Mathematics, Statistics and Computer Science (MSCS)

Chairperson: Rebecca L. Sanders, Ph.D.
Department of Mathematics, Statistics and Computer Science website (http://www.marquette.edu/mscs/grad.shtml)

Program Overview
The Department of Mathematics, Statistics and Computer Science offers a range of master’s and doctoral programs in accord with the breadth of the disciplines it encompasses. Bulletin entries for each of the programs described below may be found by exploring the options provided on this page. Further information about the programs can be found on the departmental website (http://www.marquette.edu/mscs/grad.shtml).

Degrees Offered

M.S. in Applied Statistics (http://www.marquette.edu/mscs/grad-applied-statistics.shtml)
The applied statistics program is focused on producing graduates who can deal with big data, perform statistical analysis to detect hidden patterns in data, perform risk factor analysis and perform predictive analysis. The program is intended for students who have a mathematical background (not necessarily having a degree in mathematics or statistics) that want to develop strong data analytic skills to solve complex, real world problems. In addition to course work, students also take a statistical consulting practicum course. The practicum is intended to give students practical, hands-on statistical consulting training.

M.S. in Bioinformatics (http://bulletin.marquette.edu/grad/programs/mathstatsandcomputerscience/bioinformatics)
A joint program between Marquette University and Medical College of Wisconsin, the bioinformatics specialization is geared toward creating computing applications for the biological sciences.

M.S. and Ph.D. in Computational Sciences (http://bulletin.marquette.edu/grad/programs/mathstatsandcomputerscience/computationalsciences)
Our computational sciences program is designed to equip graduates with a distinctive blend of theoretical and computational skills, for employment in industry, research laboratories and institutions of higher education. A distinctive feature of our program is that all core aspects of a student’s program of study, constituting in general the first two years of study, are undertaken within our one interdisciplinary department. While the bulk of their course work will be undertaken in this department, their research topics may range across the computational aspects of a broad spectrum of disciplines.

M.S. in Computing (http://bulletin.marquette.edu/grad/programs/mathstatsandcomputerscience/computing)
The computing program is a professional (terminal) master's degree that spans the study of computer science, computer engineering, software engineering, information technology and information systems. It is designed for individuals who wish to enhance their computing skill set whether they are current practitioners or interested in moving into the computing field.

M.S. in Mathematics Education: Mathematics for Secondary School Teachers (MSST) (http://bulletin.marquette.edu/grad/programs/mathstatsandcomputerscience/mscs)
The mathematics for secondary school teachers specialization provides a master of science degree for mathematics teachers who wish to enhance their practice by deepening their understanding of mathematics and mathematics education beyond the bachelor’s level.

Courses

MSCS 5020. The Teaching of Mathematics. 3 cr. hrs.
Historical background, problems, curricular materials, and teaching procedures in the various areas of mathematics pertinent to the needs of a secondary school mathematics teacher. In addition, a three-hour time block on one day each week between 8 a.m. and 3 p.m. must be kept free for clinical experience.

MSCS 5030. Concepts in Geometry and Calculus from an Advanced Standpoint. 3 cr. hrs.
Topics chosen primarily from geometry and calculus, taught from an advanced standpoint to enrich and deepen the student's understanding. Emphasis on alternative approaches, generalizations, historical contexts and connections with prior mathematical studies.

MSCS 5040. Concepts in High School Algebra and Number Theory from an Advanced Standpoint. 3 cr. hrs.
Topics closely related to the high school mathematics curriculum, chosen primarily from algebra and number theory, taught from an advanced standpoint to enrich and deepen the student’s understanding. Emphasis on alternative approaches, generalizations, historical contexts and connections with prior mathematical studies.
MSCS 5110. Formal Languages and Computability. 3 cr. hrs.
Regular languages, finite state automata, and lexical analysis; context free languages, push-down automata, parsing, and the rudiments of LL and LR parsers; general phrase-structure languages, Turing machines, the Church-Turing thesis, the halting problem, universal programming languages.

