COLLEGE OF SCIENCE, ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MATHEMATICS and STATISTICAL SCIENCES

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The Department of Mathematics and Statistical Sciences offers a doctoral degree program with a concentration in computational mathematics and statistical sciences through the College of Science, Engineering and Technology's Ph.D. program in Computational Data-Enabled Sciences and Engineering (CDS&E). The Department also offers programs leading to the MST degree in mathematics designed for persons who wish additional preparation for mathematics teaching or mathematics supervision and the MS degree in Pure or Applied Mathematics for students who seek careers in academia, government, industry or the business sector. The programs are designed for persons with adequate background in undergraduate mathematics beyond the calculus sequence.

Program Mission

The Department of Mathematics and Statistical Sciences aims to equip its graduate with the necessary advanced mathematics and statistical knowledge and skills that prepares them to find solutions to mathematics or statistics problems arising in other academic fields and in areas outside the normal academic setting and to use this knowledge to solve society problems of challenge. The program aims for national and international distinction in preparing mathematics students for a spectrum of careers including academic and non-academic employment.

Program Objectives

1. To provide quality mathematics training at the doctoral and master's degree level.
2. To provide a learning and research friendly environment for all students.
3. To prepare students to recognize opportunities for advancing mathematics or statistical ideas arising in other fields.
4. To increase the pool of mathematicians seeking academic and non-academic employment.

Transfer of Credits

A course for which transfer credit is sought must have been completed with a grade of "B" or better. Departmental approval is required.

Time Limit

Students with adequate mathematics preparation at the undergraduate level will normally take two years to complete any of the Master's degree programs and a minimum of five years to complete the doctoral program. However, all students must complete their programs within eight years of starting coursework at Jackson State University or elsewhere.

Degree Programs

CDS&E Ph.D. Program in Computational Mathematics and Statistical Sciences Track

The CDS&E Ph.D. with a concentration in Computational Mathematics and Statistical Sciences Program is an interdisciplinary program designed to ensure that the student acquires knowledge in a broad spectrum of the mathematics and statistical sciences through quantitative exploration of data. The Ph.D. in CDS&E programs of study are structured to reflect the belief that a student in the program should not only be proficient in a specialized track, but also understand how it relates to other academic fields and big data and be able to recognize opportunities for developing new ideas of the track and solve real-world problems. As a result, the Ph.D. graduate in computational mathematics and statistical sciences is equipped with all necessary tools and skills to recognize opportunities for developing and advancing mathematics and statistical ideas arising from other academic fields and for work outside of the traditional mathematics and statistics academic setting. In addition to opportunities for consulting experience through the Laboratory for Interdisciplinary Statistical Analysis through Quantitative Exploration of Data (LISA-QED), students in the Ph.D. track may have opportunities for participation on research projects through other facilities on campus designed for Computational and Quantitative Simulations and make presentations at professional CDS&E conferences.

Admission Requirements

To be considered for admission, the following requirements should be met:

- Applicants must have completed the Graduate Application for Admission.
- Applicants must have provided official copies of transcripts from all colleges/universities attended.
  - The applicant must have a Bachelor's or Master's degree from an accredited college or university in STEM field or related fields, and
  - A minimum GPA of 3.00 (on a 4.00 scale) on the highest degree earned.
- A satisfactory TOEFL score for international students whose native language is not English.
- Three letters of recommendation from three professors knowledgeable of the applicant's professional academic ability, job experiences, and leadership potential.
- An official score on the Graduate Record Examination (GRE).
- A statement of purpose.

Degree Requirements
Common Core = 12 credit hours
Track Requirement = 12 credit hours
Track electives = 24 credit hours
Dissertation = 24 credit hours

Please refer to the College of Science, Engineering and Technology section of the catalog for details regarding the CDS&E Ph.D. degree completion. Students are advised to follow the guidelines given by the Division of Graduate Studies for the completion of a Doctorate degree program at JSU.

