DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE

McQuaid Hall, 2nd Floor
(973) 761-9466
math@shu.edu and cs@shu.edu
shu.edu/math-compsci (https://www.shu.edu/math-compsci/)

Faculty: Albagli-Kim; Anand (*Computer Science Adviser)*; Costa; Gross; Hemann (*Computer Science Adviser)*; Kahl (*Adviser, Mathematics Graduate Adviser*); Lin; Luttrell (*Financial Mathematics Adviser*); Madnick; Masterson; Minimair (*Director, Computer Science*, *Cybersecurity, Data Science, Data Visualization and Analysis)*; Morazán (*Computer Science Adviser)*; Phillips (*Mathematics Adviser*); J.T. Saccoman (*Chair; Mathematics Adviser*); Wachsmuth
Faculty Associates: K. Ganning; McNeill(*Math/Ed Adviser*); Sethi (*Director, Developmental Mathematics*); Wager
Faculty Emeritus and Retired: *Marlowe
Lecturers: Davidson; E. Ganning; Reynolds (*Internship Adviser*)

The Department of Mathematics and Computer Science offers programs of study leading to the degrees Bachelor of Science (B.S.) in Mathematics and Bachelor of Science (B.S.) in Computer Science. It also offers interdisciplinary undergraduate and graduate certificate programs in Data Visualization and Analysis, jointly with the Department of Psychology. In addition, the department offers several options for 3 + 2 programs that result in the graduate M.S. in Data Science and undergraduate B.S. degrees in either Mathematics or Computer Science majors. Financial Mathematics majors have an option for a 4+1 program that results in either a M.S. Financial Engineering or M.S. Financial Analytics from Steves Institute of Technology.

The department aims to develop students' analytical skills and attitudes necessary for the effective understanding and application of mathematics and computer science.

A variety of program options are available for undergraduates majoring in mathematics or computer science. Students' programs are determined in consultation with a faculty adviser from the department and tailored to each undergraduate's career goals. With the proper choice of electives, students will be prepared to enter teaching, industry or graduate study in mathematics, computer science, business, law or medicine.

Programs for undergraduates majoring in secondary education with mathematics as a teaching field are determined in consultation with a faculty adviser from the Department of Educational Studies in the College of Education and Human Services, as well as the Department of Mathematics and Computer Science.

The Center for Developmental Mathematics offers classes to strengthen the mathematical foundation for students, and tutoring in mathematics and statistics in the Mathematics Learning Lab in association with the Ruth Sharkey Academic Resource Center. For further information, please refer to the Mathematics Learning Lab website (https://www.shu.edu/math-compsci/math-learning-lab.html).

Departmental Honors

The Department of Mathematics and Computer Science offers the opportunity for students to graduate with departmental honors in mathematics and/or computer science. The requirements for departmental honors include a GPA and credit requirement, as well as the completion of a capstone project under supervision of a faculty member. It is recommended that any interested student should meet with the chair of the department or his/her adviser by the end of the sophomore year to discuss options for the senior project. Please, see the respective major programs for the corresponding listing of requirements.

Major

- 4+1 B.S. in Financial Mathematics from Seton Hall and M.S. from Stevens Institute of Technology (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/financial-mathematics-4-1-bs-ms/)
- Accelerated 3+2 B.S. in Computer Science with MS in Data Science (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/accelerated-32-bs-in-computer-science-with-ms-in-data-science20/)
- Computer Science Major (B.S.) (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/computer-science-major-bs/)
- Financial Mathematics Major, (B.S.) (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/financial-mathematics-major-bs/)
- Mathematics Major, (B.S.) (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/mathematics-major-bs/)

Accelerated and Dual Degree

- 4+1 B.S. in Financial Mathematics from Seton Hall and M.S. in Financial Analytics from Stevens Institute of Technology (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/4-plus-1-bs-financial-mathematics-seton-hall-ms-financial-analytics-stevens-institute-technology/)
- 4+1 B.S. in Financial Mathematics from Seton Hall and M.S. in Financial Engineering from Steven Institute of Technology (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/i41-bs-financial-mathematics-seton-hall-ms-financial-engineering-stevens-institute-technology/)
- Accelerated 3+2 BS in Mathematics with MS in Data Science (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/accelerated-32-bs-mathematics-ms-data-science/)
- Accelerated 3+2 Mathematics Minor with MS in Data Science (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/accelerated-32-mathematics-minor-ms-data-science/)

Minor

- Applied Scientific Mathematics Minor (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/scientific-mathematics-minor/)
- Computer Science Minor (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/computer-science-minor/)