MSCS 5120. Abstract Algebra 1. 3 cr. hrs.
Sets, mappings, operations on sets, relations and partitions. A postulational approach to algebraic systems including semigroups, groups, rings and fields. Homomorphisms of groups and rings, number systems, polynomial rings.

MSCS 5121. Abstract Algebra 2. 3 cr. hrs.
A continuation of MSCS 5120 with emphasis on groups, rings, fields, and modules.

MSCS 5200. Intermediate Analysis 1. 3 cr. hrs.
Limits and continuity, differentiability, Riemann integration. Topology of N-dimensional spaces.

MSCS 5201. Intermediate Analysis 2. 3 cr. hrs.
Transformations of N-spaces, line and surface integrals, sequences and series, uniform convergence.

MSCS 5210. Complex Variables. 3 cr. hrs.
Complex numbers, analytic functions, differentiation, series expansion, line integrals, singularities, and residues.

MSCS 5290. Real-Time and Embedded Systems. 3 cr. hrs.
Focuses on event-driven programming, real-time scheduling, and synchronization; worst-case execution time analysis and deadline analysis; real-time operating systems and real-time programming languages.

MSCS 5300. Networks and Internets. 3 cr. hrs.
Focuses on data communication and network protocols, including the TCP/IP protocol suite; Internet transport, packet switching and routing; network programming and network applications. May consist of a 3 hr. lec. or a 2 hr. lec. and 2 hr. lab.

MSCS 5310. History of Mathematical Ideas. 3 cr. hrs.
Topics include: development of the number system (need for irrational and complex numbers); development of geometry including the effects of the discovery of non-Euclidean geometry; limit concept; need for axiomatic structures; 20th century problems. Current mathematics research and place of mathematics in today's world.

MSCS 5320. Theory of Numbers. 3 cr. hrs.
Integers, unique factorization theorems, arithmetic functions, theory of congruences, quadratic residues, partition theory.

MSCS 5360. Computer Security. 3 cr. hrs.
Fundamentals of computer security, including cryptography, access control, security policy models, attacks, surveillance, privacy, and forensics. Draws examples of security vulnerabilities and defenses from many areas of computer science such as operating systems, databases, networks and software engineering.

MSCS 5400. Compiler Construction. 3 cr. hrs.
Lexical analysis, parsing, code generation, and optimization. Includes theoretical foundations and the practical concerns of implementation.

MSCS 5420. Foundations of Geometry. 3 cr. hrs.
Modern postulational development of Euclidean and non-Euclidean geometries.

MSCS 5450. Topology. 3 cr. hrs.
Topological spaces, mappings, metric spaces, product and quotient spaces. Separation axioms, compactness, local compactness and connectedness.

MSCS 5500. Theory of Differential Equations. 3 cr. hrs.
Existence and uniqueness theorems, linear and non-linear systems, numerical techniques, stability.

MSCS 5510. Elementary Partial Differential Equations. 3 cr. hrs.
Fourier series, method of separation of variables, eigenfunction expansions, application of eigenfunctions to partial differential equations, Green's functions and transform methods.

MSCS 5540. Numerical Analysis. 3 cr. hrs.
Numerical solution of algebraic and transcendental equations, linear systems and the algebraic eigenvalue problem, interpolation and approximation, numerical integration, difference equations, numerical solution of differential equations, and finite difference methods.

MSCS 5600. Fundamentals of Artificial Intelligence. 3 cr. hrs.
An introduction to the broad field of artificial intelligence. Topics include: problem solving by searching, knowledge representation, reasoning, planning, decision-making, learning, perception, and language processing.

MSCS 5610. Data Mining. 3 cr. hrs.
Techniques for extracting and evaluating patterns from large databases. Introduction to knowledge discovery process. Fundamental tasks including classification, prediction, clustering, association analysis, summarization, and discrimination. Basic techniques including decision trees, neural networks, statistics, partitional clustering, and hierarchical clustering.

MSCS 5630. Mathematical Modeling and Analysis. 3 cr. hrs.
Construction and analysis of mathematical models from biological, behavioral, and physical sciences.
MSCS 5650. Theory of Optimization. 3 cr. hrs.
Fundamental theorems describing the solution of linear programs and matrix games. Minimax, duality, saddle point property, simplex and specialized algorithms. Zero sum games, transportation and assignment problems, applications to economics.