Ph.D. Required Examinations and Procedures

- Comprehensive Examination
- Preliminary Examination
- The Dissertation (Thesis)
- The Dissertation Defense

Comprehensive Examination
In order to ensure that the skills and basic knowledge have been acquired to carry out the research necessary for the dissertation, the student must demonstrate competence in four subject areas chosen from the set of the required Ph.D. courses. Competence is demonstrated by passing a written comprehensive examination in each of the four subject areas. One of the four examinations is waived by completing a sequence of two courses from the list of elective courses with a grade of B or better. Completion of the required courses should be adequate preparation for the comprehensive examination. Comprehensive examinations will be administered at the beginning of the Spring Semester and once during summer. Satisfactory progress toward the degree is demonstrated by passing the comprehensive examination by the end of the third full academic year of Ph.D. work. The comprehensive examination may be repeated only once.

Preliminary Examinations
After the comprehensive examination have been passed, the foreign language requirements met and all required course work is completed, the student request the preliminary examination for admission to degree candidacy. The preliminary examination is an oral examination on the core and required courses for the computational mathematics and statistical sciences track. It is design to test the student's general knowledge of CDS&E with a focus on computational mathematics and statistical sciences. It will be given by the student's doctoral committee. A pass or fail will be determined by a simple majority vote of the committee.

The Dissertation
After the preliminary examination has been passed, the student's doctoral committee will be reconstituted to form the dissertation committee. The student and the major professor of the doctoral committee will select the student's dissertation committee, subject to the approval of the departmental Graduate Coordinating Committee. The dissertation committee will consist of at least five graduate faculty members, including a major professor and at least three additional graduate faculty members from the other CDS&E tracks. The primary responsibility of the committee will be to supervise the student's research and writing of a dissertation in the area of specialization, and its members should be chosen with this mission in mind.

In the early stages of the research effort, the student will make a formal dissertation proposal to the dissertation committee. The dissertation will be an original work that makes a significant contribution to the student's area of specialization.
A person from outside the Department of Mathematics and Statistical Sciences who has expertise in the dissertation area will be enlisted by the student and his/her committee to serve as an external examiner for the dissertation. This person will read the dissertation and submit written comments regarding its quality and significance to the student's committee.

Dissertation Defense
After completing the dissertation, the student's committee will schedule the final dissertation defense for the student. This is an oral defense of the dissertation open to the public.
After consultation with the Graduate Coordinator/Department Chair, the major professor

will publicize the time and place of the dissertation defense a week prior to the scheduled defense date.
A pass or fail on the defense will be determined by a simple majority vote of the student's committee. In making its decision, the committee will give due consideration to the external examiner's assessment of the dissertation

Master's Degrees

The M.S. degree is research oriented but it can be completed in any of the options of a Thesis, Project or Course work. The M.S.T. degree, in general, can be completed with only course work, a Thesis or Project is optional. However, all of the programs are designed to meet academic requirements for students who are interested in seeking degrees beyond the master's or specialist's level. The M.S.T. degree would lead to a Class "AA" Teaching Certificate for students who hold the Class "A" Teaching Certificate. A student can also receive the M.S.T. degree without seeking the Class "AA" Teaching Certificate. The coursework requirement for this option is the same with those holding the Class "A" Teaching Certificate.

Admissions Requirements
Admission to any of the Master's degree program in mathematics requires at least 15 semester hours of undergraduate mathematics above the regular calculus sequence and the fulfillment of the admission requirement into graduate studies at Jackson State University, which is an earned Bachelor's degree with a cumulative GPA of at least 3.0 on the 4.0 scale in all undergraduate courses taken at a regional accredited degree granting institution. GRE is not required for admission into any of the Master's degree programs. However, students who are seeking to pursue the doctoral degree are encouraged to take the GRE exams, general and subject area, to increase their chances for competitive admission and financial assistance. These exams can be taken while students are taking courses or after they have completed all coursework.

Master of Science in Mathematics

The department offers programs leading to the M.S. degree in Pure or Applied Mathematics for students who plan on pursuing the doctoral degree or wish to seek careers in college or university teaching, government, industry and the business sector. The programs are designed for persons with adequate background in undergraduate mathematics beyond the calculus sequence.

To receive the M.S. degree a student must be in residence at Jackson State University for at least one semester, complete all degree requirements and must take and pass the Graduate English Competency Exam. If a student's GPA upon completion of all coursework is below 3.33, then such a student is required to take and score at least 70% on a comprehensive exit exam given by the Department.