- Cybersecurity Minor (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/cybersecurity-minor/)
- Data Analytics Minor (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/data_analytics_minor/)
- Mathematics Minor (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/mathematics-minor/)

Certificate

- Cybersecurity Certificate (http://catalogue.shu.edu/undergraduate/college-arts-sciences/department-mathematics-computer-science/cybersecurity-certificate/)

Note to Students: The following listing represents those courses that are in the active rotation for each department, i.e., have been offered in the past five years. Some departments have additional courses offered more rarely but still available – to find the complete list of all official courses for a department, please use the "Course Catalogue Search" function in Self-Service Banner

Course Descriptions

CSAS 1015 Foundations of Computer Science (3 Credits)
General overview of the many facets of computer science and information technology: Data, hardware, software, networks. System software in including operating systems and programming environments. Software engineering; program development using data structures, algoriths, files, and databases. Exposure to other topics and issues in computer science, such as data compression, security, theory of computation, computational complexity. Prerequisites: MATH 0012 or appropriate placement.
Prerequisites: MATH 0012 (may be taken concurrently)

CSAS 1092 Error Messaging in FSM (2 Credits)

CSAS 1111 Introduction to Computer Science I (4 Credits)
Problem solving using computers. The design and implementation of computer programs. Major areas and issues in computer science including social and ethical concerns. Problem solving and pseudocode. Formal specification and verification. Basic software engineering techniques and software reuse. Data structures. Structured types: arrays, records, files. Objects and methods. Programming in a high-level language, such as C++ or Java. Corequisite: MATH 1015.

CSAS 1112 Introduction to Computer Science II (4 Credits)
Major issues, areas, and applications of computer science. Data structures and algorithms. Linked lists, trees and graphs. Stacks, queues, and heaps. Object-oriented programming. Problem solving and software engineering. Algorithm design, induction, recursion, and complexity. Social, economic, and ethical concerns. Programming in a high-level language, such as C++ or Java. Prerequisite: CSAS 1111. Corequisite: MATH 1501/1401.
Prerequisites: CSAS 1111A (may be taken concurrently) and (MATH 1501 (may be taken concurrently) or MATH 1401 (may be taken concurrently))

CSAS 1113 Computing for Science Majors (4 Credits)
A course in programming in C++ with emphasis on applications to the sciences and to numeric algorithms. Basics of software development (variables, control structures, functions), data structures (records, arrays, lists), dynamic structures (pointers, linked lists) and principles of object-oriented programming (fields and methods, classes, inheritance). The course will focus on creating programs for topics of interest in the natural sciences. Corequisite: MATH 1015 or equivalent.

CSAS 1114 Intro to Program Design I (3 Credits)
Programming skills are important to virtually every profession. Professionals must make decisions on how to achieve goals by deciding what steps are necessary. This course is an introduction to computer programming that teaches students how to make plans, to organize their thoughts, to pay attention to detail, and to be self-critical. The main focus of the course is the design process that leads students from a problem statement and a blank page to a well-organized solution. Topics include the processing of simple forms of data, the processing of arbitrarily large data, and the process of abstraction. This course assumes no prior computer programming experience. Corequisite Math 1014, 1015, 1401 or 1501.

CSAS 1115 Intro to Program Design II (3 Credits)
This course continues the study of the design and the programming processes started in CSAS 1114. Building on the abstraction skills acquired in CSAS 1114, the course focuses on new programming design techniques such as generative recursion, tail-recursion, and the changing of state variables through the use of assignment. The disciplined introduction to assigment prepares students to study modern object-oriented design and programming. Prerequisite: CSAS 1114, Corequisite: MATH 1015, 1501 or 1401.
Prerequisites: CSAS 1114

CSAS 2123 Intro Object-Orient Design I (3 Credits)
This course is an introduction to object-oriented design and programming. Building on the knowledge gained in CSAS 1114-1115 students learn to design a system of classes to represent information. Given a system of classes and a piece of information students will be able to create objects and represent this information with data. Conversely, given an instance of a class in the system, students will be able to interpret this object as information in the real world. Topics include varieties of data, functional methods, and abstraction with classes. Prerequisite: CSAS 1114, MATH 1501/1401.
Prerequisites: CSAS 1115 and MATH 1611

CSAS 2124 Intro Object-Orient Design II (3 Credits)
This continues the investigation of object-oriented design and programming started in CSAS 2123. Topics include circular objects, imperative methods, abstraction over data definitions, and the use of commercial programming environments for object-oriented programs. By the end of this course, students will have a solid grasp on the principles and practice of object-oriented programming. Prerequisite: CSAS 2143.