MSCS 5670. Applied Combinatorial Mathematics. 3 cr. hrs.
Permutations and combinations, recurrence relations, inclusions and exclusion, Polya's theory of counting, graph theory, transport networks, matching theory.

MSCS 5700. Theory of Probability. 3 cr. hrs.
Random variables, distributions, moment generating functions of random variables, various derived probabilistic models and applications.

MSCS 5710. Mathematical Statistics. 3 cr. hrs.
Sampling theory and distributions, estimation and hypothesis testing, regression, correlation, analysis of variance, non-parametric methods, Bayesian statistics.

MSCS 5720. Statistical Methods. 3 cr. hrs.
Probability, discrete and continuous distributions. Treatment of data, point and interval estimation, hypothesis testing. Large and small sample method, regression, non-parametric methods. An introduction to the basic understanding of statistical methods. Applications-oriented.

MSCS 5740. Biostatistical Methods and Models. 3 cr. hrs.
Introduction to the statistics of life science and the use of mathematical models in biology. Data analysis and presentation, regression, analysis of variance, correlation, parameter estimation and curve fitting. Biological sequence analysis, discrete and continuous mathematical models and simulation.

MSCS 5760. Time Series Analysis. 3 cr. hrs.

MSCS 5780. Regression Analysis. 3 cr. hrs.
Basic concepts of statistical inference, simple linear regression, multiple linear regression, diagnostic analysis, selecting the best equation, stepwise methods, nonlinear regression, use of statistical software.

Topics include: database concepts and architecture, data modeling, formal query languages such as relational algebra, commercial query language SQL, database access from application programs and a brief examination of advanced concepts including transactions, distributed databases, security and XML.

MSCS 5860. Component-Based Software Construction. 3 cr. hrs.
Introduction to software components in the context of the object-oriented paradigm. Component development, component selection and adaptation/customization, component deployment and assembly/integration, and system architecture. Industry standards such as JavaBeans, CORBA Component Model, and Microsoft COM/DOM/COM+.

MSCS 5931. Topics in Mathematics, Statistics and Computer Science. 1-3 cr. hrs.
Topics selected from one of the various branches of mathematics, statistics or computer science. Specific topics to be announced in the Schedule of Classes.

MSCS 6010. Probability. 3 cr. hrs.
Foundations of probability for modeling random processes and Bayesian approaches, including: counting techniques, probability of events, random variables, distribution functions, probability functions, probability density functions, expectation, moments, moment generating functions, special discrete and continuous distributions, sampling distributions, prior and posterior distributions, Law of Large Numbers, Central Limit Theorem, Bayesian paradigm. Prereq: Three semesters of mathematics beyond calculus.

MSCS 6020. Simulation. 3 cr. hrs.

MSCS 6030. Applied Mathematical Analysis. 3 cr. hrs.
Foundational topics in analysis considered from a modeling and numerical viewpoint. Emphasizes techniques of proof and approximation, and their role in the solution of problems arising in applications. Prereq: Multivariable calculus and linear algebra.

MSCS 6040. Applied Linear Algebra. 3 cr. hrs.
Foundational linear algebra considered from a numerical viewpoint. Focus is on solutions of linear systems of equations, eigenvalues and eigenvectors, and transformations. Emphasizes and illustrates proof and numerical implementation using problems arising in applications. Prereq: Multivariable calculus and linear algebra.

MSCS 6050. Elements of Software Development. 3 cr. hrs.
Students explore the software design and development processes through a term project. Concepts covered include: requirements gathering and analysis, mapping requirements to a design, sound coding and documentation practices, configuration management, testing and quality assurance, system deployment and maintenance. Prereq: Programming in a high-level language, knowledge in data structures such as stacks, recursion, queues, trees and graphs.
MSCS 6051. Professional Software Engineering 1. 3 cr. hrs.
Covers software engineering topics typically including the Software Development Lifecycle (SDLC), development methodologies, software quality overview, configuration management, designing for risks and fault tolerance, languages and design, object-oriented programming, observational research and prototyping, requirements, software architectures, operating systems design and real time systems. Offered at General Electric facilities. As this course extends beyond the Marquette term, students receive the grade of IC initially. The IC grade converts to an A-F grade at the completion of the course. Prereq: GE employee in the Software Edison program.

