School of Natural Sciences and Mathematics

Department of Mathematical Sciences

Objectives

The Mathematical Sciences Department at The University of Texas at Dallas offers graduate studies in seven specializations namely - Mathematics, Applied Mathematics, Engineering Mathematics, Statistics, Applied Statistics, Data Science and Actuarial Science, and an interdisciplinary degree in Bioinformatics and Computational Biology. The degree programs offer students the opportunity to prepare for careers in these disciplines themselves or in any of the many other fields for which these disciplines offer such indispensable tools. As other sciences develop, problems which require the use of these tools are numerous and pressing.

In addition to a wide range of courses in mathematics, statistics, and actuarial science, the Mathematical Sciences Department offers a unique selection of courses that consider mathematical and computational aspects of engineering, biology and other scientific problems.

The Master of Science degree programs are designed for persons seeking specializations in Mathematics, Applied Mathematics, Engineering Mathematics, Statistics, Applied Statistics, Data Science, Actuarial Science, or Bioinformatics and Computational Biology. The Master of Science degree is also available for those who plan to teach Mathematics or Statistics above the remedial level at a community college or at a college or university. The Master of Science degree is recommended as a minimum, since a doctorate degree is sometimes required.

For information concerning the Master of Arts in Teaching in Mathematics Education, designed for persons who are teaching in grades 6-12, see the Science and Mathematics Education section.

The Doctor of Philosophy degree programs cover two basic areas of concentration: Statistics and Mathematics. They are designed for those who plan to pursue academic, government, financial, actuarial, or industrial careers.

Facilities

The faculty, staff, and students have access to a large network of workstations and servers on campus.

Admission Requirements

The University's general admission requirements are discussed on the Graduate Admission page (catalog.utdallas.edu/2016/graduate/admission).

Specific additional admission requirements for students in degree programs in the Department of Mathematical Sciences follow. Students lacking undergraduate prerequisites for graduate courses in their area must complete these prerequisites or receive approval from the graduate advisor and the course instructor before registering.

One of the components of a student's academic history which is evaluated when the student is seeking admission to the graduate program is his/her performance on certain standardized tests. Since these tests are designed to indicate only the student's potential for graduate study, they are used in conjunction with other measures of student proficiency, such as GPA (grade point average), etc., in determining the admission status.
of a potential graduate student. Accordingly, there is no rigid minimum cutoff score for admission to the program. Most applicants admitted to either the MS or PhD programs have GRE scores of at least 143 verbal, 155 quantitative, and 310 combined. However, exceptions are made in some cases when other credentials are especially strong. Higher standards prevail for applicants seeking Teaching Assistantships.

Master of Science in Mathematics

36 semester credit hours minimum

Department Faculty

Professors: Larry P. Ammann, Zalman I. Balanov, Vladimir Dragovic, Sam Efromovich, Yulia Gel, M. Ali Hooshyar, Wieslaw Krawcewicz, Susan E. Minkoff, L. Felipe Pereira, Dmitry Rachinskii, Viswanath Ramakrishna, Robert Serfling, Janos Turi, John Zweck

Professors Emeritus: Patrick Odell, John W. Van Ness

Clinical Professors: Natalia Humphreys, Wenyi (Roy) Lu

Associate Professors: Swati Biswas, Yan Cao, Min Chen, Pankaj K. Choudhary, Mieczyslaw K. Dabkowski

Assistant Professors: Mohammad Akbar, Maxim Arnold, Bhargab Chattopadhyay, Qingwen Hu, Frank Koniechke, Yifei Lou, Oleg Makarenkov, Tomoki Oshawa, Qiongxia (Joanne) Song, Anh Tran

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UT Dallas Affiliated Faculty: Hervé Abdi, Titu Andreescu, Alain Bensoussan, Stefano Leonardi, John J. Wiorkowski, Zhenyu Xuan, Hyuntae Yoo, Michael Qiwei Zhang

Adjunct Faculty from the Research for Mathematics of the Mexican Council and Technology: Jose Gomez-Larranaga, Adolfo (Sanchez) Valenzuela

Degree Requirements

The University's general degree requirements are discussed on the Graduate Policies and Procedures page (catalog.utdallas.edu/2016/graduate/policies/policy).