CSAS 2125 Computer Systems-Assembly Prog (3 Credits)
This course introduces the basic design of computing systems: CPU, memory, input and output. In addition, it provides a complete introduction to assembly language:the basics of an instruction set plus experience in assembly language programming using a RISC architecture. During the course student will gain experience using system calls and interrupt-driven programming emphasizing the interaction with the operating system. Other topics include: machine representation of integers, characters, floating point numbers, and virtual memory. Prerequisite: CSAS 1115, MATH 1611, or permission of instructor.

CSAS 2126 Data Structures and Algorithms (3 Credits)
This course discusses data structures such as arrays, stacks, queues, lists, trees, and graphs and the algorithms that manipulate these structures. Algorithm analysis for the cost of time and space is introduced. Students will learn essential tools for designing efficient software applications, needed in all application areas of computer science, such as industrial and scientific computation and database management. Prerequisite: CSAS 1114, MATH 1611.

CSAS 2193 Topics/Applled Modern Compu I (3 Credits)

CSAS 2293 Topics/Applied Modern Comp II (3 Credits)

CSAS 3010 Data Mining (3 Credits)
This course introduces the foundations of applied data mining. There is a need for extracting useful information from raw data in fields such as social and health sciences, business, the natural sciences and engineering. This course covers the fundamental ideas and algorithms of data mining. Furthermore, it teaches applying data mining techniques in order to extract useful information from data. Standard software for data mining will be used. The course is intended for any student desiring an introduction to data mining.

CSAS 3085 Sp Top - Robotics and the Mind (3 Credits)
Signature III course with substantial computer science or related content, typically interdisciplinary and perhaps team-taught, taught on an experimental basis with topics to be determined by the instructor(s) in cooperation with the University Core Curriculum process. See Co-op Adviser.Crosslisted with PSYC 3698 and CORE 3490 Engaging the World

CSAS 3092 Independent Study (2 Credits)

CSAS 3093 Computer Science Internship (3 Credits)

CSAS 3094 Computer Science Co-Op I (3 Credits)
See Co-op Adviser.

CSAS 3111 Operating Systems and Computer Architecture (3 Credits)
Interdependence of operating systems and architectures. System structure and system evaluation. Emphasis on memory management: addressing, virtual memory, paging, segmentation and secondary storage; processes management: scheduling, context switching, priority, concurrency and deadlock; and resource management: memory, secondary storage, buses and printers. Prerequisite: CSAS 2122.
Prerequisites: CSAS 2124 and CSAS 2126

CSAS 3113 Organization of Programming Languages (3 Credits)
Introduction to principles of programming languages and nonprocedural, non-object-oriented programming. Programming language concepts, including higher-order functions, first-class functions, recursion, tail-recursion and iteration, tree-recursion; issues of pure versus impure languages in relation to performance, implementation and ease of abstraction; environments, parameter passing, and scoping. Structure, the syntax, and implementation of languages, illustrated using interpreters. Emphasis on programming in a language such as Scheme or Prolog; individual programming assignments and team project. Prerequisite: CSAS 2122.
Prerequisites: CSAS 2126

CSAS 3204 Logic and the Limits to Know (3 Credits)
The course presents an overview of topics in and related to logic, including development of formal logic and an axiomatic first-order logic. It explores the history of mathematics and logic in the Catholic Intellectual and wider Western Traditions, as well as the mutual interactions of mathematics, philosophy and religion. It then considers extensions of first-order logic, and provable limits to knowledge: the three unsolvable problems of Euclidean geometry, and examples from Gödel, Turing, Arrow, quantum physics, and others
Prerequisites: PHIL 1104 or PHIL 1204

CSAS 3211 Networks and Networking (3 Credits)
Principles of computer and networking. The layered model of a computer network and its implementation. Standard protocols. Applications. Mathematical principles and theory. Team and individual programming projects. Prerequisite: CSAS 2122 or permission of instructor.
Prerequisites: CSAS 2125

CSAS 3411 Graph Algorithms (3 Credits)
This course introduces discrete graphs and their applications, with emphasis on applications. It covers the fundamental structures of and algorithms on discrete graphs, teaching students how to use graph algorithms to extract useful information from graph and network data, how to model complex processes using graph theoretic techniques, and how to investigate and validate resulting models in order to test graph models and make predictions.
Prerequisites: MATH 1611 and (MATH 2813 or MATH 2814)

CSAS 4063 Special Topics in Comp Science (3 Credits)

CSAS 4066 Special Topics in Comp Sciend (3 Credits)

