduate assistant and on the student's academic achievement and potential in applied mathematics or statistics. In addition, a number of teaching and research positions are available for financial support of graduate assistants during the summer months (June and July).

Writing Proficiency. All students in the graduate program are expected to demonstrate an acceptable level of writing ability. Students needing help to remedy their writing deficiencies will be referred to the Writing Center for diagnosis and assistance. All M.S. candidates will enroll in one of the MATH 632, STAT 632, and BDA 632 for a master's project.

Programs

Doctor of Philosophy Programs

- Computational and Applied Mathematics with a Concentration in Applied Mathematics (PhD) (http://catalog.odu.edu/graduate/sciences/mathematics-statistics/computational-applied-mathematics-applied-mathematics-phd/)
- Computational and Applied Mathematics with a Concentration in Biostatistics (PhD) (http://catalog.odu.edu/graduate/sciences/mathematics-statistics/computational-applied-mathematics-biostatistics-phd/)
- Computational and Applied Mathematics with a Concentration in Mathematics of Data Science (PhD) (http://catalog.odu.edu/graduate/sciences/mathematics-statistics/computational-applied-mathematics-data-science-phd/)
- Computational and Applied Mathematics with a Concentration in Statistics (PhD) (http://catalog.odu.edu/graduate/sciences/mathematics-statistics/computational-applied-mathematics-statistics-phd/)

Master of Science Programs

- Computational and Applied Mathematics with a Concentration in Applied Mathematics (MS) (http://catalog.odu.edu/graduate/sciences/mathematics-statistics/computational-applied-mathematics-applied-mathematics-ms/)
- Computational and Applied Mathematics with a Concentration in Biostatistics (MS) (http://catalog.odu.edu/graduate/sciences/mathematics-statistics/computational-applied-mathematics-biostatistics-ms/)
- Computational and Applied Mathematics with a Concentration in Mathematics of Data Science (MS) (http://catalog.odu.edu/graduate/sciences/mathematics-statistics/computational-applied-mathematics-data-science-ms/)
- Computational and Applied Mathematics with a Concentration in Statistics (MS) (http://catalog.odu.edu/graduate/sciences/mathematics-statistics/computational-applied-mathematics-statistics-ms/)

Courses

Big Data Analytics (BDA)

BDA 501 Programming Languages for Data Science (3 Credit Hours)
An introductory course on programming languages and tools which are relevant to data analytics. Each language or tool is introduced as a separate module and incorporates applications in mathematics and statistics. Examples of included programming languages and tools are MATLAB, Python, R and SAS. Additional languages and tools may be covered based on current trends in data analytics. Students will complete hands-on programming assignments throughout the course.
Prerequisites: MATH 312, MATH 316 and STAT 330 or STAT 331

BDA 511 Introduction to Machine Learning (3 Credit Hours)
An introductory course on machine learning. Machine Learning is the science of discovering pattern and structure and making predictions in data sets. It lies at the interface of mathematics, statistics and computer science. The course gives an elementary summary of modern machine learning tools. Topics include regression, classification, regularization, resampling methods, and unsupervised learning. Students enrolled are expected to have some ability to write computer programs, some knowledge of probability, statistics and linear algebra.
Prerequisites: MATH 312, MATH 316, and STAT 330 or STAT 331

BDA 531 Modern Statistical Methods for Big Data Analytics (3 Credit Hours)
The statistical perspective of data mining is emphasized for majority of the course. Both applied aspects (programming, problem solving, and data analysis) and theoretical concepts (learning, understanding, and evaluating methodologies) of data mining will be covered. Topics include Regularization and Kernel Smoothing Methods, Tree-based Methods, Neural Networks and optional topics such as deep learning.
Prerequisites: BDA 511 and STAT 505 or permission of the instructor

BDA 532 Introduction to Optimization in Data Science (3 Credit Hours)
Topics considered include the solution of non-smooth optimization problems arising in data science, including unconstrained and constrained optimization problems, Lagrange multiplier methods, inequality constraints, Kuhn-Tucker conditions, and applications. Also considered are linear and nonlinear inverse problems, regularization of ill-posed problem including singular value decomposition, and Tikhonov regularization methods and sparse regularization methods, inverse eigenvalue problems and applications such as compressed sensing, image reconstruction and machine learning.
Prerequisites: MATH 307, MATH 312 and MATH 316

BDA 611 Mathematical Foundations of Machine Learning (3 Credit Hours)
This course will introduce mathematical foundations of machine learning theory and algorithms. Topics include statistical learning theory, kernel methods and generative models. Some modern machine learning methods such as dictionary learning, deep learning, online learning, and reinforcement learning may also be included, time permitting. Students enrolled are expected to have some knowledge of probability, linear algebra, optimization, and analysis.
Prerequisites: BDA 511, MATH 518 and STAT 330 or 331

BDA 620 Large-Scale Optimization (3 Credit Hours)
This course will introduce optimization methods for large-scale problems by exploiting special structures including convexity and sparsity. Topics include introduction to convexity, gradient-related methods, dual methods, sparse optimization methods and nonconvex optimization methods. Students enrolled are expected to have some knowledge of linear algebra, optimization, probability, and analysis.
Prerequisites: MATH 518 and STAT 330 or 331

BDA 632 Computational Data Analytics Project (3 Credit Hours)
Under the guidance of a faculty member in the Department of Mathematics and Statistics, the student will undertake a significant computational data analysis problem. A written report and/or public presentation of results will be required.
Prerequisites: Permission of graduate program director

BDA 640 Genomic Data Science (3 Credit Hours)
Introductory discussion on central dogma of molecular biology, concepts of transcription, translation, gene regulation, and the need for high throughput methods. Other topics covered are Introduction to R and Bioconductor, Advanced microarray data analysis, NGS data analysis using edgeR in Bioconductor, Network Biology, sequence, pathway informatics, SNPs, GWAS, informatics for genome variants.
Prerequisites: BDA 511, BDA 531, and STAT 505 or permission of the instructor