Students seeking a Master of Science in Mathematics must complete a total of 12 three-semester credit hour courses. In some cases, credit for 3 semester credit hours is approved for good mathematics background. The student may choose a thesis plan or a non-thesis plan. In the thesis plan, the thesis replaces two elective courses with completion of an approved thesis (six thesis semester credit hours). The thesis is directed by a Supervising Professor and must be approved by the Head of the Mathematical Sciences Department.

Each student must earn a 3.0 minimum GPA in the courses listed for the student's program.

To satisfy the MS degree requirements, we currently offer a choice between four specializations - Mathematics, Applied Mathematics, Engineering Mathematics, and Data Science.

Mathematics Specialization (MS)
MATH 5301 Elementary Analysis I (or equivalent)
MATH 5302 Elementary Analysis II (or equivalent)
MATH 6301 Real Analysis
MATH 6302 Functional Analysis I
MATH 6303 Theory of Complex Functions I
MATH 6309 Differential Geometry or MATH 6310 Topology
MATH 6311 Abstract Algebra I
MATH 6313 Numerical Analysis
MATH 6315 Ordinary Differential Equations
MATH 6318 Numerical Analysis of Differential Equations
Plus two guided electives.

Applied Mathematics Specialization (MS)
MATH 5301 Elementary Analysis I (or equivalent)
MATH 5302 Elementary Analysis II (or equivalent)
MATH 6303 Theory of Complex Functions I
MATH 6308 Inverse Problems and Applications
MATH 6313 Numerical Analysis
MATH 6315 Ordinary Differential Equations
MATH 6318 Numerical Analysis of Differential Equations
MATH 6319 Principles and Techniques in Applied Mathematics I
MATH 6320 Principles and Techniques in Applied Mathematics II
MATH 6321 Optimization
Plus two guided electives.

Engineering Mathematics Specialization (MS)
MATH 5301 Elementary Analysis I (or equivalent)
MATH 5302 Elementary Analysis II (or equivalent)
MATH 6303 Theory of Complex Functions I
MATH 6305 Mathematics of Signal Processing
MATH 6313 Numerical Analysis
MATH 6315 Ordinary Differential Equations
MATH 6318 Numerical Analysis of Differential Equations
MATH 6319 Principles and Techniques in Applied Mathematics I
MATH 6320 Principles and Techniques in Applied Mathematics II
MATH 6331 Linear Systems and Signals
Plus two guided electives.

Data Science Specialization (MS)

CS 5303 Computer Science I
CS 5343 Algorithm Analysis and Data Structures
CS 6307 Introduction to Big Data Management and Analytics for non-CS Majors
CS 6375 Machine Learning
MATH 6312 Combinatorics and Graph Theory
MATH 6321 Optimization
MATH 6340 Numerical Linear Algebra
or MATH 6319 Principles and Techniques in Applied Mathematics
MATH 6390 Topics in Mathematics (Mathematical Foundations of Data Science)
STAT 5390 Topics in Statistics (Probability and Statistics for Data Science and Bioinformatics)
STAT 6390 Topics in Statistics (Statistical Machine Learning)
Plus two guided elective.

Other Requirements
Electives must be approved by the assigned graduate advisor. Typically, electives are 6000- and 7000-level Mathematics courses. Courses from other disciplines may also be used upon approval. Substitutions for required courses may be made if approved by the assigned graduate advisor. Instructors may substitute stated prerequisites for students with equivalent experience.

Master of Science in Statistics

36 semester credit hours minimum

Department Faculty
Professor: Larry P. Ammann, Zalman I. Balanov, Vladimir Dragovic, Sam Efromovich, Yulia Gel, M. Ali Hooshyar, Wieslaw Krawcewicz, Susan E. Minkoff, L. Felipe Pereira, Dmitry Rachinskiy, Viswanath Ramakrishna, Robert Serfling, Janos Turi, John Zweck
Professor Emeritus: Patrick Odell, John W. Van Ness
Clinical Professor: Natalia Humphreys, Wenyi (Roy) Lu
Associate Professor: Swati Biswas, Yan Cao, Min Chen, Pankaj K. Choudhary, Mieczyslaw K. Dabkowski
Assistant Professor: Mohammad Akbar, Maxim Arnold, Bhargab Chattopadhyay,
Statistics Specialization (MS)