CSAS 4086 Spec Topics-Comp Science (3 Credits)
Special topics and problems in various branches of computer science. Prerequisites: At least five CSAS courses, including CSAS 2122, or permission of chair.
Prerequisites: CSAS 2126

CSAS 4087 Special Topics Computer Scienc (3 Credits)

CSAS 4091 Ind Study-Computer Science (1 Credit)
Prerequisites: At least five CSAS courses, including CSAS 2122, or permission of chair.
Prerequisites: CSAS 2122 (may be taken concurrently)

CSAS 4093 Independent Study-Comp Science (2 Credits)
Prerequisites: At least five CSAS courses, including CSAS 2122, or permission of chair.
Prerequisites: CSAS 2122 (may be taken concurrently)

CSAS 4094 Independent Study-Comp Science (2 Credits)
Prerequisites: At least five CSAS courses, including CSAS 2122, or permission of chair.
Prerequisites: CSAS 2122 (may be taken concurrently)

CSAS 4095 Independent Study (3 Credits)
Prerequisites: At least five CSAS courses, including CSAS 2122, or permission of chair.
Prerequisites: CSAS 4096 (may be taken concurrently)

CSAS 4096 Independent Study-Comp Science (3 Credits)
Prerequisites: At least five CSAS courses, including CSAS 2122, or permission of chair.

CSAS 4111 Introduction to Artificial Intelligence (3 Credits)
Different definitions of and approaches to artificial intelligence. Problems, problems spaces and search techniques; special emphasis on heuristic search, including hill climbing, best-first search and A*. The role of knowledge and knowledge representation issues. Programming and AI application. Introductory survey paper. Prerequisites: CSAS 3113, MATH 2611.
Prerequisites: CSAS 3113 (may be taken concurrently) and MATH 2611 (may be taken concurrently)

CSAS 4113 Automata Computability and Formal Languages (3 Credits)
Introduction to the theory of finite state automata and their equivalence to regular expressions and regular grammars; pushdown automata and context-free languages; context-sensitive grammars and Turing machines; determinism and nondeterminism; issues of complexity including P and NP; and issues of computability including Turing computable versus Turing decidable, the Halting problem and other incomputable problems. Prerequisites: CSAS 2122, MATH 2611.
Prerequisites: CSAS 2124 and CSAS 2126

CSAS 4115 Theory of Relational Databases (3 Credits)
Modern relational databases. Relational algebra, views and queries, normal forms and normalization, tuning and optimization. The entity-relationship model and database design. Overview of other approaches, especially object-oriented databases, data warehouses and data mining, distributed databases and very large applications. Group project, both design and implementation, in an SQL-based environment, such as an SQL Workbench. Prerequisites: CSAS 2121, MATH 1611 or permission of department chair. MATH 2611 recommended.
Prerequisites: CSAS 2124 and MATH 1611 and CSAS 2126

CSAS 4117 Software Engineering (3 Credits)
The software universe and the role of software engineering. Project, process, and product. Approaches to system and software engineering; software architectures, including component-oriented and service-oriented architectures. Traditional and object-oriented approaches to software engineering; the modern approach, modeling languages and patterns; agile and extreme programming. Requirements elicitation and analysis and system specification; risk analysis; use cases. Knowledge management for requirements elicitation and risk analysis. Design of a software system using patterns and incremental iterative refinement. Complementary approaches, including aspects and interfaces with databases. Security and other non-behavioral considerations. Development of an initial prototype.
Prerequisites: CSAS 2124 and CSAS 2126

CSAS 4118 Software Engineering II (3 Credits)
Design and implementation of a software application. Design patterns and aspects. User and component interfaces. Approaches for software quality assurance: validation and verification, testing, static analysis and model checking. Verification, validation, and testing. Approaches to verification – theorem proving, model checking, and others. Principles and theory of testing; white box and black box testing. Unit, integration, stress, and acceptance tests. Test metrics and test coverage. Testing tools. Maintenance: corrective, preventative, adaptive, and perfective changes. Software configuration management. Technical and business management of large software projects. Technical and business metrics. Cost estimation, scheduling, and staffing – connection to risk analysis. Subcontractors, vendors and collaborators; outsourcing in software projects. Software engineering for web applications and real-time systems.
Prerequisites: CSAS 2124 and CSAS 4117