MSCS 6052. Professional Software Engineering 2. 3 cr. hrs.
Covers software engineering topics typically including systems and communication networks, security and distributed systems, interoperability and standards, design for "ility" (e.g., usability and reliability) and performance, design for parallel processing, embedded systems hardware for software developers, embedded systems software, software design patterns and algorithms. Offered at General Electric facilities. As this course extends beyond the Marquette term, students receive the grade of IC initially. The IC grade converts to an A-F grade at the completion of the course. Prereq: GE employee in the Software Edison program.

MSCS 6053. Professional Software Engineering 3. 3 cr. hrs.
Covers software engineering topics typically including database systems, decision science, data quality and analytics, user interface design, design for globalization, debugging and troubleshooting, approach, method, implementation and emerging software technologies. Offered at General Electric facilities. As this course extends beyond the Marquette term, students receive the grade of IC initially. The IC grade converts to an A-F grade at the completion of the course. Prereq: GE employee in the Software Edison program.

MSCS 6054. Professional Software Engineering 4. 3 cr. hrs.
Covers design topics related to system design with embedded computing. Topics typically include design of controls, design for low cost, design for serviceability, design for usability, design for reliability, program management, innovation, requirements management and design thinking. Offered at General Electric facilities. As this course extends beyond the Marquette term, students receive the grade of IC initially. The IC grade converts to an A-F grade at the completion of the course. Prereq: GE employee in the Software Edison program.

MSCS 6055. Software Quality Assurance. 3 cr. hrs.
Provides a perspective on people, organizations, controls, processes, and tools that collectively influence the success of a Software Quality Assurance (SOA) strategy. Discussion topics include quality approaches as they apply to requirements, design, release, configuration management, testing, defect management, operations and support. Topics are discussed in the context of a traditional development approach (waterfall, CMMI) and more contemporary models driven by lean and agile practices. Covers considerations specific to implementing an SOA approach within a regulated setting. The approach emphasizes a hands-on view of SOA, thereby providing realistic takeaways to practice in a professional career.

MSCS 6060. Parallel and Distributed Systems. 3 cr. hrs.
Students use and develop software for parallel and distributed computing systems. Topics include: job submission and management, tools for parallel and distributed software development, approaches for implementing parallel and distributed computation, parallel and distributed system architectures, and essential evaluation techniques. Prereq: Data Structures and Algorithms 2 or equiv.

MSCS 6090. Research Methods/Professional Development. 1 cr. hr.
Designed to introduce the process of research and communication of research in the computational sciences, including presentation and publication of research, preparation of grant proposals, and ethical considerations. May be repeated.

MSCS 6110. Applied Discrete Mathematics. 3 cr. hrs.
Applied discrete mathematics for the mathematics, engineering and computer science graduate student. Emphasis on graph theory and counting problems that serve as a foundation for research areas in the second term. Theory and applications are covered for topics including trees, graph coloring, chromatic polynomials, generating functions, recurrence relations, distinct colorings and Polya's Theorem. Prereq: COSC 1020 and MATH 1450 or equiv.; MATH 1451 and MATH 2100 or equiv.

MSCS 6120. Optimization. 3 cr. hrs.

MSCS 6130. Dynamical Systems. 3 cr. hrs.
Theory of discrete and continuous dynamical systems. Periodic solutions, bifurcations, chaotic systems, attractors, fractal dimension, and simulation of these systems. Prereq: MATH 5200 or equiv.

MSCS 6210. Theory of Statistics. 3 cr. hrs.
Brief review of sampling distributions, Central Limit Theorem and Law of Large Numbers. Estimation, testing hypotheses, regression and correlation analysis, non-parametric methods.

MSCS 6220. Analysis of Variance and Covariance. 3 cr. hrs.