The requirements for the M.S. degree are:
1. Thirty six (36) hours are required with a thesis, or thirty three (33) hours with a project, or thirty six (36) hours of course work with a score of 70% on an area comprehensive exam.
2. A "B" average with no more than one "C" grade is required for graduation.
3. Pass the Graduate English Competency Exam

Required Courses		**Semester**
Course	**Title**	**Hours**
Math 513	Modern Linear Algebra 1	3
Math 511	Modern Algebra 1	3
Math 531	Real Analysis 1	3
Math 541	Complex Analysis 1	3
Math 551	Introduction to General Topology 1	3
Math 561	Probability and Statistics I	3
Math 599	Thesis	6
	Total Hours	24

The student will fulfill the remaining 12 hours from mathematics electives drawn from a list of pure or applied mathematics courses to match his/her area of concentration. Courses are offered each semester to match each enrolled student's interest. In consultation with an advisor and the Chairperson of the Department, a student must develop a study plan and select sufficient electives from departmental courses to complete degree requirements with a concentration in either pure or applied mathematics. See the list of departmental courses below. A typical study plan for a student with a concentration in applied mathematics who is seeking to pursue a doctoral degree would look like this:

Coursework for Year One

Fall Semester
Math 511 - Modern Algebra I
Math 513 – Modern Linear Algebra I
Math 531 - Real Analysis I
Spring Semester
Math 577- Ordinary Differential Equations with Applications
Math 579- Partial Differential Equations with Applications Math
Math 541 - Complex Analysis I
Summer Sessions
Math 599-Thesis

Coursework for Year Two

Fall Semester
Math 551 – Introduction to General Topology I
Math 542 - Complex Analysis 11
Math 532 – Real Analysis II
Math 580 - Partial Differential Equations 11 or
Math 599 -Thesis
Extra Coursework and Thesis Defense
Spring Semester
Math 537 - Introduction to Functional Analysis

Math 547- Integral Equations
Take the GRE both General and Subject area tests
Math 599-Thesis

Master of Science in the Teaching
Mathematics and Science Education

The Mathematics and Science Education degree is a master-level degree offered within the College of Science, Engineering, and Technology under the direction of the Department of Mathematics and in cooperation with the College of Education and Human Development. There are three areas of concentration under the MST. A student can take coursework with concentrations in biology, mathematics or earth sciences. The concentration in mathematics is designed for persons with an adequate background in mathematics and who wish additional preparation for mathematics teaching or mathematics supervision. Degree requirements facilitate obtaining certification via an alternate route and is described in greater detail below, based on certification requirements of the State of Mississippi as stated in Bulletin 130, and upon the state principles and guidelines of the National Council of Teachers of Mathematics, the Mathematics Association of America, and the Mississippi Council of Teachers of Mathematics.

The requirements for the M.S.T. degree with a concentration in mathematics are:

The Mathematics and Science and Education degree offers concentrations in one of three areas: biology, mathematics or earth science. Coursework specific to biology and earth science are found within their respective department degree program requirements.

1. Thirty six (36) hours are required with a thesis, i.e. ten (10) courses plus six (6) hours for a thesis.
2. Thirty six (36) hours are required with a project, i.e. eleven (11) courses plus three (3) hours for a project.
3. Thirty six (36) hours are required if neither a thesis nor a project is done.
4. A "B" average with no more than one "C" grade is required for graduation, if a student has two "C" grades, then the student must earn an "A" grade in an additional course.
5. A maximum of eighteen (18) hours can be counted from education classes.
6. Pass the Graduate English Competency Exam

Core Educational		**Semester**
Courses	**Title**	**Hours**
EDFL 511	History and Philosophy of Education (R)	3
EDFL 515	Methods of Educational Research (R)	3
EDFL 514	Elementary Statistics (R*)	3
EDFL 568	Curriculum Methods (R*)	3
	Total Hours	12

(R) - Required
(R*) - Required for students without an undergraduate Statistics course and it is a prerequisite for EDFL 515.

Required Mathematics Courses		**Semester**
Courses	**Title**	**Hours**
Math 501	Topics in Geometry	3
Math 506	Basic Concepts for Teachers I	3
Math 510	Topics and Issues in Mathematics	3
Math 513	Linear Algebra 1	3
Math 511	Abstract Algebra 1	3
Math 531	Real Analysis 1	3
	Total Hours	18

Any substitute for the above courses must seek the Department of Mathematics approval.