BDA 721 High-Dimensional Statistics (3 Credit Hours)
Techniques for obtaining basic tail bounds and concentration inequalities, uniform laws of large numbers, Rademacher complexity of a set, covering and packing in metric spaces, and metric entropy. Also, high dimensional random matrices described in a non-asymptotic framework, with a focus on the estimation of sparse and structured covariance matrix, are studied. The sparse linear regression models and the principal component analysis in the unstructured and sparse setting will be covered.
Pre- or corequisite: STAT 727, STAT 728, MATH 616, and MATH 618

BDA 731 Applied Functional Data Analysis (3 Credit Hours)
An introduction to the statistical analysis of sample curves or functions. Topics include smoothing, registration, functional principal component analysis, scalar-on-function regression, and functional response models. All these techniques will be applied using the statistical software R.
Prerequisites: STAT 725 or STAT 825

BDA 745 Transform Methods for Data Science (3 Credit Hours)
Various transform methods from the data domain to coefficients of the data in certain discrete bases are studied. Transforms studied include FFT, DCT, wavelet transforms and framelet transform. Both theory and applications of these transforms are covered.
Prerequisites: MATH 518 and MATH 616

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Prerequisites: MATH 518 and MATH 616

Mathematical Sciences (MATH)

MATH 500 History of Mathematics (3 Credit Hours)
Seminal ideas in geometry, arithmetic, algebra, analysis and applied mathematics (along with their mathematical representations) from antiquity, the age of exploration, the Promethean age to the present day.
Prerequisites: MATH 311W or MATH 316 or MATH 317

MATH 501 Partial Differential Equations (3 Credit Hours)
Not available to students with credit in MATH 691. Separation of variable techniques, Sturm-Liouville systems, generalized Fourier series, orthogonal functions of the trigonometric, Legendre and Bessel type boundary value problems associated with the wave equation and the heat conduction equation in various coordinate systems, applications to physics and engineering.
Prerequisites: A grade of C or better in MATH 307 and MATH 312

MATH 504 Fundamental Concepts of Geometry (3 Credit Hours)
Fundamentals of Euclidean and non-Euclidean geometry. Alternatives to Euclidean geometry are examined using a variety of mathematical techniques. Special topics such as 'Taxicab' geometry, the hyperbolic plane, the art of M.C. Escher, and the mathematics of maps may be included.
Prerequisites: MATH 311W

MATH 506 Number Theory and Discrete Mathematics (3 Credit Hours)
A survey course. Topics include the prime number theorem, congruences, Diophantine equations, continued fractions, quadratic reciprocity, combinatorics, logic, graphs, trees, algorithms, coding and linear programming.
Prerequisites: A grade of C or better in MATH 311W and MATH 316

MATH 508 Applied Numerical Methods I (3 Credit Hours)
An introduction to the numerical methods commonly used by scientists and engineers. Topics include solutions of equations of one variable, direct methods for solving linear systems, matrix factorization, stability analysis, iterative techniques, polynomial interpolation, numerical differentiation and integration, approximation theory, and initial and boundary value problems for ordinary differential equations.
Prerequisites: A grade of C or better in MATH 316; CS 150 or equivalent programming ability are also required

MATH 509 Applied Numerical Methods II (3 Credit Hours)
Topics include least squares problems, the QR factorization, the conjugate gradient method, Householder transformation and the QR method for approximating eigenvalues and singular values of a matrix. For applications, the finite difference method and the finite element method for solving partial differential equations, trigonometric interpolation and FFT as well as introductory study of optimization are discussed.
Prerequisites: A grade of C or better in MATH 508

MATH 517 Intermediate Real Analysis I (3 Credit Hours)
A rigorous course in classical real analysis. Topics include the topology of Euclidean n-space, properties of vector valued functions of several variables such as limits, continuity, differentiability and integrability, pointwise and uniform convergence of sequences and series of functions; Fourier series.
Prerequisites: A grade of C or better in MATH 317

MATH 518 Intermediate Real Analysis II (3 Credit Hours)
A rigorous course in classical real analysis. Topics include the topology of Euclidean n-space, properties of vector valued functions of several variables such as limits, continuity, differentiability and integrability, pointwise and uniform convergence of sequences and series of functions; Fourier series.
Prerequisites: A grade of C or better in MATH 517

MATH 520 Applied Mathematics I: Biomathematics (3 Credit Hours)
Exploring mathematical models in various biological contexts using both difference and differential equations: single and multiple species population growth, predator-prey and competing species (using phase plane analysis), epidemiological models of epidemics and pandemics, tumor growth, pattern formation in animals and insects.
Prerequisites: A grade of C or better in MATH 307

MATH 521 Applied Mathematics II: Mathematical Modeling (3 Credit Hours)
The philosophy and methodology of mathematical modeling, its successes and limitations. Models of climate change, atmospheric and ocean dynamics, models in other physical and biological contexts, and introduction to deterministic chaos.
Prerequisites: A grade of C or better in MATH 307, MATH 312, MATH 316 and MATH 317

MATH 522 Applied Complex Variables (3 Credit Hours)
Not available to students with credit in MATH 692. Topics include complex numbers, analytical functions and their properties, derivatives, integrals, series representations, residues and conformal mappings. Applications of the calculus of residues and mapping techniques to the solution of boundary value problems in physics and engineering.
Prerequisites: A grade of C or better in MATH 312

MATH 527 Applied Mathematics III: Elasticity (3 Credit Hours)
An introduction to the mathematical theory of linear and non-linear elastic continua. Topics include vectors, tensors, deformation, stress, nonlinear constitutive theory, exact solutions, infinitesimal theory, antiplane strain, plane strain, plane stress, extension, torsion, bending and elastic wave propagation.
Prerequisites: A grade of C or better in MATH 307 and MATH 312

MATH 528 Applied Mathematics IV: Fluid Mechanics (3 Credit Hours)
A mathematical investigation of the differential equations governing fluid flow with an emphasis on steady state incompressible flows. The Navier-Stokes equations are derived and some exact solutions are presented including the potential flow solutions. Topics therefore include classical ideal fluid flow and its complex variable representation, various approximations to the Navier-Stokes equations, boundary layer theory, and also surface and internal gravity wave motion, aspects of hydrodynamic stability theory and convection. Other topics may be introduced by the instructor.
Corequisites: MATH 501