1. Five Core Courses:
   - **STAT 6331** Statistical Inference I
   - **STAT 6337** Advanced Statistical Methods I
   - **STAT 6338** Advanced Statistical Methods II
   - **STAT 6339** Linear Statistical Models
   - **STAT 6341** Numerical Linear Algebra and Statistical Computing

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https://catalog.utdallas.edu/2016/graduate/programs/nsm/mathematics

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2. Two courses selected from different specialization groups:

**Statistics Specialization Group One**
- STAT 6329  Applied Probability and Stochastic Processes
- STAT 6343  Experimental Design
- STAT 7334  Nonparametric and Robust Statistical Methods

**Statistics Specialization Group Two**
- STAT 6348  Applied Multivariate Analysis
- STAT 7331  Multivariate Analysis

**Statistics Specialization Group Three**
- STAT 6347  Applied Time Series Analysis
- STAT 7338  Time Series Modeling and Filtering

3. Students must choose remaining courses as electives approved by the graduate advisor for Statistics. Up to two of the following prerequisite 5000-level courses may be counted as electives:

- MATH 5301  Elementary Analysis I
- MATH 5302  Elementary Analysis II
- STAT 5351  Probability and Statistics I
- STAT 5352  Probability and Statistics II

### Applied Statistics Specialization (MS)

1. Five core courses:
   - STAT 5351  Probability and Statistics I
   - STAT 5352  Probability and Statistics II
   - STAT 6337  Advanced Statistical Methods I
   - STAT 6338  Advanced Statistical Methods II
   - STAT 6341  Numerical Linear Algebra and Statistical Computing

2. Two or more courses are selected from the following list:
   - STAT 6329  Applied Probability and Stochastic Processes
   - STAT 6343  Experimental Design
   - STAT 6347  Applied Time Series Analysis
   - STAT 6348  Applied Multivariate Analysis

3. The remaining elective courses can be chosen in Statistics (e.g., STAT 6326 Sampling Theory, STAT 6v99 Statistical Consulting, STAT 6390 Topics in Statistics, etc.) or in other disciplines, and must be approved by the advisor. Many students use this option to build
expertise in another subject to enhance their employment opportunities.

Data Science Specialization (MS)

- **CS 5303** Computer Science I
- **CS 5343** Algorithm Analysis and Data Structures
- **CS 6307** Introduction to Big Data Management and Analytics for non-CS Majors
- **CS 6375** Machine Learning
- **MATH 6312** Combinatorics and Graph Theory
- **STAT 5351** Probability and Statistics I
- **STAT 5352** Probability and Statistics II
- **STAT 6337** Advanced Statistical Methods I
- **STAT 6338** Advanced Statistical Methods II
- **STAT 6348** Applied Multivariate Analysis
- **STAT 6390** Topics in Statistics (Statistical Machine Learning)

Plus one guided elective.

Other Requirements

Electives must be approved by the assigned graduate advisor. Courses from other disciplines may also be used upon approval. Substitutions for required courses may be made if approved by the assigned graduate advisor. Instructors may substitute stated prerequisites for students with equivalent experience.

Master of Science in Actuarial Science

*36 semester credit hours minimum*

Department Faculty

**Professors:** Larry P. Ammann, Zalman I. Balanov, Vladimir Dragovic, Sam Efromovich, Yulia Gel, M. Ali Hooshyar, Wieslaw Krawcewicz, Susan E. Minkoff, L. Felipe Pereira, Dmitry Rachinskiy, Viswanath Ramakrishna, Robert Serfling, Janos Turi, John Zweck

**Professors Emeritus:** Patrick Odell, John W. Van Ness

**Clinical Professors:** Natalia Humphreys, Wenyi (Roy) Lu

**Associate Professors:** Swati Biswas, Yan Cao, Min Chen, Pankaj K. Choudhary, Mieczyslaw K. Dabkowski

**Assistant Professors:** Mohammad Akbar, Maxim Arnold, Bhargab Chattopadhyay, Qingwen Hu, Frank Koniechke, Yifei Lou, Oleg Makarenkov, Tomoki Oshawa, Qiongxia (Joanne) Song, Anh Tran

**Senior Lecturers:** Mohammad Ahsan, Kelly Aman, Malgorzata Dabkowska, Rabin Dahal, Anatoly Eydelzon, Manjula Foley, Bentley T. Garrett, Farid Khafizov, Yuly Koshevnik, David L. Lewis, Changsong Li, Brady McCary, Dereje Mussa, My Linh Nguyen, Jigarkumar Patel, Paul Stanford, Julie Sutton, Tristan Whalen