MSCS 6230. Multivariate Statistical Analysis. 3 cr. hrs.
Basic properties of random vectors, multivariate normal distribution, estimations of mean vector and covariance matrix, Wishart distribution, hypothesis testing, Hotelling's T2, multivariate analysis of variance, principal component analysis, factor analysis, canonical correlation analysis, classification and discriminant analysis. Prereq: MATH 3100 and MATH 5710.
MSCS 6240. Design of Experiments and Data Analysis. 3 cr. hrs.
Single factor, two-factor and multi-factor designs and their analysis, Latin-square design and its analysis; power analysis and sample size selection; 2^k factorial designs; confounding/blocking designs; orthogonality and orthogonal contrasts; 3^k factorial designs; response surface methodology. Prereq: A course in statistical methods, such as MATH 4720/MSCS 5720.

MSCS 6250. Advanced Multivariate Data Analytics. 3 cr. hrs.
Multivariate data and exploratory analysis; random vector and multivariate normal distribution; multivariate linear regression; principal component and other dimensional reduction techniques; linear discriminant analysis; recursive partition and tree-based methods including classification tree and regression tree; cluster analysis; neural network; support vector machine. Prereq: A course in statistical methods, such as MATH 4720/ MSCS 5720, and a course in linear algebra.

MSCS 6320. Logic and Set Theory. 3 cr. hrs.
Naive set theory, first-order logic, elementary model theory, non-standard analysis, Godel's incompleteness theorems for elementary arithmetic, axioms for set theory, ordinal and cardinal arithmetic, the continuum hypothesis, methods of inner models and forcing for proving consistency and independence results. Prereq: MATH 5120 or equiv.
MSCS 6440. Topology. 3 cr. hrs.
Metric spaces, fundamental topology notions, subspace topology, product spaces, quotient spaces, separation axioms, Tietze's theorem, compactness, metrization, uniform spaces, function spaces, homotopy relation, fundamental group, computing manifold groups. Prereq: MATH 5200 or equiv.

MSCS 6500. Foundations of Computing. 7 cr. hrs.
Prepresents the breadth and current status of computer science in our computerized society and the fundamentals of professional knowledge, skills, and abilities. Foundational topics are intermixed with study of software development which include an introduction to abstraction, algorithmic thinking, simulation and testing for computer based problem solving using higher-level programming languages. Algorithm analysis and computational complexity are presented in the context of considering data structures, algorithms and alternatives. Students program exercises using graphical user interfaces, data base connections, parallel computing and interfaces to the World Wide Web (WWW). Experience includes using an interactive development environment, studying software development methodology, testing code, basic system administration, computer networking and operating system configuration.

MSCS 6510. Business Intelligence. 3 cr. hrs.
Foundational topics in business intelligence. Includes properties and benefits for business intelligence and methodology for the development of business intelligence solutions. Examines technology employed for managing data and creating visualizations and dashboards. Topics include developing a business case, evaluating performance and managing data. Presents overview of data architectures commonly used in business intelligence solutions and includes exercises using common techniques for prediction and time series analysis.

MSCS 6520. Business Analytics. 3 cr. hrs.
Foundational topics in the analysis of data from a business perspective. Includes methodology for the development of business analytics systems. Examines technology employed for business analytics in a variety of industry segments and the benefits derived from business analytics. Foundations of text and data mining techniques commonly used for classification, clustering and prediction. Students are presented techniques for developing a business case, evaluating predictive performance and managing data. Includes exercises using analytic technology and a project to apply analytics to a customer application.

MSCS 6530. Concepts of Data Warehousing. 3 cr. hrs.
Provides an introduction to data warehouse design. Topics in data modeling, database design and database access are reviewed. Data warehouse planning, design, implementation and administration. The role of data warehouse in supporting Decision Support Systems (DSS), Business Intelligence and Business Analytics.

MSCS 6550. Introduction to Cybersecurity. 3 cr. hrs.
Provides an introduction to cybersecurity threats, methods and security techniques. Foundations of various cybersecurity frameworks and methods for applying them to different types of organizations. Includes cyber threat environment, along with methods, tools and techniques that can help mitigate vulnerabilities and reduce risks to an organization.