MATH 557 Mathematics in Nature (3 Credit Hours)
A calculus and differential equations based description of many patterns observable in the natural world including wave motion in the air, oceans, rivers, and puddles; rainbows, halos and other meteorological phenomena; arrangement of leaves, petals and branches; height of trees; river meanders; animal and insect markings; mudcracks; spider webs; and others. Partial differential equations will be discussed as needed but a knowledge of ordinary differential equations will be assumed.
Prerequisites: A grade of C or better in MATH 307

MATH 596 Topics in Mathematics (1-3 Credit Hours)
Study of selected topics.
Prerequisites: permission of the instructor

MATH 598 Tutorial Work in Special Topics in Mathematics (1-3 Credit Hours)
Independent study under the direction of an instructor including library research and reports.
Prerequisites: permission of the instructor

MATH 605 Complex Variables I (3 Credit Hours)
An advanced course in complex analysis.
Prerequisites: MATH 501, MATH 518 and MATH 522

MATH 615 Advanced Calculus for Teachers (3 Credit Hours)
An introduction to real analysis. Topics include the field and order axioms, completeness of the real line, theory of sequences, limits of function, continuity, differentiablility, sequences and series of functions, uniform convergence.
Prerequisites: MATH 212

MATH 616 Computational Linear Algebra (3 Credit Hours)
Topics include singular value decomposition, sparse systems, Krylov subspace methods, large sparse eigenvalue problems and iterative methods. This course also covers applications of computational linear algebra in the areas of image compression, data processing and principal component analysis.
Prerequisites: MATH 312, MATH 316 and MATH 508

MATH 617 Measure and Integration (3 Credit Hours)
An introduction to measure theory and integration theory with special emphasis on Lebesgue measure and the Lebesgue integral including Fatou's Lemma, the Monotone Convergence Theorem and the Dominated Convergence Theorem.
Prerequisites: MATH 518

MATH 618 Applied Functional Analysis (3 Credit Hours)
Topics include orthogonal projections to subspaces, duality, the Hahn-Banach theorem and the Banach-Steinhaus theorem, L-2 spaces and convolution operators, fixed point theory, construction of Hilbert spaces, approximation procedures in Hilbert spaces, and spectral theory.
Prerequisites: MATH 617

MATH 620 Optimization Techniques (3 Credit Hours)
Theory and computational algorithms for the optimization of constrained linear and nonlinear systems or for locating the maximum of a constrained nonlinear function. Applications to problems in economics, operations research and systems theory.
Prerequisites: MATH 312 and MATH 316

MATH 622 Numerical Solutions to Differential Equations (3 Credit Hours)
An in-depth study of the numerical solution to ordinary and partial differential equations. Topics include linear multi-step methods, Runge-Kutta methods, stiff differential equations, collocation methods, and strong and weak stability analysis for ODEs. For PDEs, finite difference methods are examined.
Prerequisites: MATH 509

MATH 632 Master's Project (3 Credit Hours)
Under the guidance of a faculty member in the Department of Mathematics and Statistics, the student will undertake a significant data analysis problem in a scientific setting outside the department. A written report and/or public presentation of results will be required.
Prerequisites: permission of graduate program director

MATH 637 Tensor Calculus and Differential Geometry (3 Credit Hours)
Topics include metric spaces, bilinear and quadratic forms, tensors, point manifolds, theory of curves, geodesic differentiation, theory of surfaces, curvature of general manifolds, integrability.
Prerequisites: MATH 517

MATH 638 Mathematical Theories of Continua (3 Credit Hours)
Topics include deformation, motion, stress, conservation laws, and constitutive theories.
Prerequisites: MATH 501 and MATH 637

MATH 691 Engineering Analysis I (3 Credit Hours)
Not available to students with credit in MATH 501. Separation of variable techniques, Sturm-Liouville systems, generalized Fourier series, orthogonal functions of the trigonometric, Legendre and Bessel type, boundary value problems associated with the wave equation and the heat conduction equation in various coordinate systems, applications to physics and engineering.

MATH 692 Engineering Analysis II (3 Credit Hours)
Not available to students with credit in MATH 522. Topics include complex numbers, analytical functions and their properties, derivatives, integrals, series representations, residues and conformal mappings. Applications of the calculus of residues and mapping techniques to the solution of boundary value problems in physics and engineering.
Prerequisites: MATH 312

MATH 693 Engineering Analysis III (3 Credit Hours)
Advanced topics in the theory and application of ordinary differential equations, distributions, Green's functions, classification of partial differential equations, initial-value problems, eigenfunction expansions for boundary-value problems, selected special functions, singular perturbation theory for differential equations.
Prerequisites: MATH 501 or MATH 691

MATH 695 Seminar in Mathematics (1-3 Credit Hours)
Seminar in advanced topics.
Prerequisites: permission of the instructor

MATH 696 Topics in Mathematics (1-3 Credit Hours)
Advanced study of selected topics.
Prerequisites: permission of the instructor

MATH 697 Topics in Mathematics (1-3 Credit Hours)
Advanced study of selected topics.

MATH 698 Research (3 Credit Hours)

MATH 699 Thesis (3 Credit Hours)

MATH 702 Integral Equations (3 Credit Hours)
Advanced material in theory and application of integral equations. Formulation of the integral equation problems, cause and effect, connection with differential equations, scattering theory, boundary values of partial differential equations, Fredholm and Volterra theory, expansions in orthogonal functions, theory of Hilbert-Schmidt singular integral equations, method of Wiener-Hopf, monotone operator theory, and direct methods.
Prerequisites: MATH 618 and MATH 693

MATH 720 Advanced Applied Functional Analysis (3 Credit Hours)
In the first half of this course, several concepts in the classical functional analysis are studied. Topics include Banach Spaces, the dual spaces, the Baire category theorem, the adjoint operator, weak convergence, spectral theory and compact operators. In the second half, at the instructor's discretion, special topics are studied. Possible topics include ill-posed problems, inverse scattering theory, the regular Sturm-Liouville problem and the Dirichlet problem for Laplace's equation.
Prerequisites: MATH 617 and MATH 618