CSAS 4122 Computer Graphic Visualization (3 Credits)
Computer Graphics Visualization is used throughout society, including science, engineering, enterprises, politics, art, etc., for visualizing data and processes. Visualization is crucial for mining usable information from the ever increasing amounts of data and ever more complex procedural relationships of today's society. This course introduces the foundations for computer graphics visualization: basics of visual thinking and perception, techniques for visualization, such as maps, time series, trees, graphs, etc., and applications, such as in medical imaging, biochemistry, social sciences, etc. The course also teaches developing visualizations using a standard programming system. Visualizations will be demonstrated using online material, such as Many Eyes or Google Maps. Prerequisite: CSAS 4121 or permission or instructor.
Prerequisites: CSAS 4121

CSAS 4201 Approaches to Big Data (3 Credits)

CSAS 4202 Honors Research Project I (3 Credits)

CSAS 4911 Big Data Analytics (3 Credits)
The course covers algorithms and software frameworks that are used for automating data analysis of big data. The course topics include Python for data science, big data stack, data analytics architecture, MapReduce, Hadoop and case studies such as recommendation engines. The course teaches practical skills in implementing big data analytics using industry-standard software, such as Python and MapReduce, and cloud computing services. Cross-listed with DASC 6911. Prerequisites: DASC 3010 and (MATH 2111 or MATH 2711) and have at least junior level and demonstrate basic Python programming skills (such as CSAS 4124 or ISCI 1117.) 3 credits.

MATH 0012 Developmental Math II (3 Credits)
Topics covered: review of arthimetic skills, simplifying algebraic expressions, exponents, equations, polynomials, graphing, factoring, square roots, algebraic fractions and elementary word problems. Successful completion of this class will satisfy the Developmental Math requirements. Prerequisite: MATH 0011 or appropriate placement.

MATH 0015 College Algebra Coreq Lab (3 Credits)
A 3-credit lab linked with specified sections of MATH 1014 required for students whose placement indicated the need for additional mathematics skills mastery. Topics covered: review of arithmetic skills, simplifying algebraic expressions, exponents, equations, polynomials, graphing, factoring, radical expressions, algebraic fractions and elementary word problems.
Prerequisites: Math Placement Test with a score of CAT1

MATH 1014 College Algebra (3 Credits)
The real number system, algebraic manipulations, solving equations and inequalities, exponents and radicals, functions and graphing. Prerequisite: MATH 0012 or appropriate placement.

MATH 1015 Pre Calc Math Alg and Trig (4 Credits)
The real number system, functions, polynomial functions and equations, exponential and logarithmic functions, trigonometric functions (graphs, applications, identities and equations), analytic geometry. Prerequisite: MATH 1014 or appropriate placement.

MATH 1061 Math for Elem Educators II (3 Credits)

MATH 1101 Stat Concepts and Methods (3 Credits)
Nature of statistics. Descriptive statistics, graphical methods, measures of central tendency and variability. Probability, correlation and regression, sampling distributions. Inferential statistics, estimation and hypothesis testing, tests of independence and nonparametric statistics. Use of computer statistical packages. Prerequisite: MATH 0012 or appropriate placement.

MATH 1102 Mathematical Perspective (3 Credits)
Introduction to traditional and contemporary mathematical ideas in logic, number theory, geometry, probability and statistics. Historical and cultural development of these topics, as well as connections to other disciplines and various problem-solving strategies are included. Prerequisite: MATH 0012 or appropriate placement.

MATH 1151 Math for Elem Educators I (3 Credits)

MATH 1161 Math for Elem Educators II (3 Credits)

MATH 1203 Stats Models for Soc Science (3 Credits)
Applications of statistics in the social sciences. Analysis and interpretation of statistical models. Sampling techniques, common flaws and errors in sampling and in using statistics. Descriptive statistics, levels of measurement, measures of central tendency and dispersion. Contingency tables and measures of association for categorical variables. Correlation and linear regression. Probability and frequency distributions. Parametric and nonparametric inferential statistics. Confidence intervals and hypothesis testing. Prerequisite: MATH 0012 or appropriate placement.

MATH 1205 Finite Math w Calculus for Bus (3 Credits)
For students in the School of Business. Functions and linear models, systems of linear equations, linear programming, sets and counting, probability, random variables and statistics, quadratic functions, introduction to the derivative, marginal analysis, maximum and minimum problems, the mathematics of finance. Specific and real-world applications to problems illustrate each topic. Prerequisite: MATH 0012 or appropriate placement.

MATH 1311 Calculus for Business- Econ II (3 Credits)
Implicit differentiation, related rates, differential equations, improper integrals and probability density functions, partial derivatives and applications and multiple integrals. Introduction to matrix theory, solution of systems of linear equations and linear programming. Prerequisite: MATH 1303.
Prerequisites: MATH 1303 (may be taken concurrently)

MATH 1401 Calculus I (4 Credits)
Real numbers, functions, elements of plane analytic geometry, limits, continuity, derivatives, differentiation of algebraic functions, applications of the derivative, antiderivatives, definite integral and Fundamental Theorem of Calculus. Applications using computer software packages. Prerequisite: MATH 1015 or appropriate placement.