Students who do not hold the Class "A" Teaching Certificate must also complete the following requirements for certification: Take the PRAXIS I Pre-professional Skills Test (PPST) and make the required cut scores on each of the subtests- reading, writing, and mathematics and successfully complete the PRAXIS 11, mathematics Area Examination. Then complete the following pre-teaching required coursework:

EDFL 581	Principles of Measurement	3
EDFL 556	Special Topics: Classroom Management	3
EDFL 500	Secondary Internship(R*)	6
	Total Hours	12

(R*) - Required and a student must be employed and have a GPA of at least 2.5 for all undergraduate course work.

After successful completion of the pre-teaching required coursework, the PRAXIS I and PRAXIS 11, the Mississippi Department of Education Office of Teacher Licensure will issue the applicant upon receipt of PRAXIS test scores, a transcript, a completed application, and institutional recommendation a license that is valid for 5 years.

Requirements for Option Choices

Option 1: Math 590 Thesis 6
Option 2: Math 584 Independent Study (Project) 3
plus 3 hour course selected from List I,
or
Option 3: Six hours selected from List I
and three hours selected from List II or List III.

Total number of hours for students
with Class "A" Teaching Certificate: 36

Total number of hours for students
without the Class "A" Teaching Certificate: 48

A student may concentrate in Applied Mathematics by taking the four (4) elective courses from: Math 514, 537, 541, 542, 561, 562, 565, 566, 577, 579, 580, 581, 582, CSC 511, 512, 515, 518, 531 and 561 or Foundation of Mathematics by taking from: Math 503, 512, 535, 541, 542, CSC 511, 512, 515, 518, 531 and 561.

List I

1. Math 503 Foundations of Mathematics I
2. Math 504 Foundations of Mathematics II
3. Math 512 Modern Algebra II
4. Math 514 Modern Linear Algebra II
5. Math 532 Real Analysis II
6. Math 541 Complex Analysis I
7. Math 542 Complex Analysis II
8. Math 561 Probability and Statistics I
9. Math 562 Probability and Statistics II
10. Math 551 Introduction to General Topology I
11. Math 552 Introduction to General Topology II
12. Math 581 Number Theory I
13. Math 582 Number Theory II

List II

14. Math 505 Mathematics for Secondary Teachers
15. Math 506 Mathematics Concepts for Teachers I
16. Math 507 Mathematics Concepts for Teachers II
17. Math 509 Mathematical Structures
18. Math 519 Topics in Mathematics Education I
19. Math 520 Topics in Mathematics Education II

List III

20. CSC 511 Computers and Programming
21. CSC 512 Introduction to Computer Systems and Organization
22. CSC 515 Data Structures and File Management
23. CSC 518 Principles of Operating Systems
24. CSC 531 Computer Simulation Methods and Models
25. CSC 561 Probability and Statistical Inference I

Master's Degree in any of the Education Areas with a Concentration in Mathematics Requirements

Students in any of the Master's Degree Programs in the College of Education and Human Development who wish to seek a concentration in Mathematics must meet the following requirements:

1. Satisfaction of the admission requirement in the mathematics graduate programs of three advanced mathematics courses beyond the calculus sequence, or completion of an undergraduate degree program at a regionally accredited institution in Elementary or Secondary Education with a concentration in mathematics.
2. Meet the 18 credit hours requirement in Mathematics as follows:
3. 9 credit hours must be taken from the following courses with a cumulative average of at least a "B":
   Math 513 -Linear Algebra 1, Math 511 - Abstract Algebra 1, Math 531 - Real Analysis I or Math 541 -Complex Analysis 1.
4. The remaining 9 hours can be taken in any combination of the graduate level mathematics education courses and the general mathematics courses.

DESCRIPTION OF COURSES

Mathematics Courses for Education Majors

MATH 501 Topics in Geometry. (3 Hours) Prerequisite: Approval of department. A survey of geometries and their structures. Emphasis is on both synthetic and analytic methods.

MATH 502 Topics in Algebra. (3 Hours) Prerequisite: Approval of department. An amalgamation of classical and modern theory, stressing the synthesis of ideas in areas from equation solvability, special algebraic forms (permutations, combinations, arrangements, binomial and multinomial theorems, partial fractions, progressions, groups, rings, domains of integrity, and ideas of interest).