MATH 721 Advanced Applied Numerical Methods I (3 Credit Hours)
Numerical solutions of partial differential equations and integral equations. For PDEs, the finite difference method, the finite element method and the boundary element method are studied. A priori and a posteriori error estimates are examined. For integral equations, topics include Galerkin methods, collocation methods, and the Petrov-Galerkin method.
Prerequisites: MATH 501, MATH 508 and MATH 509

MATH 722 Advanced Applied Numerical Methods II (3 Credit Hours)
Numerical solutions of partial differential equations and integral equations. For PDEs, the finite difference method, the finite element method and the boundary element method are studied. A priori and a posteriori error estimates are examined. For integral equations, topics include Galerkin methods, collocation methods, and the Petrov-Galerkin method.
Prerequisites: MATH 501, MATH 508 and MATH 509

MATH 725 Computational Fluid Dynamics (3 Credit Hours)
An introduction to the theory of finite volume methods for scalar and vector conservation laws and the Euler and Navier-Stokes equations. Topics include weak solutions, characteristics, Rankine-Hugoniot conditions, energy and entropy inequalities, Riemann solvers, and numerical methods for compressible and incompressible flows including MUSCL and total variation diminishing (TVD) schemes, essentially non-oscillatory (ENO), weighted ENO, and entropy stable scheme.
Prerequisites: MATH 501 and MATH 508

MATH 726 Discontinuous Galerkin Methods (3 Credit Hours)
An introduction to the theory of nodal discontinuous Galerkin (DG) methods for solving linear and nonlinear conservation law equations. Topics include fundamental properties of conservation laws including their ability to generate non-smooth solutions, thus leading to the notion of weak solutions and entropy inequalities, consistency and stability properties of nodal DG methods as well as their efficient implementation techniques, and application of nodal DG methods for solving both linear and nonlinear equations, such as the advection-diffusion, Burgers, and Navier-Stokes equations.
Prerequisites: MATH 725

MATH 745 Transform Methods (3 Credit Hours)
Use of integral transforms for students of applied mathematics, physics and engineering. Integral transforms studied are Laplace, Fourier, Hankel, finite Z-transforms and other special transforms.
Prerequisites: MATH 691 and MATH 692

MATH 750 Calculus of Variations (3 Credit Hours)
Maximum and minimum techniques in calculus and dynamic programming. Derivation of Euler-Lagrange equations for a variety of conditions, formulation of extremum problems with side conditions for ordinary and partial differential equations. Application to dynamics, elasticity, heat and mass transfer, energy principles and finite element techniques.
Prerequisites: MATH 691 and MATH 692

MATH 755 Introduction to Kinetic Theory and Mesoscopic Methods for Computational Mechanics I (3 Credit Hours)
The goal of this course is to provide an introduction to kinetic theory and nonequilibrium statistical mechanics, which bridges the microscopic theories and the macroscopic continuum theories of flows. Topics include the molecular dynamics of N particles, Hamiltonian equation, Liouville equation, Boltzmann equation, binary collision, linearized collision operator and its eigen theory, the H-theorem and irreversibility, calculation of the transport coefficients.
Prerequisites: MATH 501 or MATH 691 or permission of the instructor

MATH 756 Introduction to Kinetic Theory and Mesoscopic Methods for Computational Mechanics II (3 Credit Hours)
This is the second part of the study of the interaction between kinetic theory and nonequilibrium statistical mechanics. Models of Boltzmann equation and numerical techniques for hydrodynamic equations (Euler and Navier-Stokes equations) and the Boltzmann equation are studied. Topics include Non-normal and moment method, Maxwell's moment method, BGK model equation, gas mixtures and transport phenomena in mixtures, the Wang-Chang-Uhlenbeck equation, Enskog equation for dense gases, the lattice Boltzmann equation for incompressible flows, the gas-kinetic scheme for compressible flows and the Direct Simulation Monte Carlo (DSMC) method.
Prerequisites: MATH 755/MATH 855

MATH 771 Scientific Computing in Applied Mathematics (3 Credit Hours)
Numerical methods for algebraic systems, partial differential equations, integral equations, optimization, Monte Carlo method, and statistics, with emphasis on computational performance using modern programming languages such as Fortran 90 or C/C++ and modern computer architecture. Basic techniques of parallel computing using MPI (Message Passing Interface), openMP, or other distributed/multicore computing platforms. Common tools in scientific computing, such as Unix shell commands, debuggers, version control systems, scientific libraries, graphics and visualization, will also be introduced.
Prerequisites: MATH 501, MATH 508 and MATH 509

MATH 795 Seminar in Mathematics (1-3 Credit Hours)
Seminar in advanced topics.
Prerequisites: permission of the instructor

MATH 796 Topics in Mathematics (1-3 Credit Hours)
Advanced study of selected topics.
Prerequisites: permission of the instructor

MATH 797 Topics in Mathematics (1-3 Credit Hours)
Advanced study of selected topics.
Prerequisites: permission of instrictor

MATH 801 Asymptotic and Perturbation Methods (3 Credit Hours)
Asymptotic and perturbation methods are developed and used to solve linear and nonlinear differential equations. Included are analyses of Duffing's Equation, Van der Pol's Equation, and Mathieu's Equation. Singular perturbation theory and the Method of Matched Asymptotic Expansions are used to solve equations with boundary layer type solutions. Asymptotic expansions of integrals using Laplace's Method, Method of Steepest Descent and Method of Stationary Phase are developed. Applications from all areas of applied mathematics are given.
Prerequisites: MATH 693

MATH 802 Integral Equations (3 Credit Hours)
Advanced material in theory and application of integral equations. Formulation of the integral equation problems cause and effect, connection with differential equations, scattering theory, boundary values of partial differential equations, Fredholm and Volterra theory, expansions in orthogonal functions, theory of Hilbert-Schmidt singular integral equations, method of Wiener-Hopf, monotone operator theory, and direct methods.
Prerequisites: MATH 618 and MATH 693

MATH 803 Advanced Applied Mathematics I (3 Credit Hours)
Advanced techniques of mathematics applied to specific topics of physical interest. Examples could include high activation energy asymptotics applied to combustion, singular integral equations applied to fracture mechanics, or bifurcation theory applied to non-linear phenomena such as transition to turbulence, phase transitions and hydrodynamic stability.
Prerequisites: MATH 702