MATH 1411 Calculus II (4 Credits)
Applications of integration. Differentiation of trigonometric and exponential functions and their inverses. Techniques of integration. Improper integrals, indeterminate forms, polar coordinates and vectors. Applications using computer software packages. Prerequisite: MATH 1401.
Prerequisites: MATH 1401 (may be taken concurrently)

MATH 1501 Calculus I - Math - Phys Sci (4 Credits)
Real numbers, proof by induction, functions, definition by recursion, limits, continuity, derivatives and applications, definite integral, Fundamental Theorem of Calculus and inverse functions. Applications using computer software packages. Emphasis on theory. Prerequisite: MATH 1015 or appropriate placement.
Prerequisites: MATH 1015 or Math Placement Test with a score of CAT4

MATH 1511 Calculus II - Math - Phys Sci (4 Credits)
Applications of integration, polar coordinates, techniques of integration, infinite series, conics, two-dimensional vectors and differential equations. Applications using computer software packages. Emphasis on theory. Prerequisite: MATH 1401 or 1501.

MATH 1611 Intro to Discrete Mathematics (3 Credits)
Basic counting rules, permutations, combinations, Pigeonhole principle, inclusion-exclusion, generating functions, recurrence relations, graphs, digraphs, trees and algorithms. Prerequisite: MATH 1015 or appropriate placement

MATH 2111 Statistics for Science Majors (4 Credits)
Oriented toward direct application to research problems in the sciences. Collecting and organizing data, design of experiments, standard distributions, statistical tests and procedures used in hypothesis testing. A discursive treatment of the probability theory necessary to understand statistical tests is included but minimized. Emphasis on statistical inference and developing an awareness of statistical methods in a given situation. Prerequisite: MATH 1401.
Prerequisites: MATH 1401 or MATH 1501

MATH 2411 Calculus III (4 Credits)
Elements of solid analytic geometry, parametric equations, vector-valued functions, partial differentiation, multiple integrals, line integrals and surface integrals. Applications using computer software packages. Prerequisite: MATH 1411.
Prerequisites: MATH 1411 (may be taken concurrently)

MATH 2511 Calculus III - Math - Phys Sci (4 Credits)
Vectors in space, vector-valued functions, partial differentiation, multiple integrals, vector analysis, and line and surface integrals. Applications using computer software packages. Emphasis on theory. Prerequisite: MATH 1511.
Prerequisites: MATH 1511 (may be taken concurrently)

MATH 2711 Intro Probability - Statistics (4 Credits)
Introduction to statistics. Levels of measurement; central tendency and dispersion; accuracy, precision, error and bias. Probability spaces, random variables, and sampling. Counting: principles, permutations and combinations, combinatorics. Continuous and discrete probability, conditional probability and expectation. Approaches for summarizing and visualizing statistical information. Univariate, bivariate, and multivariate distributions; standard continuous and discrete distributions, including Binomial, Poisson, Exponential, Normal and Chi-Square distributions; introduction to moment generating functions. The Central Limit Theorem. Overview of confidence intervals and hypothesis testing. Independence and association, correlation and regression, and the Chi-Square test. Use of software packages such as Maple, Excel, and/or StatCrunch for statistics. Prerequisite: MATH 1401 or MATH 1501, and MATH 1611. (Note: Students cannot receive credit for both MATH 2711 and MATH 2111.)
Prerequisites: (MATH 1401 or MATH 1501) and MATH 1611

MATH 2810 Linear Algebra - Diff Equation (4 Credits)
First order and linear second order differential equations, matrices and linear equation systems, eigenvalues and eigenvectors, and linear systems of differential equations. Separable partial differential equations.
Prerequisites: MATH 1511

MATH 2813 Linear Algebra (4 Credits)
Matrix algebra, determinants, solutions of systems of linear equations, Rn, abstract vector spaces, linear transformations, inner product spaces and eigenvectors. Prerequisites: MATH 2611.
Prerequisites: MATH 1611 or MATH 2511

MATH 2814 Intro Linear Algebra Comp Math (3 Credits)
Topics essential for computer science selected from traditional linear algebra and Calculus II. The material is presented in a constructive and algorithmic way to increase relevance for computer science students. The students will implement relevant mathematical algorithms in a programming language taught during the freshman or sophomore year. Students will acquire skills that are essential for designing efficient software applications, needed in industrial and scientific applications of computer science.
Prerequisites: (MATH 1501 or MATH 1611) and CSAS 1114