MATH 503-504 Foundations of Mathematics I-II (3-3 Hours): The fundamental elements of set theory and finite mathematical structures; cardinals and ordinals; logical deduction, elements of probability; vectors and matrices, linear programming, theory of games and applications.

MATH 505 Mathematics for Secondary Teachers (3 Hours): Prerequisite: Approval of department. The basis of the content, philosophy and methodology employed in the teaching of secondary school mathematics is of prime interest here.

MATH 506-507 Mathematics Concepts for Teachers I-II (3-3 Hours): Prerequisite: Approval of department. Higher mathematics for teachers, reviewing the fundamental areas of algebra, geometry and analysis, with stress on rigor and validity of ideas.

MATH 510 Topics and Issues in Mathematics (3 Hours): This course is designed for in-service teachers who are interested in the renewal of teaching licenses and the pursuit of graduate studies in the teaching of mathematics. Emphasis is on individualized research dealing with the stages of development of mathematics, new trends in the teaching of mathematics, and the exploration of teaching theories resulting from the work of experimental psychologists such as Piaget, Aushel and Bruner. Because of the individualized nature of the course, students with diverse backgrounds in mathematics can be accommodated.

Courses for all Graduate Mathematics Majors

MATH 511-512 Modern Algebra I-II (3-3 Hours) Groups, (homomorphisms), rings, integral domains, modules and fields, elementary linear algebra, number theory.

MATH 513-514 Modern Linear Algebra I-II (3-3 Hours) Vector spaces, matrices, linear transformations, determinants and linear equations. Selected topics on eigenvalues, canonical forms, inner products, inner product spaces, bilinear and quadratic forms.

MATH 515-516 Advanced Modern Algebra III-IV (3-3 Hours) Prerequisite: Mathematics 512. Special topics in groups, rings and fields, factorization theory,

extensions of rings and fields, modules, elementary theory of fields.

MATH 521-522 Modern Geometry I-II (3-3 Hours): Prerequisite: Mathematics 511, concurrent enrollment or approval of department. Historical development; sets and projective planes and geometries; vectors, transformations, axiomatic affine, projective and plane geometry.

MATH 523-524 Modern Geometry III-IV (3-3 Hours) Prerequisite: Mathematics 523 or approval of department. Motions and transformations, projective and topological transformations, projective plane, analytic projective geometry; absolute, ordered, affine and hyperbolic geometries; elementary differential geometry, topology of surfaces.

MATH 525-526 Introduction to Differential Geometry I-II (3-3 Hours): Prerequisite: Mathematics 523 or approval of department. Curves and surfaces in three dimensions by classical methods, introduction to corresponding problems in n-dimensions involving tensor methods.

MATH 527-528 Projective Geometry I-II. (3-3 Hours) Prerequisite: Mathematics 512 or approval of department. The projective plane, polarities and conic sections, affine geometry, projective metrics, non-Euclidean Geometry, spatial geometry.

MATH 529-530 Systems Analysis I-II. (3-3 Hours) Prerequisite: Approval of department. An analysis of the numerical and abstract systems of mensuration. Stress is placed on the metric and English systems, conversion analysis and other systems of interest.

MATH 531-532 Real Analysis I-II. (3-3 Hours) Prerequisite: Math 511 or approval of department. Metric spaces, regulated functions and integrals; integrals of Riemann and Lebesgue; trigonometrical and Fourier series; differentiation and Stieltjes Integrals.

MATH 533-534 Advanced Analysis I-II. (3-3 Hours) Prerequisite: Mathematics 532 or approval of department. Further treatment of limits, continuity, differentiability and integrability of functions of one and more variables. Infinite series and products, power and trigonometric series; selected topics.

MATH 535-536 Introduction to Measure and Integration I-II. (3-3 Hours) Prerequisite: Mathematics 531 or approval of department. Lebesgue measure of linear sets, measurable functions, definite integral, convergence, integration and differentiation, spaces of functions, orthogonal expansions, multiple integrals and the Stieltjes Integral.

MATH 537-538 Introduction to Functional Analysis I-II. (3-3 Hours) Prerequisites: Mathematics 512, 531, or approval of department. Fundamentals of the theory of vector spaces; Banach spaces; Hilbert spaces. Linear functionals and operators in such spaces; spectral resolution of operators, applications.