**UT Dallas Affiliated Faculty:** Hervé Abdi, Titu Andreescu, Alain Bensoussan, Stefano
Program Objective

The objective of the program is to educate future leaders of the actuarial industry with training in actuarial theory and methods in a wide spectrum of actuarial applications involving probabilistic and statistical models. All students will be prepared to take five actuarial preliminary exams and will take two advanced actuarial classes to prepare for professional accreditation. Furthermore, students who did not take classes required for VEE (Validation of Educational Experience) credits in statistics, finance, and economics will have such opportunity. With this combined knowledge of mathematics particularly of probability, statistics, and decision theory together with knowledge of financial mathematics and insurance, the expected passing of five actuarial exams, and the three required VEE credits, graduates of the program will be able to work as senior actuaries in insurance, consulting, finance, government, and emerging markets.

Course Requirements

The University's general degree requirements are discussed on the Graduate Policies and Procedures page (catalog.utdallas.edu/2016/graduate/policies/policy). The minimal total required number of classes for graduation is 36 semester credit hours. Among them, 27 semester credit hours of required courses and 9 semester credit hours of electives.

Required Courses: 27 semester credit hours

- **STAT 5351** Probability and Statistics I
- **STAT 5352** Probability and Statistics II
- **ACTS 6301** Theory of Actuarial Models: Life Contingencies I
- **ACTS 6302** Theory of Actuarial Models: Financial Economics
- **ACTS 6303** Theory of Actuarial Models: Life Contingencies II
- **ACTS 6304** Construction and Evaluation of Actuarial Models I
- **ACTS 6305** Construction and Evaluation of Actuarial Models II
- **ACTS 6306** Advanced Actuarial Applications
- **ACTS 6308** Actuarial Financial Mathematics

Prescribed Elective Courses: 9 semester credit hours

For the prescribed elective courses select three courses from the following:

- **STAT 6337** Advanced Statistical Methods I
- **STAT 6329** Applied Probability and Stochastic Processes
- **STAT 6338** Advanced Statistical Methods II
Experimental Design
Applied Time Series Analysis
Time Series Modeling and Filtering
Applied Multivariate Analysis
Topics in Statistics-Level 6
Nonparametric and Robust Statistical Methods
Numerical Analysis
Statistical Inference I
Financial Management
Regulation of Business and Financial Markets
Investment Management
Fixed Income Securities
Options and Future Markets
Numerical Methods in Finance
Risk and Decision Analysis
Business Economics
Accounting for Managers
Economics for Public Policy

Preparation for Actuarial Exams

These classes prepare for the three preliminary actuarial examinations jointly administered by the Society of Actuaries (SOA), Casualty Actuarial Society (CAS) and the Canadian Institute of Actuaries (CIA):

Exam 1/P: STAT 5351 and STAT 5352
Exam 2/FM: ACTS 6308
Exam 3L/MLC: ACTS 6301
Exam 3F/MFE: ACTS 6302
Exam 4/C: ACTS 6304
Exam 5/FAP: ACTS 6306

Validation by Educational Experience (VEE) Credits

Applied Statistical Methods: STAT 6337 and STAT 6347
Corporate Finance: FIN 6301
Economics: MECO 6303

https://catalog.utdallas.edu/2016/graduate/programs/nsm/mathematics
Mathematics Faculty

**Professors:** Larry P. Ammann, Zalman I. Balanov, Vladimir Dragovic, Sam Efromovich, Yulia Gel, M. Ali Hooshyar, Wieslaw Krawcewicz, Susan E. Minkoff, L. Felipe Pereira, Dmitry Rachinskiy, Viswanath Ramakrishna, Robert Serfling, Janos Turi, John Zweck

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**UT Dallas Affiliated Faculty:** Hervé Abdi, Titu Andreescu, Alain Bensoussan, Stefano Leonardi, John J. Workowski, Zhenyu Xuan, Hyuntae Yoo, Michael Qiwei Zhang

**Adjunct Faculty from the Research for Mathematics of the Mexican Council and Technology:** Jose Gomez-Larranaga, Adolfo (Sanchez) Valenzuela