MATH 3104 Dynamical Systems Theory (3 Credits)
This course is a rigorous introduction to continuous and discrete dynamical systems. It seeks to convey the fundamental theories and methods of dynamical systems, from local behavior near a critical point or periodic orbit, to the global, such as global structural stability, bifurcations, and chaos. Modeling and applications in physical, biological, and social sciences are also explored. Prerequisite: MATH 2511 and MATH 2813

MATH 3111 History of Mathematics (3 Credits)
The development of mathematical ideas in various cultures, civilizations, and eras including Ancient Greece, Medieval China, the Renaissance, Era of Descartes and Fermat, Era of Newton and Leibniz, as well as the logical foundations and the use of the computer in Modern Mathematics. Prerequisite: MATH 2511 and MATH 1611.

MATH 3204 Logic and the Limits to Know (3 Credits)
The course presents an overview of topics in and related to logic, including development of formal logic and an axiomatic first-order logic. It explores the history of mathematics and logic in the Catholic Intellectual and wider Western Traditions, as well as the mutual interactions of mathematics, philosophy and religion. It then considers extensions of first-order logic, and provable limits to knowledge: the three unsolvable problems of Euclidean geometry, and examples from Gödel, Turing, Arrow, quantum physics, and others
Prerequisites: PHIL 1104 or PHIL 1204

MATH 3411 Graph Algorithms (3 Credits)
This course introduces discrete graphs and their applications, with emphasis on applications. It covers the fundamental structures of and algorithms on discrete graphs, teaching students how to use graph algorithms to extract useful information from graph and network data, how to model complex processes using graph theoretic techniques, and how to investigate and validate resulting models in order to test graph models and make predictions.
Prerequisites: MATH 1611 and (MATH 2813 or MATH 2814)

MATH 3512 Intro to Complex Analysis (3 Credits)
Analytic functions, elementary functions and mappings, integrals, Cauchy's integral theorem and formula, power series, residues and poles. Prerequisite: MATH 2511. 3 credits

MATH 3514 Differential Equations (3 Credits)
Existence theorems, graphical methods, phase plane analysis, boundary value problems and selected topics. Prerequisites: MATH 2511, MATH 2813.
Prerequisites: MATH 2511

MATH 3515 Analysis (4 Credits)
Structure of R1 and Rn. Sets, equivalence classes, countability; compactness and connectedness; continuity, differentiability and integrability. Theory of series. Pointwise and uniform convergence. Prerequisites: MATH 2411 or 2511; MATH 2813.
Prerequisites: MATH 2411 (may be taken concurrently) or MATH 2511 (may be taken concurrently) and MATH 2813 (may be taken concurrently)

MATH 3611 Intro to Ops Res (3 Credits)
Construction and use of mathematical models in operations research. Classical techniques for optimization of functions of one and several variables. Linear programming problem and simplex method for their solutions. Applications to practical problems. Prerequisites: MATH 2511, MATH 2813.
Prerequisites: MATH 2511 (may be taken concurrently) and MATH 2813 (may be taken concurrently)

MATH 3612 Discrete Mathematics (3 Credits)
Combinatorial methods and discrete structures. Topics may include enumeration techniques, subsets and designs, partitions, generating functions and recurrence relations; codes and graphs. Prerequisites: MATH 1611, MATH 2813 or MATH 2814.
Prerequisites: MATH 2511 (may be taken concurrently) and MATH 2813 (may be taken concurrently)

MATH 3614 Graph Theory (3 Credits)
Graphs, trees and digraphs. Various properties are discussed and may include connectivity, colorability, planarity, matchings, extremal graph theory, spanning trees, and reliability. Applications to real world problems will be introduced.
Prerequisites: MATH 1611 and (MATH 2813 or MATH 2814)

MATH 3626 Applied Matrix Techniques (3 Credits)
This course introduces fundamental matrces and matrix algorithms used in applied mathematics, and essential theorems and their proofs. It covers matrices used in linear optimization, solving systems of linear differential equations, and modeling of stochastic processes. It also covers implementing matrx algorithms with mathematical software,
Prerequisites: MATH 3913 and CSAS 1114

MATH 3711 Statistical Analysis (3 Credits)
Overall emphases on modeling, on concepts and theory, and on standard statistical tools and approaches. Review of probability spaces, random variables, and sampling. Continuous and discrete probability, moment generating functions, standard distributions. Functions of random variables. The Law of Large Numbers and the Central Limit Theorem. Point estimation, confidence intervals and hypothesis testing. The power of a test. Correlation and regression; the Chi-Square Test. Use of software packages such as Maple, Excel and/or StatCrunch/SPSS for statistics. Prerequisites: Either MATH 2111 or MATH 2711, and either MATH 2813 or MATH 2814.
Prerequisites: MATH 1611 and (MATH 2411 or MATH 2511)