MATH 804 Advanced Applied Mathematics II (3 Credit Hours)
Advanced techniques of mathematics applied to specific topics of physical interest. Examples could include high activation energy asymptotics applied to combustion, singular integral equations applied to fracture mechanics, or bifurcation theory applied to non-linear phenomena such as transition to turbulence, phase transitions and hydrodynamic stability.
Prerequisites: MATH 702

MATH 817 Mathematical Analysis III (3 Credit Hours)
Topics in mathematical analysis. Measure and integration; classical Banach spaces; operators on linear spaces; Fourier series and integrals.
Prerequisites: MATH 617 and MATH 618

MATH 820 Advanced Applied Functional Analysis (3 Credit Hours)
In the first half of this course, several concepts in the classical functional analysis are studied. Topics include Banach Spaces, the dual spaces, the Baire category theorem, the adjoint operator, weak convergence, spectral theory and compact operators. In the second half, at the instructor's discretion, special topics are studied. Possible topics include ill-posed problems, inverse scattering theory, the regular Sturm-Liouville problem and the Dirichlet problem for Laplace's equation.
Prerequisites: MATH 617 and MATH 618

MATH 821 Advanced Applied Numerical Methods I (3 Credit Hours)
Numerical solutions of partial differential equations and integral equations. For PDEs, the finite difference method, the finite element method and the boundary element method are studied. A priori and a posteriori error estimates are examined. For integral equations, topics include Galerkin methods, collocation methods, and the Petrov-Galerkin method.
Prerequisites: MATH 501, MATH 508 and MATH 509

MATH 822 Advanced Applied Numerical Methods II (3 Credit Hours)
Numerical solutions of partial differential equations and integral equations. For PDEs, the finite difference method, the finite element method and the boundary element method are studied. A priori and a posteriori error estimates are examined. For integral equations, topics include Galerkin methods, collocation methods, and the Petrov-Galerkin method.
Prerequisites: MATH 821

MATH 823 Approximation and Optimization I (3 Credit Hours)
Introductory and advanced topics representing current research in approximation and optimization techniques for various application problems. Topics include recent developments in algorithms, their analysis, and applications such as data fitting and pattern separation.
Prerequisites: permission of the graduate program director

MATH 825 Computational Fluid Dynamics (3 Credit Hours)
An introduction to the theory of finite volume methods for scalar and vector conservation laws and the Euler and Navier-Stokes equations. Topics include weak solutions, characteristics, Rankine-Hugoniot conditions, energy and entropy inequalities, Riemann solvers, and numerical methods for compressible and incompressible flows including MUSCL and total variation diminishing (TVD) schemes, essentially non-oscillatory (ENO), weighted ENO, and entropy stable scheme.
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An introduction to the theory of nodal discontinuous Galerkin (DG) methods for solving linear and nonlinear conservation law equations. Topics include fundamental properties of conservation laws including their ability to generate non-smooth solutions, thus leading to the notion of weak solutions and entropy inequalities, consistency and stability properties of nodal DG methods as well as their efficient implementation techniques, and application of nodal DG methods for solving both linear and nonlinear equations, such as the advection-diffusion, Burgers, and Navier-Stokes equations.
Prerequisites: MATH 725 or MATH 825

MATH 845 Transform Methods (3 Credit Hours)
Use of integral transforms for students of applied mathematics, physics and engineering. Integral transforms studied are Laplace, Fourier, Hankel, finite Z-transforms and other special transforms.
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MATH 850 Calculus of Variations (3 Credit Hours)
Maximum and minimum techniques in calculus and dynamic programming. Derivation of Euler-Lagrange equations for a variety of conditions, formulation of extremum problems with side conditions for ordinary and partial differential equations. Application to dynamics, elasticity, heat and mass transfer, energy principles and finite element techniques.
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Prerequisites: MATH 501 or MATH 691 or permission of the instructor

MATH 856 Introduction to Kinetic Theory and Mesoscopic Methods for Computational Mechanics II (3 Credit Hours)
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Prerequisites: MATH 755/MATH 855

MATH 871 Scientific Computing in Applied Mathematics (3 Credit Hours)
Numerical methods for algebraic systems, partial differential equations, integral equations, optimization, Monte Carlo method, and statistics, with emphasis on computational performance using modern programming languages such as Fortran 90 or C/C++ and modern computer architecture. Basic techniques of parallel computing using MPI (Message Passing Interface), openMP, or other distributed/multicore computing platforms. Common tools in scientific computing, such as Unix shell commands, debuggers, version control systems, scientific libraries, graphics and visualization, will also be introduced.
Prerequisites: MATH 501, MATH 508 and MATH 509

MATH 895 Seminar in Mathematics (1-3 Credit Hours)
Seminar in advanced topics.
Prerequisites: permission of the instructor

MATH 896 Topics in Mathematics (1-3 Credit Hours)
Advanced study of selected topics.
Prerequisites: permission of the instructor

MATH 897 Topics in Mathematics (1-3 Credit Hours)
Advanced study of selected topics.

MATH 898 Research (1-9 Credit Hours)

MATH 899 Dissertation (1-9 Credit Hours)

MATH 999 Doctoral Graduate Credit (1 Credit Hour)
This course is a pass/fail course doctoral students may take to maintain active status after successfully passing the candidacy examination. All doctoral students are required to be registered for at least one graduate credit hour every semester until their graduation.