MSCS 6560. Principles of Service Management and System Administration. 3 cr. hrs.
Introduction to the concepts, principles and practices involved in the operations of secure computing systems. Presents principles of service management and explores how the principles of system administration are derived from concepts of delivering quality services. Lab exercises performing rudimentary tasks of a system administrator using virtual machine environments. Foundation topics include cryptography, popular operating systems for servers, network configuration, system components, networked systems, host management, user management, configuration of servers and services, incident management, change management, security, monitoring and analysis of operations. Prereq: Basic knowledge of scripting, operating systems and services.

MSCS 6770. Innovations in Secondary Mathematics: Meeting the NCTM Standards. 3 cr. hrs.
Online course designed for teachers of secondary mathematics. Emphasizes relevant NCTM standards through discussion, projects, and implementation in a secondary mathematics classroom. Mathematics content amplifies and extends selected topics of secondary mathematics. Title and content vary. Credit may be earned multiple times-once for each title. Prereq; Cons. of dept. ch.; one term of calculus and access to an algebra or geometry class of secondary students; or cons. of course coordinator. For students in MSST or College of Education.

MSCS 6931. Topics in Mathematics, Statistics and Computer Science. 3 cr. hrs.
MSCS 6935. Seminar in Mathematics Curriculum Development and Material 1. 3 cr. hrs.
The historical evolution of mathematics learning theories and research-generated conceptions of mathematics learning; comparisons of various learning theories and their impact on research in mathematics learning; implications of research and learning theories on curriculum development; implications of mathematics learning research/theories on the teaching and learning of mathematics. Prereq: Teaching experience in secondary mathematics. For students in MSST or College of Education.

MSCS 6954. Seminar in Mathematics Curriculum Development and Material 2. 3 cr. hrs.
Philosophy of education with particular attention to mathematics education; development by students of useful curricula in the form of teaching units, evaluation materials, and student and teacher bibliographies for specific topics, grade levels, and ability groups; aspects of supervision as related to the role of department chairperson. Prereq; MSCS 6953. For students in MSST or College of Education.

MSCS 6964. Practicum for Research and Development in Computing. 3-6 cr. hrs.
S/U grade assessment. Prereq: 3.00 MU GPA; must be enrolled in Plan B option of the M.S. in computing program and have completed at least 15 credit hours earned in graduate (6000-level) courses. Available only to full-time students. Cons. of Director of Graduate Studies for the Computing Program or cons. of dept. ch.
This course for computing professionals involves practical application of the knowledge and skills being studied concurrently, and previously studied, in other course work. Prereq: Admission into the Integrated Practicum Option; Cons. Of Director of Graduate Studies for the Computing Program or cons. of dept. ch.

MSCS 6974. Practicum for Research in Computational Sciences. 1-3 cr. hrs.
S/U grade assessment. Prereq: Cons. of dept. ch.

MSCS 6975. Practicum for Statistical Consulting. 3 cr. hrs.
Provides students with the opportunity to explore real-world examples of data analysis as a statistical consultant. Prereq: 3.00 MU GPA; must be enrolled in the Plan B option of the M.S. program in applied statistics, and have completed at least 18 credit hours. Cons. of the applied statistics dir. of graduate studies; or cons. of dept. ch.

MSCS 6995. Independent Study in Mathematics, Statistics and Computer Science. 1-5 cr. hrs.
Prereq: Cons. of dept. ch.

MSCS 6998. Professional Project in Mathematics, Statistics and Computer Science. 0 cr. hrs.
SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

MSCS 6999. Master's Thesis. 1-6 cr. hrs.
S/U grade assessment. Prereq: Cons. of dept. ch.

MSCS 8995. Independent Study in Math, Statistics and Computer Science. 1-3 cr. hrs.
In-depth research on a topic or subject matter usually not offered in the established curriculum with faculty and independent of the classroom setting. Prereq: Cons. of dept. ch.

MSCS 8999. Doctoral Dissertation. 1-12 cr. hrs.
S/U grade assessment. Prereq: Cons. of dept. ch.