MATH 539-540 Introduction to Infinite Series I-II. (3-3 Hours) Prerequisites: Mathematics 511 and approval of department. Complex numbers, sets and functions; limits and continuity; analytic functions of a complex variable, elementary functions; integration; power and Laurent series, calculus of residues, conformal representation, special topics.

MATH 541-542 Complex Analysis I-II. (3-3 Hours) Complex numbers, sets and functions; limits and continuity; analytic functions of a complex variable, elementary functions; integration; power and Laurent series, calculus of residues, conformal representation, special topics.

MATH 544 Introduction to Entire Functions. (3 Hours) Prerequisite: Mathematics 541. Entire functions, maximum absolute value and order, zeroes of entire functions, fundamental theorem of algebra, Picard's Little Theorem, algebraic relationships and addition theorem; special theorems and functions.

MATH 545 Laplace Transforms. (3 Hours) Prerequisites: Math 534 and approval of department. The Stieltjes Integral; fundamental formulae; moment problem, Tauberian theorems, bilateral Laplace Transform, inversion and representation problems, the Stieltjes Transform.

MATH 546 Special Functions. (3 Hours) Prerequisites: Math 535 and approval of department. Infinite products, Gamma and Beta functions, series, polynomials, functions, relations and sets of analysis and differential equations.

MATH 547-548 Integral Equations I-II. (3-3 Hours) Prerequisites: Math 534, 542, and approval of department. Theory of Fredholm and Volterra equations; Hilbert-Schmidt theory; singular integral equations and some applications.

MATH 549-550 Methods in Applied Mathematics I-II. (3-3 Hours) Prerequisite: Approval of department. Elements of linear algebra; applications to systems of linear variables; function spaces; tensor analysis, applications to geometry, electromagnetic theory, Lagrangian and Hamiltonian formulations of mechanics; other topics of interest.

MATH 551-552 Introduction to General Topology I-II. (3-3 Hours) Prerequisites: Mathematics 223 and approval of department. Elementary set theory, ordinals and cardinals; topological spaces; cartesian products; connectedness; special topologies; separation axioms; covering axioms, metric spaces; convergence; compactness; function spaces; spaces of continuous functions and complete spaces; homotopy; maps into spheres; topology of En; homotopy type; introduction to algebraic topological ideas.

MATH 553-554 Introductory Algebraic Topology I-II. (3-3 Hours) Prerequisites: Mathematics 552 and approval of department. Complexes, simplicial, singular and Cech Homology Theory. Homotopy groups and basic theorems of algebraic topology.

MATH 555-556 Introduction to Combinatorial Topology I-II. (3-3 Hours) Prerequisites: Mathematics 553 and approval of department. Properties of topological spaces; Jordan's theorem, surfaces, complexes, coverings, dimension; the Betti Groups, homology theory, manifolds, the duality theorems, cohomology groups of compacta, introduction to theory of continuous mappings of polyhedra.

MATH 557-558 Introduction to Algebraic Geometry I-II. (3-3 Hours) Prerequisites: Mathematics 512, 521, or approval of the department. Algebraic preliminaries, local rings valuation theory, power series, rings, geometry of algebraic varieties with emphasis on curves and surfaces.

MATH 559-560 Linear Programming I-II. (3-3 Hours) Basic Concepts, graph theory, theory of games, Markov Chains, Leontief Economic Models, Optimizing linear functions of variables subject to constraints, a geometric approach, simplex method, convex sets duality, applications.

MATH 561-562 Probability and Statistics I-II. (3-3 Hours) Prerequisite: Mathematics 532 or approval of department. Basic concepts of measure theory and integration axiomatic foundations of probability theory, distribution functions and characteristics functions, central limit problem, modern statistical inference, analysis, variance, decision functions.

MATH 563-573 Design I-II. (3-3 Hours) Prerequisite: Mathematics 272. Experimental Design: Completely randomize design; randomize block designs, factorial experiments split plot design. confounding.

MATH 564 Linear Models. (3 Hours) Prerequisite: Mathematics 562 or departmental approval. Linear statistical models, some noise-reducing experimental designs, an example-of a volume-increasing design, fitting the general linear model, inference making, multi parameter hypothesis: the analysis of variance, the effect of coding on the analysis, seeking a maximum or minimum response, fractional factorial experiments and incomplete block designs, an example of a completely random model, mixed models.