Statistics (STAT)

STAT 505 Introduction to Data Handling (3 Credit Hours)
Use of SAS and R to handle data sets. Topics for SAS include data input, creating permanent data sets, merging data sets, creating new variables, sorting, printing, charting, formatting, IML programming, macro programming, and an overview of proc SQL and other statistical procedures. Topics for R include data structure, control structure, writing functions, and graphics.
Prerequisites: A grade of C or better in STAT 130M or equivalent, and a grade of C or better in MATH 316 or equivalent, or permission of the instructor

STAT 531 Theory of Statistics (3 Credit Hours)
Topics include point and interval estimation, tests of hypotheses, introduction to linear models, likelihood techniques, and regression and correlation analysis.
Prerequisites: A grade of C or better in STAT 331 or permission of the instructor

STAT 532 Sampling Theory (3 Credit Hours)
Sampling from finite populations is discussed. Topics such as simple random sampling, stratified random sampling and ratio and regression estimation are included. Also discussed are aspects of systematic sampling, cluster sampling, and multi-stage sampling.
Prerequisites: A grade of C or better in STAT 431/STAT 531

STAT 535 Design and Analysis of Experiments (3 Credit Hours)
Topics include introduction to design of experiments, analysis of variance with a single factor, power and OC curves, and two factors with interactions, random effects models, randomized blocks, Latin square and related designs, introduction to factorial and 2k factorial designs. Statistical software will be used to analyze real life data.
Prerequisites: STAT 431/STAT 531 or STAT 437/STAT 537
Pre- or corequisite: STAT 405/STAT 505

STAT 537 Applied Regression and Time Series Analysis (3 Credit Hours)
Topics include introduction to regression and model building, simple linear regression, multiple regression, logistic regression, and simple time series, residual analysis, selection of variables, model adequacy checking, regression on dummy variables, analysis of covariance, regression analysis of time series data, and applications of these techniques to real life data using statistical software.
Prerequisites: A grade of C or better in STAT 531
Pre- or corequisite: STAT 405 or STAT 505

STAT 540 Clinical Trials (3 Credit Hours)
This course will introduce basic statistical concepts and methods used in clinical trials. Topics include trial designs, including parallel, group allocation, cross-over, and factorial designs; randomization; sample size and power calculation; survival analysis; and monitoring of trials for safety and efficacy.
Prerequisites: A grade of C or better in STAT 431 or STAT 531

STAT 542 Environmental Statistics (3 Credit Hours)
Topics include nonlinear and generalized linear models, quantitative risk assessment, analysis of stimulus-response and spatially correlated data, methods of combining data from several independent studies. Regression settings are emphasized where one or more predictor variables are used to make inferences on an outcome variable of interest. Applications include modeling growth inhibition of organisms exposed to environmental toxins, spatial associations of like species, risk estimation, and spatial prediction. SAS is used extensively in the course.
Prerequisites: A grade of C or better in STAT 431 or STAT 531; STAT 437 or STAT 537 recommended

STAT 547 Analysis of Longitudinal Data (3 Credit Hours)
This course introduces statistical methods for analyzing multivariate and longitudinal data. Topics include multivariate normal distribution, covariance modeling, multivariate linear models, principal components, analysis of continuous response repeated measures, and models for discrete longitudinal data. Emphasis will be on the applications to the biological and health sciences and the use of the statistical software.
Prerequisites: A grade of C or better in STAT 431 or STAT 531
Pre- or corequisite: STAT 405 OR STAT 505

STAT 549 Nonparametric Statistics (3 Credit Hours)
Topics include the theory and applications of binomial tests and rank tests, including the tests of McNemar, Mann-Whitney, Friedman, Kruskal-Wallis, and Smirnov.
Prerequisites: A grade of C or better in STAT 330 or STAT 331 or departmental permission

STAT 550 Categorical Data Analysis (3 Credit Hours)
Topics include types of categorical data, relative risk and odds ratio measures for 2 x 2 tables, the chi-square and Mantel-Haenszel tests, Fisher's exact test, analysis of sets of 2 x 2 tables using Cochran-Mantel-Haenszel methodology, analysis of I x J and sets of I x J tables for both nominal and ordinal data, logistic regression including the logit and probit models. Emphasis will be on the application of these statistical tools to data related to the health and social sciences. Interpretation of computer output will be stressed.
Prerequisites: A grade of C or better in STAT 431 or STAT 531
Pre- or corequisite: STAT 405 or STAT 505

STAT 597 Topics in Statistics (1-3 Credit Hours)
The advanced study of selected topics.
Prerequisites: permission of the instructor

STAT 603 Statistical/Probability Models for Data Science and Analytics (3 Credit Hours)
This course will serve as an introduction for modeling data using probability and statistical methods. Topics include basic concepts of probability, Bayes theorem, frequently-occurring discrete and continuous probability distributions, as well as how to simulate data from these distributions. Basic properties of the probability distributions will be discussed, which will provide an insight into the use of these distributions in data science. The course will also cover bivariate and conditional distributions, linear correlation and statistical inference concepts that include likelihood, parameter estimation, and goodness of fit.
Prerequisites: STAT 330 or equivalent or permission of the instructor

STAT 604 Statistical Tools for Data Science and Analytics (3 Credit Hours)
This course will cover statistical tools for data exploration. Topics taught include descriptive statistics, correlation, confidence intervals, linear and logistic regressions, t-test for one and two samples, and analysis of variance. For analyzing categorical data, students will study contingency tables, odds ratios for measuring association, and chi-square tests for testing independence. The course will also introduce principal components and clustering methods to analyze multivariate data. R and/or Python software for computing various statistics for real data analysis will be used.
Prerequisites: STAT 603 or equivalent or permission of the instructor

STAT 613 Applied Statistical Methods I (3 Credit Hours)
Intended for graduate students in all academic disciplines; not available for credit to graduate students in the Department of Mathematics and Statistics. Topics include descriptive statistics, probability computations, estimation, hypothesis testing, linear regression, analysis of variance and categorical data analysis. Emphasis will be on statistical analysis of data arising in a research setting. The rationale for selecting methods to address research questions will be emphasized. Examples will be given from the health sciences, social sciences, engineering, education and other application areas.
Prerequisites: A grade of C or better in STAT 130M or STAT 330 or MATH 211 or permission of the instructor

STAT 625 Mathematical Statistics I (3 Credit Hours)
An introduction to probability. Topics include axiomatic foundations of probability, conditional probability, Bayes formula, random variables, density and mass functions, stochastic independence, expectation, moment generating functions, transformations, common families of distributions, multiple random variables, covariance and correlation, multivariate distributions, convergence concepts, law of large numbers, limit theorems.
Prerequisites: A grade of C+ or better in STAT 531