Biology Faculty

**Professors:** Lee A. Bulla, Rockford K. Draper, Juan E. González, Lawrence J. Reitzer, Stephen Spiro, Li Zhang, Michael Qiwei Zhang

**Professors Emeritus:** Hans Bremer, Donald M. Gray, Claud S. Rupert

**Associate Professors:** Gail A. M. Breen, John G. Burr, Jeff L. Dejong, Ernest M. Hannig, Tae Hoon Kim, Dennis L. Miller

**Assistant Professors:** Zachary Campbell, Nikki Delk, Heng Du, Jung-whan (Jay) Kim, Faruck Morcos, Kelli Palmer, Duane D. Winkler, Zhenyu Xuan, Hyuntae Yoo

**Research Assistant Professors:** Monique Duncan, Lan Guo

**Senior Lecturers:** Irina Borovkov, Mehmet Candas, Vincent P. Cirillo, Brenna Hill, Wen-Ju Lin, Robert C. Marsh, David Murchison, Jing Pan, Elizabeth Pickett, Ruben D. Ramirez, Scott A. Rippel, Elizabeth L. Rugg, Ilya Sapozhnikov, Uma Srikanth, Michelle Wilson, Wen-Ho Yu

Program Objective

The Master of Science in Bioinformatics and Computational Biology (BCBM) is offered jointly by the Departments of Mathematical Sciences and Biological Sciences, with the former serving as the administrative unit. The BCBM combines coursework from the disciplines of biology, computer science, and mathematics. It seeks to address the demand for a new breed of scientists who have fundamental understanding in the fields of biology, mathematics, statistics, and computer science. With this interdisciplinary training, these scientists will be well prepared to meet the demand and challenges that have arisen and will continue to develop in the biotechnology arena.

A successful applicant is expected to have a Bachelor’s degree in Mathematics, Biology or another Science/Engineering and must have completed Differential and Integral Calculus.
courses. One or several of the following courses taken prior to enrollment are desirable: biology courses, a high level programming language, Linear Algebra, and Differential Equations.

Degree Requirements

1. Three introductory electives
The three introductory electives are 5000 level classes with possible prefixes BIOL, CS, MATH and STAT, and are chosen with the consent of the advisor, according to the background, strengths, and interests of a student. For a candidate with a strong and broad background, some introductory electives may be replaced by 6000 level electives. The list of introductory electives includes:

   - **CS 5303** Computer Science I
   - **CS 5343** Algorithms Analysis and Data Structures
   - **STAT 5352** Probability and Statistics II
   - **BIOL 5410** Biochemistry
   - **BIOL 5420** Molecular Biology
   - **BIOL 5460** Quantitative Biology
   - **BIOL 5376** Applied Bioinformatics
   - **MATH 5301** Elementary Analysis I
   - **MATH 5302** Elementary Analysis II
   - **MATH 5390** Topics in Mathematics

2. Four Core courses

3. Five advanced electives
The five advanced electives are 6000 or 7000 level classes with possible prefixes BIOL, CS, MATH and STAT, and are chosen according to the interests of a student with the consent of the advisor. Two of the advanced electives could be replaced by 6 hours research followed by a master thesis, according to the general University rules. The list of advanced electives includes:

   - **CS 6333** Discrete Structures or **MATH 6312** Combinatorics and Graph Theory

https://catalog.utdallas.edu/2016/graduate/programs/nsm/mathematics
MATH 7313  Partial Differential Equations I
BIOL 6385  Computational Biology
STAT 6337  Advanced Statistical Methods I
STAT 6338  Advanced Statistical Methods II
Other courses may also be taken with the advisor's approval.

Doctor of Philosophy in Mathematics

75 semester credit hours minimum beyond the baccalaureate degree

Degree Requirements

The University's general degree requirements are discussed on the Graduate Policies and Procedures page (catalog.utdallas.edu/2016/graduate/policies/policy).

The Doctor of Philosophy degree program is tailored to the student. The student must arrange a course program with the guidance and approval of the graduate advisor. Adjustments can be made as the student's interests develop and a specific dissertation topic is chosen. A minimum of 75 semester credit hours beyond the bachelor's degree is required.