MATH 565 Multivariate Analysis. (3 Hours) Prerequisites: Mathematics 562 and approval of department. General linear hypothesis; least square estimation; confidence regions, multiple comparison; analysis of complete layouts; effects of departures from underlying assumptions. Analysis of covariance.

MATH 566-566W Operations Research. (3-3 Hours) Prerequisite: Math 232, 355. Linear programming, network analysis, PERT-CPM, dynamic programming, queuing theory and decision analysis.

MATH 567-568 Nonparametric Statistics I-II. (3-3 Hours) Prerequisites: Mathematics 562 and approval of department. Problems of estimating testing hypotheses when the functional form of the underlying distribution is unknown. Robust methods; sign test, rank test and confidence procedures based on these tests; tests based on permutations of observations. Non-parametric tolerance limits; large sample properties of the tests, multi sample problems; ranking methods in analysis of variance; Bivariate and multivariate procedures, efficiency comparisons.

MATH 569-570 Functions of Several Real Variables I-II. (3-3 Hours) Prerequisites: Mathematics 533 and approval of department. Euclidean spaces, Mapping and differentials, manifolds, differential forms, vector analysis.

MATH 571 Numerical Analysis I (3 hrs): This course is an introduction to parallel computer programming for numerical calculations, round-off error, approximation and interpolation, numerical quadrature, and solution of ordinary differential equations.

MATH 572 Numerical Analysis II (3 hrs): This course is a continuation of MATH 625. Topics covered include, iterative solution of systems of nonlinear equations, evaluation of eigenvalues and eigenvectors of matrices, applications to simple partial differential equations and quantitative exploration of data.

MATH 573 Fractal Geometry. (3 Hours) Prerequisite: Math 511 or departmental approval. Metric spaces, equivalent spaces, classification of subsets, and the Space of Fractals. Transformations on metric spaces, contraction mappings, and the Construction of Fractals. Chaotic Dynamics of Fractals, Fractal Dimension. Fractal Interpolation. Julia Sets. Parameter Spaces and Mandelbort Sets. Measures on Fractals.

MATH 574 Numerical Linear Algebra. (3 Hours) Prerequisite: Approval of department. Elementary numerical analysis; matrix algebra; elimination and compact elimination methods; orthogonalization methods; condition, accuracy, and precision; comparison of methods; iterative and gradient methods; iterative and transformation methods for latent roots and vectors; error analysis for latent roots and vectors.

MATH 575-576 Approximation and Interpolation I-II. (3-3 Hours) Prerequisite: Approval of department. Interpolation, remainder theory; convergence theorems; infinite interpolation; uniform approximation; best approximation; least squares approximation; Hilbert space; orthogonal polynomials; closure and completeness.

MATH 577-578 Ordinary Differential Equation I-II. (3-3 Hours) Ordinary differential equations: basic theorems of existence, uniqueness, and continuous dependence of the solutions; linear differential equations and systems; stability theory; topology of integral curves; differential equations in the complex domain, asymptotic integration; boundary value problems. Partial differential equations; equations of first order method of characteristics, Hamilton-Jacobi theory; equations of second order-classification according to type; elliptic equations-potential equation, maximum principle, characteristics, and other topics of interest.

MATH 579-580 Partial Differential Equations I-II. (3-3 Hours) Prerequisite: Mathematics 577 or departmental approval. Linear equations with constant coefficients in two independent variables, applications, eigenfunction expansions, homogeneous and nonhomogeneous equations. Fourier series, existence, solution uniqueness and representation, Initial boundary value problems, Laplace's equation, and special topics.

MATH 581-582 Number Theory I-II. (3-3 Hours) Prerequisites: Approval of department. Diophantine analysis, primes, residue classes, theorems of Euler,

Fermat, and Wilson, Continued Fractions, Chinese Remainder Theorem, quadratic reciprocity, valuations, extensions of valuations, local and global fields, discriminant.

MATH 583 Advanced Number Theory. (3 Hours) Prerequisite: Mathematics 581 or departmental approval. Quadratic and Cyclotomic extensions, elementary class field theory, and selected topics.