STAT 626 Mathematical Statistics II (3 Credit Hours)
An introduction to statistical inference. Principles of data reduction, sufficiency, completeness, ancillary, likelihood principle, point estimation, method of moments, maximum likelihood and Bayes estimation, Cramer-Rao inequality, hypothesis testing, likelihood ratio tests, Bayesian tests, most powerful tests, Neyman-Pearson Lemma, interval estimates, pivotal quantities, asymptotic evaluations, consistency and asymptotic relative efficiency.
Prerequisites: A grade of C+ or better in STAT 625

STAT 630 Time Series Models (3 Credit Hours)
This course examines the principles and concepts of time series and forecasting. Study includes theory, methods, and model parameter estimation taking into account correlation and autocorrelation structures with data applications from pollution, economics, seasonal trends, and the stock market. Notions of autoregressive, moving, average, stationary and nonstationary ARIMA models will be discussed. The multivariate version and state-space models will also be introduced. Simulation of time series data will be discussed in depth.
Prerequisites: STAT 626, STAT 505, and STAT 537

STAT 632 Master's Project (3 Credit Hours)
Under the guidance of a faculty member in the Department of Mathematics and Statistics, the student will undertake a significant data analysis problem in a scientific setting outside the department. A written report and/or public presentation of results will be required.
Prerequisites: permission of graduate program director

STAT 635 Statistical Consulting (3 Credit Hours)
This course is intended to teach statistical consulting techniques to graduate students in statistics. Students are expected to work on statistical consulting problems brought by faculty and graduate students in various fields.
Prerequisites: STAT 626

STAT 637 Advanced Regression and Time Series (3 Credit Hours)
Topics include theory of least squares regression, multiple linear regression (including its matrix formulation), transformations and weighting, diagnostics for leverage and influence, polynomial and indicator regression model, multi-collinearity, variable selection and model building, validation of regression models, introduction to nonlinear regression, robust regression, regression for time series data, and applications of these techniques using statistical software.
Prerequisites: STAT 437/STAT 537
Pre- or corequisite: STAT 405/STAT 505

STAT 638 Advanced Design and Analysis of Experiments (3 Credit Hours)
Topics include blocking and confounding in factorial designs, power, balanced incomplete block designs, fractional factorial designs, factors with mixed levels, response surface methods and designs, Latin and Graeco-Latin square designs, optimality criterion, examples of optimal designs, experiments with random factors, nested and split-plot designs, analysis of covariance, robust designs. Statistical software will be used to analyze real life data.
Prerequisites: STAT 435/STAT 535 or STAT 437/STAT 537 or STAT 637

STAT 640 Survival Analysis (3 Credit Hours)
This course will introduce basic concepts and methods for analyzing survival time data obtained from following individuals until the occurrence of an event or their loss to follow-up. It will cover nonparametric, semi-parametric, and parametric models and two-sample test techniques. It will demonstrate mathematical and graphical methods for evaluating the goodness of fit and introduce the concept of dependent censoring/competing risk. Both SAS and R software will be used to analyze survival data.
Prerequisites: STAT 626

STAT 660 Advanced Programming in R (3 Credit Hours)
This course is a data-based tour of advanced statistical techniques using R, exploring a catalog of data sets (real or simulated). Topics include matrix factorization, data visualization, application of linear models and generalized linear models, numerical optimization, simulating random numbers, Bootstrap resampling, permutation tests, and Monte Carlo techniques. This course focuses on writing actual R codes and functions and not just using built-in R packages. This is a finishing course for statisticians and professionals willing to pursue a career in statistical programming and simulation.
Prerequisites: A grade of C or better in STAT 505 and two of STAT 535, STAT 537, STAT 547 and STAT 550

STAT 667 Cooperative Education (1-3 Credit Hours)
Student participation for credit based on academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and the cooperative education program prior to the semester in which the work experience is to take place.

STAT 697 Topics in Statistics (1-3 Credit Hours)
Advanced study of selected topics.
Prerequisites: permission of the instructor

STAT 725 Linear Statistical Models (3 Credit Hours)
Topics include the multivariate normal distribution, distributions of quadratic forms, the general linear model, estimability, the Gauss-Markov theorem and general linear hypotheses, analysis of variance (ANOVA) and covariance (ANCOVA) with special attention to unbalanced data, and analysis of mixed effects and variance components models including repeated measures and split-plot designs.
Prerequisites: STAT 626

STAT 727 Advanced Statistical Inference I (3 Credit Hours)
Topics to be covered include introduction to measure theoretic probability, properties of group and exponential families, sufficiency, unbiasedness, equivariance, properties of estimators, large sample theory, maximum likelihood estimation, EM algorithm, information inequality, asymptotic optimality.
Prerequisites: A grade of C+ or higher in MATH 517 and STAT 626

STAT 728 Advanced Statistical Inference II (3 Credit Hours)
Topics to be covered include convergence concepts, limit theorems, large sample theory, asymptotic distributions, decision theory, minimax, admissibility, Bayes estimates, generalized Neyman-Pearson Lemma, uniformly most powerful tests, unbiased tests, invariant tests, and Bayesian tests.
Prerequisites: A grade of C+ or higher in STAT 727 or STAT 827

STAT 730 Multivariate Statistics (3 Credit Hours)
Topics include the multivariate normal distribution, graphical display of multivariate data and tests for normality, Hotelling's T2, multivariate analysis of variance (MANOVA) and regression, profile analysis, growth curve models, canonical correlation analysis, principal components, factor models, clustering, and discriminant analysis. All methods are implemented using the SAS statistical software.
Prerequisites: STAT 537 or STAT 725/STAT 825

STAT 740 Clinical Trials I (3 Credit Hours)
This course will discuss sequential and adaptive designs for clinical trials; the statistical properties and challenges these designs engender; and the advantages and disadvantages of utilizing sequential and adaptive designs compared to a standard, fixed-sample design.
Prerequisites: STAT 440 or STAT 540

STAT 741 Clinical Trials II (3 Credit Hours)
This course will discuss sequential and adaptive designs for clinical trials; the statistical properties and challenges these designs engender; and the advantages and disadvantages of utilizing sequential and adaptive designs compared to a standard, fixed-sample design.
Prerequisites: A grade of C or better in STAT 440/STAT 540 or permission of the instructor