MATH 3721 Financial Calculus (3 Credits)
The course presents an overview of topics in and related to actuarial math, including the time value of money, annuities, and amortization. It looks at financial mathematics in terms of bonds, internal rate of return, and term structure of interest rates. It then considers financial calculus with discrete financial models, market models, risk free assets with a concentration on bonds and money markets, and risky assets. Finally, the course introduces financial engineering including the Black-Scholes Equations using probabalistic methods and applications to options and derivatives.
Prerequisites: MATH 2111 or MATH 2711

MATH 3814 Linear Alg and Matrix Theory (3 Credits)
Vector spaces and algebras, unitary and orthogonal transformations, characteristic equation of a matrix, the Jordan canonical form. Bilinear, quadratic and Hermitian forms. Spectral theorem. Prerequisite: MATH 2813.
Prerequisites: MATH 2813 (may be taken concurrently)

MATH 3815 Abstract Algebra (4 Credits)
Introduction to algebraic structures: monoids, groups, rings and fields. Examples are given, and the elementary theory of these structures is described. Prerequisite: MATH 2813.
Prerequisites: MATH 2813 (may be taken concurrently)

MATH 3913 Junior Seminar (3 Credits)
Seminars and discussions designed to integrate readings of mathematical literature with both oral and written presentations.
Prerequisites: MATH 3515 or MATH 3815

MATH 4092 Topics in Applied Math II (3 Credits)
Topics chosen from among operations research, optimization, including an introduction to the calculus of variations, combinatorics, discrete mathematics, Fourier analysis, integral equations, partial differential equations. Students acquire some experience.
Prerequisites: MATH 2511 (may be taken concurrently) and MATH 2813 (may be taken concurrently)

MATH 4095 Independent Study-Math (2 Credits)
Prerequisite: permission of department chair.

MATH 4097 Independent Study-Math (3 Credits)
Prerequisite: permission of department chair.

MATH 4098 Independent Study-Math (3 Credits)
Prerequisite: permission of department chair.

MATH 4099 Mathematics Independent Study (1 Credit)
Independent study on a select topic completed under the supervision of the instructor.

MATH 4512 Intro to Complex Analysis (3 Credits)
Analytic functions, elementary functions and mappings, integrals, Cauchy's integral theorem and formula, power series, residues and poles. Prerequisite: MATH 2511.
Prerequisites: MATH 2511 (may be taken concurrently)

MATH 4516 Advanced Topics in Analysis (3 Credits)
Consequences of continuity, differentiability and integrability in Rn; introduction to metric spaces. Lebesgue integration.
Prerequisites: MATH 3515

MATH 4712 Adv Topic in Appl Prob - Stat (3 Credits)
Advanced topics in probability and statistics or its application, selected by the instructor. Possible topics include, but are not limited to: advanced statistical modeling, stochastic models, applications to actuarial science and reliability, statistical data analysis and visualization, simulation and validation, design of experiments.

MATH 4722 Adv Topics Financial Calculus (3 Credits)
The course presents an overview of topics in and related to financial calculus and financial engineering, including portfolio management, hedging strategy, and risk management. It will introduce Brownian Stochastic Processes and Martingales and Continuous Financial Models. It then considers extensions of optimal portfolios and risk management, including swaps and currency forward contracts.
Prerequisites: MATH 3721

MATH 4816 Advanced Topics in Algebra (3 Credits)
Further properties of groups and fields, with a section on the applications of finite fields. Galois theory, the theory of the solution of algebraic equations.
Prerequisites: MATH 3815

MATH 4911 Intro to Topology (3 Credits)
Topological spaces, subspaces, product spaces, identification spaces. General convergence. Connected and compact spaces. Separation and countability. Compactifications. Prerequisite: MATH 3515.
Prerequisites: MATH 3515 (may be taken concurrently)

MATH 4912 Senior Project (3 Credits)
Individual research project applying skills developed in Junior Seminar (MATH 3912) under the guidance of faculty adviser. Grade is ordinarily based on oral and written presentations. Prerequisites: MATH 3912 and permission of department chair.
Prerequisites: MATH 3912 (may be taken concurrently)

MATH 5011 Mathematics Seminar (3 Credits)
Special topics and problems in various branches of mathematics. Prerequisite: permission of department chair.