MATH 584 Independent Study. (3 Hours) Prerequisite: Departmental consent. Intensive study and research of a subject selected in accordance with student needs and arranged in consultation with the staff. Topics will vary. Student will make periodic reports on his/her reading and will-prepare a scholarly paper on a problem.

MATH 588-589 Sampling Methods I-II. (3-3 Hours) Prerequisite: Mathematics 272. Sampling methods: Simple random sampling, sampling for proportions and percentages, estimation of sample size, stratified random sampling ratio estimates.

MATH 590 Thesis. (3 Hours) The candidate for the Master of Science in Teaching degree must present a Thesis embodying the results of the research. The candidate chooses the problem, but approval by the adviser is required.

MATH 599 Thesis. (3 Hours) The candidate for the Master's degree must present a Thesis embodying the results of the research. The candidate chooses the problem, but approval by the adviser is required.

MATH 628 Advanced Partial Differential Equations I (3 hrs): The theory of initial value and boundary value problems for hyperbolic, parabolic, and elliptic partial differential equations, with emphasis on nonlinear equations. Laplace's equation, heat equation, wave equation, nonlinear first-order equations, conservation laws, Hamilton-Jacobi equations, Fourier transform, Sobolef and other spaces, etc.

MATH 629 Advanced Partial Differential Equations II (3 hrs): The theory of boundary value and initial value problems for partial differential equations, with emphasis on nonlinear equations. Second-order elliptic equations, parabolic and hyperbolic equations, calculus of variations methods, additional topics selected by instructor.

MATH 670 Computational Methods in Mathematics I (3 hrs): This course is designed to give an overview of the design, analysis and implementation of the most fundamental numerical techniques in numerical linear algebra, the interpolation of functions, and the evaluation of integrals. This course in most part will depend on programming with MATLAB and/ or C++. While we present many MATLAB examples throughout the course, students are strongly advised to have some previous programming experience in any computer programming language.

MATH 671 Computational Methods in Mathematics II (3 hrs): This course is a continuation of MATH 770. Topics covered includes introduction to mathematical and computational problems arising in the context of molecular biology. Theory and applications of combinatorics, probability, statistics, geometry, and topology to problems ranging from sequence determination to structure analysis. The course depends on parallel and distributed programming.

MATH 673 Quantitative Exploration of Data (3 hrs): This course covers how to analyze and mine data with the Structured Query Language (SQL). Understand SQL fundamentals, and then advance into the uses of SQL data analysis and data mining with real applications. Learn to use Microsoft Excel to further analyze, manipulate and present your data exploration and data-mining findings in tabular and graphical formats. Students will be exposed to Extreme Science and Engineering Discovery Environment (XSEDE).

MATH 700 Mathematical and Statistical applications (3 hrs): The course may be repeated for credit. It covers current trends and challenges of mathematical and statistical applications in CDS&E.

MATH 827 Numerical Solution of Differential Equations (3 hrs): Ordinary differential equations: Runge-Kutta and predictor-corrector methods; stability theory, Richardson extrapolation, stiff equations, boundary value problems. Partial differential equations: stability, accuracy and convergence, Von Neumann and CFL conditions, finite difference solutions of hyperbolic and parabolic equations. Finite differences and finite element solution of elliptic equations

STAT 661 Advanced Probability and Statistics (3 hrs): Prerequisite: Mathematics 532 or approval of department. Basic concepts of probability theory, distribution functions and characteristics functions, central limit problem, modern statistical inference, analysis, variance, and decision functions

STAT 672 Computational Statistics (3 hrs): Prerequisite: Departmental approval. This course covers R, SAS, SPSS, S-Plus, Mathematica, computational statistics packages and other big data statistical computational packages with emphasis on reading, manipulating, summarizing and modeling data and implementations of simulation through random number generating, Monte Carlo method and bootstrapping

STAT 680 Computational Data Analysis and Visualization I (3 hrs): This course is about learning the fundamental computing skills necessary for effective data analysis.

STAT 681 Computational Data Analysis and Visualization II (3 hrs): This course covers exploratory and objective data analysis methods applied to the physical, engineering, and biological sciences.

Dissertation Course

MATH 899 Dissertation Research (Variable 1-9 Hours): Dissertation representing independent and original research in the area of Computational Mathematics and Statistical Sciences. Prerequisite: permission of advisor.