STAT 747 Advanced Analysis of Longitudinal Data (3 Credit Hours)
Topics include general linear models, weighted least squares (WLS), maximum likelihood (ML), restricted maximum likelihood (REML) methods of estimation, analysis of continuous response repeated measures data, parametric models for covariance structure, generalized estimating equations (GEE) for discrete longitudinal data, marginal, random effects, and transition models. Limitations of existing approaches will be discussed. Emphasis will be on the application of these tools to data related to the biological and health sciences. Methods will be implemented using statistical software.
Prerequisites: STAT 447/STAT 547

STAT 749 Advanced Nonparametric Statistics (3 Credit Hours)
Topics include multivariate permutation tests, multivariate rank tests, permutation and rank tests for censored data, bootstrap methods, permutation and rank tests for the analysis of multifactor experiments, and nonparametric smoothing methods.
Prerequisites: STAT 449/STAT 549

STAT 750 Advanced Categorical Data Analysis (3 Credit Hours)
This course will cover statistical models and methods appropriate for analyzing categorical responses, contingency tables, Pearson Chi-square test, Fisher's Exact test, Mantel-Haenszel test, Cochran-Armitage trend test, independence and conditional independence, Simpson's paradox, generalized linear models, logistic and Poisson regression models, matched paired studies, McNemar test, conditional logistic regression model and random effects logistic model for data from matched paired studies, models for multinomial data.
Prerequisites: STAT 450/STAT 550

STAT 795 Seminar in Statistics (1-3 Credit Hours)
Seminar.
Prerequisites: permission of the instructor

STAT 797 Topics in Statistics (1-3 Credit Hours)
Advanced study of selected topics.
Prerequisites: Permission of the instructor

STAT 825 Linear Statistical Models (3 Credit Hours)
Topics include the multivariate normal distribution, distributions of quadratic forms, the general linear model, estimability, the Gauss-Markov theorem and general linear hypotheses, analysis of variance (ANOVA) and covariance (ANCOVA) with special attention to unbalanced data, and analysis of mixed effects and variance components models including repeated measures and split-plot designs.
Prerequisites: STAT 626

STAT 827 Advanced Statistical Inference I (3 Credit Hours)
Topics to be covered include introduction to measure theoretic probability, properties of group and exponential families, sufficiency, unbiasedness, equivariance, properties of estimators, large sample theory, maximum likelihood estimation, EM algorithm, information inequality, asymptotic optimality.
Prerequisites: A grade of C+ or higher in MATH 517 and STAT 626

STAT 828 Advanced Statistical Inference II (3 Credit Hours)
Topics to be covered include convergence concepts, limit theorems, large sample theory, asymptotic distributions, decision theory, minimax, admissibility, Bayes estimates, generalized Neyman-Pearson Lemma, uniformly most powerful tests, unbiased tests, invariant tests, and Bayesian tests.
Prerequisites: A grade of C+ or higher in STAT 727 or STAT 827

STAT 830 Multivariate Statistics (3 Credit Hours)
Topics include the multivariate normal distribution, graphical display of multivariate data and tests for normality, Hotelling's T2, multivariate analysis of variance (MANOVA) and regression, profile analysis, growth curve models, canonical correlation analysis, principal components, factor models, clustering, and discriminant analysis. All methods are implemented using the SAS statistical software.
Prerequisites: STAT 537 or STAT 725/STAT 825

STAT 840 Clinical Trials I (3 Credit Hours)
This course will discuss sequential and adaptive designs for clinical trials; the statistical properties and challenges these designs engender; and the advantages and disadvantages of utilizing sequential and adaptive designs compared to a standard, fixed-sample design.
Prerequisites: STAT 440/STAT 540

STAT 841 Clinical Trials II (3 Credit Hours)
This course will discuss sequential and adaptive designs for clinical trials; the statistical properties and challenges these designs engender; and the advantages and disadvantages of utilizing sequential and adaptive designs compared to a standard, fixed-sample design.
Prerequisites: A grade of C or better in STAT 440/STAT 540 or permission of the instructor

STAT 847 Advanced Analysis of Longitudinal Data (3 Credit Hours)
Topics include general linear models, weighted least squares (WLS), maximum likelihood (ML), restricted maximum likelihood (REML) methods of estimation, analysis of continuous response repeated measures data, parametric models for covariance structure, generalized estimating equations (GEE) for discrete longitudinal data, marginal, random effects, and transition models. Limitations of existing approaches will be discussed. Emphasis will be on the application of these tools to data related to the biological and health sciences. Methods will be implemented using statistical software.
Prerequisites: STAT 447/STAT 547

STAT 849 Advanced Nonparametric Statistics (3 Credit Hours)
Topics include multivariate permutation tests, multivariate rank tests, permutation and rank tests for censored data, bootstrap methods, permutation and rank tests for the analysis of multifactor experiments, and nonparametric smoothing methods.
Prerequisites: STAT 449/STAT 549

STAT 850 Advanced Categorical Data Analysis (3 Credit Hours)
This course will cover statistical models and methods appropriate for analyzing categorical responses, contingency tables, Pearson Chi-square test, Fisher’s Exact test, Mantel-Haenszel test, Cochran-Armitage trend test, independence and conditional independence, Simpson’s paradox, generalized linear models, logistic and Poisson regression models, matched paired studies, McNemar test, conditional logistic regression model and random effects logistic model for data from matched paired studies, models for multinomial data.
Prerequisites: STAT 450/STAT 550

STAT 895 Seminar in Statistics (1-3 Credit Hours)
Seminar.
Prerequisites: permission of the instructor

STAT 897 Topics in Statistics (1-3 Credit Hours)

STAT 898 Research (1-9 Credit Hours)

STAT 899 Dissertation (1-9 Credit Hours)

STAT 999 Doctoral Graduate Credit (1 Credit Hour)
This course is a pass/fail course doctoral students may take to maintain active status after successfully passing the candidacy examination. All doctoral students are required to be registered for at least one graduate credit hour every semester until their graduation.