MATH 6301  Real Analysis
MATH 6302  Functional Analysis I
MATH 6303  Theory of Complex Functions I
MATH 6309  Differential Geometry or MATH 6310  Topology
MATH 6311  Abstract Algebra I
MATH 6313  Numerical Analysis
MATH 6315  Ordinary Differential Equations
MATH 6316  Differential Equations

https://catalog.utdallas.edu/2016/graduate/programs/nsm/mathematics
MATH 6318 Numerical Analysis of Differential Equations
MATH 6319 Principles and Techniques in Applied Mathematics I
MATH 6320 Principles and Techniques in Applied Mathematics II
MATH 7313 Partial Differential Equations I
MATH 7319 Functional Analysis II

Electives and Dissertation
An additional 18-24 semester credit hours designed for the student's area of specialization are taken as electives in a degree plan designed by the student and the graduate advisor. This plan is subject to approval by the Department Head. After completion of the first 3 or 4 academic semesters of the course program, the student must pass a PhD Qualifying Examination in order to continue on to the research and dissertation phase of the PhD program. Finally, a dissertation is required and must be approved by the graduate program.

There must be available a dissertation research advisor or group of dissertation advisors willing to supervise and guide the student. A dissertation Supervising Committee should be formed in accordance with the UT Dallas policy memorandum (UTDPP1052).

Doctor of Philosophy in Statistics

75 semester credit hours minimum beyond the baccalaureate degree

Department Faculty

Professors: Larry P. Ammann, Zalman I. Balanov, Vladimir Dragovic, Sam Efromovich, Yulia Gel, M. Ali Hooshyar, Wieslaw Krawcewicz, Susan E. Minkoff, L. Felipe Pereira, Dmitry Rachinskiy, Viswanath Ramakrishna, Robert Serfling, Janos Turi, John Zweck
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Degree Requirements

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The Doctor of Philosophy degree program is tailored to the student. The student must arrange a course program with the guidance and approval of the graduate advisor. Adjustments can be made as the student's interests develop and a specific dissertation topic is chosen. A minimum of 75 semester credit hours beyond the bachelor's degree is required.
Electives and Dissertation
An additional 18-24 semester credit hours designed for the student's area of specialization are taken as electives in a degree plan designed by the student and the graduate advisor. This plan is subject to approval by the Department Head. After completion of the first 3 or 4 academic semesters of the course program, the student must pass a PhD Qualifying Examination in order to continue on to the research and dissertation phase of the PhD program. Finally, a dissertation is required and must be approved by the graduate program. There must be available a dissertation research advisor or group of dissertation advisors willing to supervise and guide the student. A dissertation Supervising Committee should be formed in accordance with the UT Dallas policy memorandum (UTDPP1052).

Research
Within the Mathematical Sciences Department opportunities exist for work and/or research in Applied Mathematics, Engineering Mathematics, Mathematics, and Statistics. The opportunity to take coursework in several of the other University programs also allows the student to prepare for interdisciplinary work. Such coursework must be approved by the assigned graduate advisor.
Some of the broad research areas represented in Statistics are as follows: probability theory, stochastic processes, statistical inference, asymptotic theory, statistical methodology, time series analysis, Bayesian analysis, robust multivariate statistical methods, nonparametric methods, nonparametric curve estimation, sequential analysis, biostatistics, statistical genetics, and bioinformatics.
For a complete list of faculty and their areas of research, visit the Department of Mathem
Graduate Certificate in Data Science: 12 semester credit hours

The Department of Mathematical Sciences, in cooperation with the Department of Computer Science, offers a graduate certificate in Data Science.

Admission Requirements

Students must gain admission to a graduate program at UT Dallas and have the pre-requisites needed to take the certificate courses.

Certificate Requirements

Students must complete the following four courses with a GPA of 3.0 or better.

- **CS 6307** Introduction to Big Data Management and Analytics for non-CS Majors
- **CS 6375** Machine Learning
- **MATH 6312** Combinatorics and Graph Theory
- **STAT 6390** Topics in Statistics (Statistical Machine Learning)

1. Exam 1/P
2. Exam 3L/MLC, Part I
3. Exam 3F/MFE
4. Exam 3L/MLC, Part II
5. Exam 4/C, Part I
6. Exam 4/C, Part II
7. Exam 5/FAP
8. Exam 2/FM
9. VEE, Applied Statistical Methods
10. VEE, Corporate Finance
11. VEE, Economics

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